CASE REPORT

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Polysplenia syndrome – a rare case report

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SUMMARY

The aim of this study is to report a case of polysplenia syndrome observed in an 1 1/2 yr. old male patient who came for CT thorax for preoperative evaluation of congenital heart disease. There was partial anomalous pulmonary venous drainage – right lung was draining into right atrium and left lung into left atrium. The IVC was interrupted and venous return was via the continuation of enlarged azygos vein, which was running adjacent to the aorta and to its right side. The bronchial and vascular anatomy of the right lung was identical to that of the left lung, i.e, bilateral bilobed lungs with bilateral hyparterial bronchi - a variant condition called left thoracic isomerism. In the abdomen splenule was present. The pathogenesis is not completely clear, but it is thought to be caused by an abnormality of embryonic curvature with a possible genetic basis.

Key words: Polysplenia – Heterotaxia – Azygos continuation – Left isomerism

INTRODUCITION

Polysplenia syndrome is considered a type of situs ambiguous characterized by bilateral left-sidedness. Situs ambiguous or Heterotaxy is the abnormal arrangement of viscera across the left -right axis. There are 2 recognized variants of heterotaxy: left isomerism and right isomerism. Left isomerism is associated with paired left - sided viscera, whereas right - sided viscera may be absent. The situation is the oppopsite in right isomerism. Both variants are associated with complex cardiac malformations. Typical findings in left isomerism are bilateral morphologic left atrial appendages, viscerocardiac heterotaxy, multiple cardiac anomalies, bilateral morphologic left (bilobed) lungs with hyparterial bronchi, multiple splenuli (polysplenia), intestinal malrotation, and interruption of the inferior vena cava with azygos continuation (Peoples et al., 1983; Van Praagh et al., 1988; Winer-Muram and Tonkin, 1989; Ho et al., 1991; Berg et al., 2003; Huggon et al., 2000; Phoon et al., 1996; Atkinson and Drant, 1998; Lin et al., 2002). The greatest attrition in left isomerism occurs in the pre-

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natal period and is frequently associated with heart block and hydrops (Berg et al., 2003; Phoon et al., 1996; Schmidt et al., 1991).

Material and methods

A thoracic CT examination using a Siemens Sensation 64 slice CT scanner was performed. After a test dose, non - ionic iodine contrast material was injected at the rate of 2ml / second. The total volume of contrast injected was 18.0ml (1.5ml/kg). With a bolus tracking technique, the study was performed in two phase. After the study had been completed, the images were reconstructed in multiple planes at a separate work station.

Observation

For a 1 1/2 yr. old male patient, who was brought to the radiology department for preoperative evaluation of congenital heart disease, a thoracic CT examination was done using a Siemens Sensation 64 slice CT scanner. The CT scan showed left thoracic isomerism. The bronchus intermedius was absent, indicating a bilobar right lung (Fig. 1). The ratio of the length of the left mainstem bronchus to the right one was 1.07:1, according to the method described by Partridge et al. (1975) (Fig. 2). No minor fissures were present. Closer examination suggested that the position of the pulmonary artery was altered by the anomalous hyparterial location of the right mainstem bronchus (Fig. 3). The expected opacity due to a normally positioned right pulmonary artery was absent because each pulmonary artery was superior and posterior to its respective bronchus. Partial pulmonary venous return was diagnosed since both of the right pulmonary veins drained into the right atrium and both the left pulmonary veins drained into the left atrium (Fig. 4, 4a). Interruption of the IVC below the drainage of the hepatic veins was also noted (Fig. 5). Venous return occurred via continuation of the azygos vein, which coursed adjacent to aorta and to its right and was enlarged (a large azygos vein may appear as a mediastinal mass) and finally drained into the superior vena cava (Fig. 6). The spleen and single splenule were in the abdomen (Fig. 7).

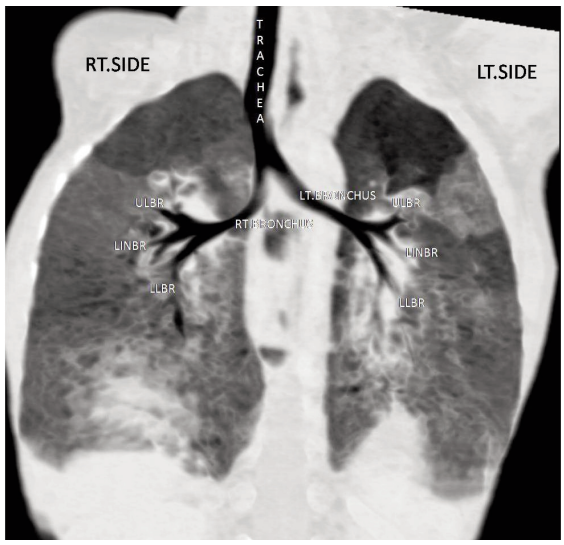

Fig. 1. CT scan of thorax showing bilobar right lung. ULBR - upper lobe branch; LINBR - lingular branch; LLBR - lower lobe branch.

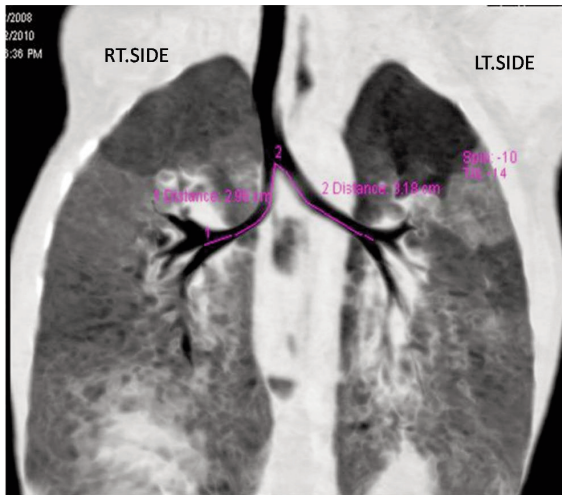

Fig. 2. CT scan of thorax showing the measurement of the length of the left mainstem bronchus and the right one according to the method described by Partridge et al. (1975). Distance 1 - length of right mainstem bronchus: 2.96 cm; Distance 2 - length of left mainstem bronchus: 3.18 cm; Ratio = 1.07:1.

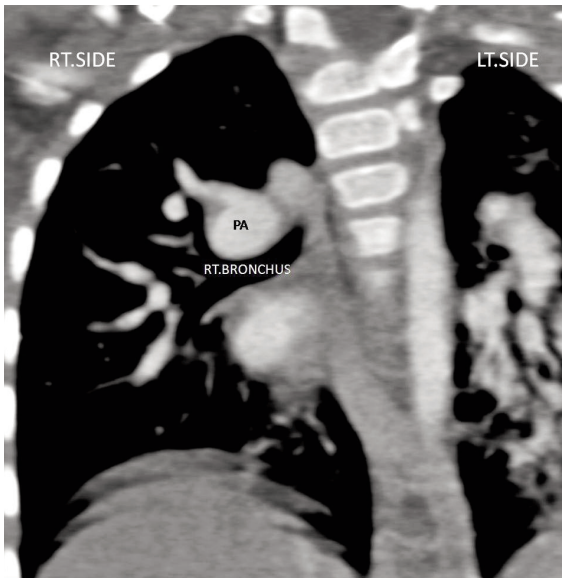

Fig. 3. CT scan of thorax showing the position of pulmonary artery (PA) superior and posterior to its respective bronchus. RT. BRONCHUS - right bronchus.

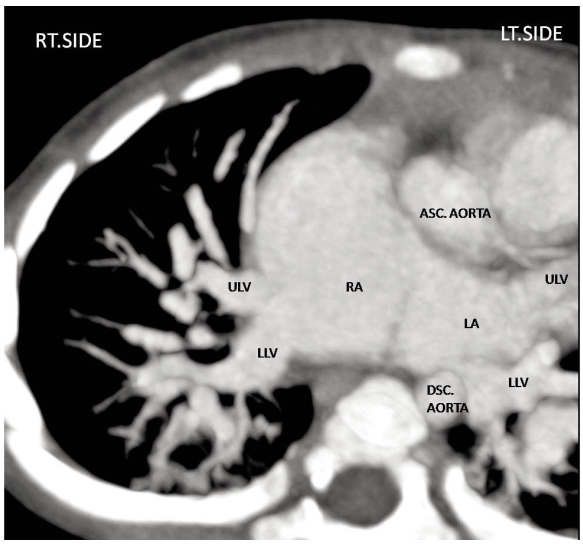

Fig. 4. CT scan of thorax showing partial pulmonary venous return as the right pulmonary veins drain into the right atrium and left pulmonary veins drain into the left atrium. RA - right atrium; LA - left atrium; ULV - upper lobe vein; LLV - lower lobe vein; ASC.AORTA - ascending aorta; DSC. AORTA - descending aorta.

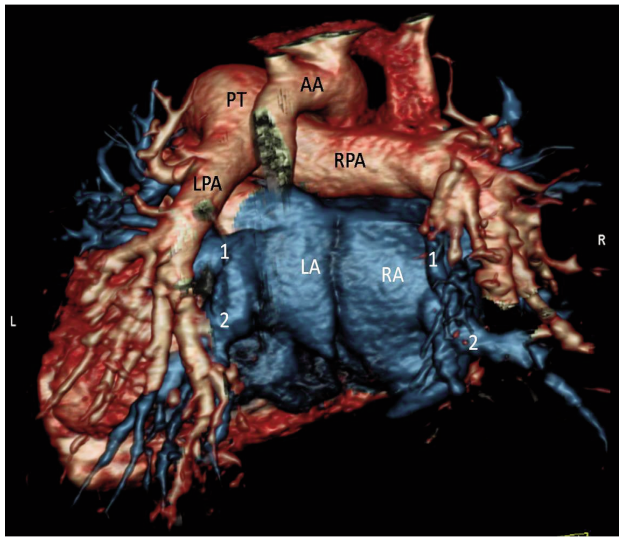

Fig. 4a. 3D (dimensional) SSD (shaded surface display) posterior view image showing partial pulmonary venous return. RA - right atrium; LA - left atrium; 1 - upper lobe vein; 2 - lower lobe vein; AA - arch of aorta; PT - pulmonary trunk; L - left side; R - right side.

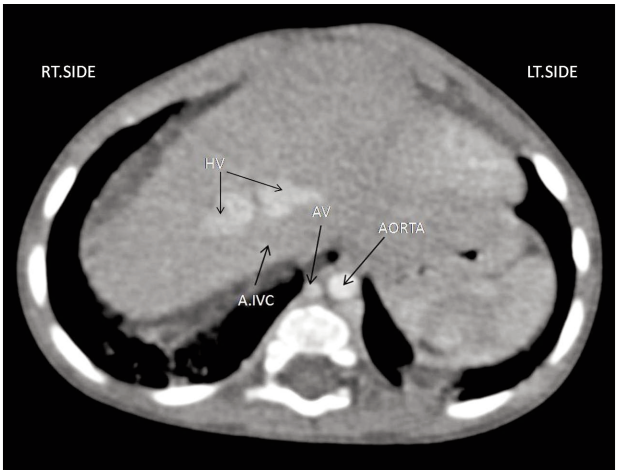

Fig. 5. CT scan of thorax showing interruption of IVC below the drainage of the hepatic veins. The azygos vein courses adjacent to aorta and to its right and is enlarged (a large azygos vein may appear as a mediastinal mass). HV - hepatic vein; AV - azygos vein; A.IVC - absent inferior vena cava; AORTA - descending aorta.

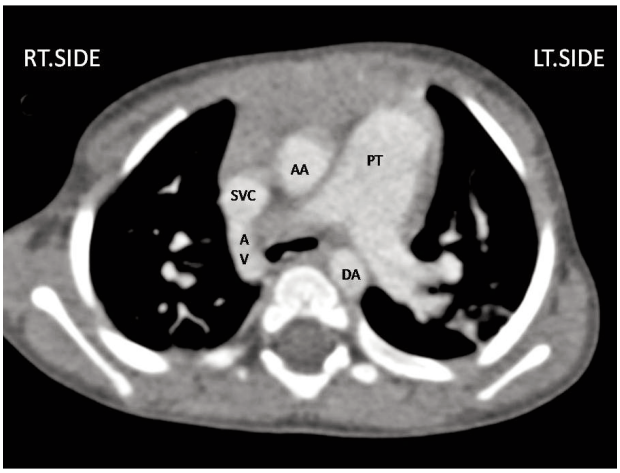

Fig. 6. CT scan of thorax showing englarged azygos vein draining into superior vena cava. SVC - superior vena cava, AV - azygos vein; PT - pulmonary trunk; AA - ascending aorta; DA - descending aorta.

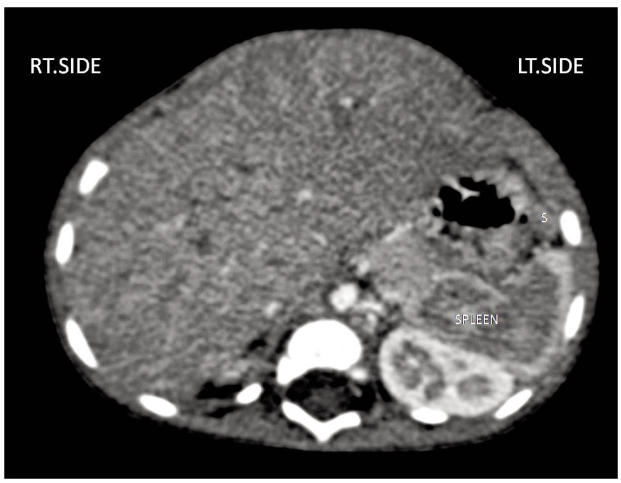

Fig. 7. CT scan of thorax showing spleen and splenule (S).

Discussion

Although symmetry is a characteristic of the external mammalian phenotype and of some internal organs, notably the genitourinary system, much of our internal anatomy, in particular the cardiovascular, pulmonary, and gastrointestinal systems, are asymmetrical (Izpisúa Belmonte, 1999; Casey, 1998; Fujinaga, 1997; Srivastava, 1997). The asymmetry is specific and originates in the genetic and molecular identity of the embryonic midline developmental field complex (Martínez-Frías, 1995; Opitz and Gilbert, 1982). This normal asymmetrical arrangement is called situs solitus. Thus, situs solitus signifies the customary, or normal, asymmetrical arrangement of the

viscerovascular anatomy (Maldjian and Saric, 2007; Cohen et al., 2007). Patients with situs ambiguus tend to be grouped with those in whom right – or left – sided structures predominate. Generalizations may be made in these groups. Patients with right – sided symmetry typically lack a spleen, whereas patients with left - sided symmetry typically have a segmented spleen or multiple splenules (Herman and Siegel, 1991). These common characteristics have led to the somewhat arbitrary classification of asplenia and *polysplenia*. Polysplenia syndrome recognizes the fact that left - and right – sided tendencies are on a continuum of heterotaxy or midline derangement. Radiologists and other clinicians must be aware of the viscerovascular arrangements that are possible in infants with these conditions, and they must attend to the specific viscerovascular anomalies in the patient. Many infants with situs ambiguus present with severe congenital cardiac anomalies. In these patients, knowing the presence of an associated interruption of the inferior vena cava is helpful before performing cardiac catheterization (Ruscazio et al., 1998). Situs ambiguous, or heterotaxia, is associated with other conditions of major clinical relevance, such as intestinal malrotation, biliary atresia, splenic abnormalities and consequent immunologic derangements, faulty gastric suspension mechanisms, displacement of abdominal viscera, and aberrant vascular structures and vascular connections. Each of these abnormalities is derived from an embryologic inability to determine laterality and establish the complex solitus asymmetry, whereas symmetrical structures remain unaffected (Horwich and Brueckner, 1993). The pathogenesis of the polysplenia syndrome is not completely clear, but it is thought to be caused by an abnormality of embryonic curvature, with a possible genetic basis (Hutchins et al., 1983; de Ia Monte and Hutchins, 1985). The pathophysiology of the control of normal human somatic asymmetry is not yet known. A mouse animal model exists in which a spontaneous mutation called the *iv* locus is localized to the 12th chromosome (Iida et al., 2000; Layton et al., 1993). Homozygous animals have a random phenotype: approximately 30% have situs solitus; 30%, situs inversus; and 40%, situs ambiguus. A second murine genetic mutation has been identified in the *inv* gene (Mazziotti et al., 1999; Morishima et al., 1998). Homozygous individuals show reversed embryonic turning, the earliest manifestation of laterality in mouse embryos. Asymmetrical expressions of genes have been identified in other animal models, notably *Xenopus* species and chick embryos (Levin, 1997). In humans, familial situs ambiguous has been related to both autosomal and X-linked inheritance patterns, although most cases arise sporadically (Casey, 1998; Casey et al., 1996; Alonso et al., 1995; Lindor et al., 1995; Fishman and Lavine, 1994). Situs inversus and situs ambiguous have been described within the same family trees; this finding indicates a phenotypic arrangement similar to that seen in *iv*/*iv* mice. *ZIC 3* is an X-linked gene identified in both sporadic and familial cases; affected males typically have the situs ambiguus phenotype, and females have either situs solitus or situs inversus. This particular genetic code is also associated with midline anomalies; specifically, neural tube defects. A submicroscopic deletion in Xq26 and a deletion at 18p have been associated with familial situs ambiguous (Digilio et al., 2000; Ferrero et al., 1997). Further, balanced and unbalanced autosomal translocations have also been described in sporadic cases of situs ambiguous (Freeman et al., 1996). Finally, environmental factors, including exposure to retinoic acid and maternal diabetes, have been implicated in laterality defects among the offspring of affected parents (Kim et al., 1995; Morishima et al., 1996). As a result of selective resorption of embryonic paired structures, vascular structures typically demonstrate a variety of abnormalities related to malpositioning or segmental absence (Zhang et al., 2009; Mohapatra et al., 2009). The major causes of mortality and morbidity in heterotaxy syndromes are undoubtedly cardiac malformations. Although most cases of heterotaxia are sporadic, many cases are familial, and some are X -linked. Thus, the abnormality is more common in males than in females. However, the clinical manifestations depend on the individual's specific anatomic derangements. Severe and complex cardiac abnormalities are likely to be apparent at birth or soon afterward.

Patients with polysplenia have large variations in the configurations of the splenic tissue. Splenules develop along both sides of the dorsal mesogastrium (rather than just on the left side, as in solitus asymmetry). The resultant splenic tissue is always found along the greater curvature of the stomach. It may con-

sist of multiple small splenules or a single splenic mass with 1 or more septae. In polysplenic patient, biliary atresia may be present (Puche et al., 2007; Herman, 1999; Varela-Fascinetto et al., 1998; Vazquez et al., 1995; Davenport and Howard, 1992). In fact, 10% of all patients with biliary atresia also have polysplenia. This co-diagnosis is important, because it has the potential for anomalous caval and portal venous connections and because it is relevant to eventual surgical planning. Some patients may also have a congenitally short pancreas, which is the result of maldevelopment or agenesis of the dorsal pancreas (which develops in the dorsal mesogastrium) (Herman and Siegel, 1991). In approximately 50-60% of polysplenic patients, interruption of the inferior vena cava is present. In such patients the venous return occurs via the right - or left - sided azygous system. The abnormal pulmonary venous connection is partial in polysplenia. Patients with polysplenia may have only a ventricular septal defect or no cardiac anomalies at all. This subset of patients most often have biliary atresia. The incidence of L-loop ventricles occurs in approximately 38% of patients with asplenia and in 30% of those with polysplenia. Polysplenic patients often have normal hearts or only minor cardiac anomalies, whereas patients with asplenia present as newborns with cyanosis due to more severe cardiac defects (Bussatt et al., 1965). A minority (5-10%) of patients with polysplenia even live to adulthood without symptoms or untoward effects (Winer-Muram et al., 1991). In a review of 146 cases of polysplenia, the mortality rate was also high, with 50% of the patients dying by 4 months of age and 75% dying by 5 years of age (Peoples et al., 1983). This mortality rate is largely due to intractable congestive cardiac failure in infancy and surgical mortality related to correction of congenital heart and gastrointestinal anomalies (Peoples et al., 1983).

Partridge et al. (1975) and Soto et al. (1978) described the left -to -right bronchial length ratio in healthy individuals to be greater than 1.7:1 and in variant individuals to be less than 1.4:1. The ratio in our patient was 1.07:1. The patient with isolated left thoracic isomerism described by Landay (1982) had a ratio of 1.6:1, which falls within the indeterminate range. A 1.07:1 ratio could suggest an increased severity of the well-known anomalies commonly associated with left thoracic isomerism. The knowledge of this syndrome is important to cardiologists, radiologists, pulmonologists and gastroenterologists.

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