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REVIEW ARTICLE

Prenatal Diagnosis of Absent Right Superior Vena Cava in Referrals for Fetal Echocardiography

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Abstract A persistent LSVC with an absent right superior vena cava (RSVC) is unusual, encountered in about 10% of patients with persistent LSVC. We present 14 patients with a prenatal diagnosis of single LSVC and situs solitus, including prenatal findings and information on medium-term follow-up. We identified patients with situs solitus and a persistent LSVC born between March 2004 and March 2020, which had been diagnosed prenatally between December 2003 and November 2019. From this cohort, we identified those with absent RSVC. In the population of women undergoing fetal echocardiography, the prevalence of persistent LSVC in situs solitus was 0.43% (84/19,712). For the 84 identified patients and for the entire population respectively, 14/84 (17%) and 14/19,712 (0.07%) had a single LSVC (absent RSVC). Of 14 patients with a single LSVC, 8 (57%) were male. For the 84 identified patients and for the entire population respectively, 70/84 (83%) and 70/19,712 (0.36%) had bilateral SVCs. For a single LSVC (absent RSVC) and situs solitus, the majority had no associated cardiac, extracardiac, or syndromic abnormalities.

Keywords Congenital heart disease · Fetal echocardiography · Persistent left superior vena cava · Prenatal diagnosis · Situs solitus

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Introduction

Persistent left superior vena cava (LSVC) usually connects to the coronary sinus and drains to the right atrium. A persistent LSVC is the most common cardiovascular malformation of the thoracic central veins. A persistent LSVC is present in about 6% of patients with congenital heart disease; however, its prevalence in the general population is estimated to be approximately 0.5% [1, 2]. In situs solitus, a persistent LSVC is most often associated with a normal right superior vena cava (RSVC), resulting in bilateral superior vena cavas (SVCs) [3]. The prenatal finding of bilateral SVCs may be a marker for other cardiac, extracardiac, and chromosomal anomalies [4, 5].

A persistent LSVC with an absent RSVC is unusual, encountered in about 10% of patients with persistent LSVC [6]. A persistent LSVC with absent RVSC may also be termed a single LSVC. Postnatal reports of a single LSVC suggest an association with cardiac electrophysiologic and structural abnormalities [5, 7–10], including 0.07% patients undergoing transvenous pacemaker implantations and 0.09–0.13% of postmortem cases of congenital heart disease.

Current publications that describe a prenatal diagnosis of absent RSVC (single LSVC) are limited to case reports. We present 14 patients with a prenatal diagnosis of single LSVC and situs solitus, including prenatal findings and information on medium-term follow-up. To the best of our knowledge, this report represents the largest series of those prenatally diagnosed with a single LSVC.

Materials and Methods

The study protocol conforms to the principles of the Declaration of Helsinki. The local IRB approved this study, and obtaining consent is exempted for this study. We accessed data for this observational, nonrandomized report by inquiring our research database (Epi-InfoTM), a critical congenital heart disease (CCHD) database, and our electronic health records**.** The Epi-Info database is maintained by the Children's Heart Center Nevada's research director, and data is exclusively entered from coding sheets completed by our center's physicians from each patient encounter or procedure. To control data integrity, no individual or other party external to our center can access our Epi-Info database, CCHD database, or electronic health records. For the searchable parts of our EHR, we used Perspective Software by Lexmark International, Inc. Lexington, Kentucky. As the sole provider of prenatal and postnatal congenital cardiology services in the state, our electronic databases include information on all patients diagnosed with congenital heart disease in Nevada. Following the database and EHR inquiry, we reviewed patient records and collated data for analysis. As this was a short case series, we used descriptive statistics and performed no statistical testing.

We identified patients with situs solitus and a persistent LSVC born between March 2004 and March 2020, which had been diagnosed prenatally between December 2003 and November 2019. From this cohort, we identified those with absent RSVC. All diagnoses were confirmed by postnatal echocardiography. Patients underwent at least one fetal ultrasound by a maternal-fetal medicine specialist, at least one fetal echocardiogram by a fetal cardiologist, and at least one postnatal clinical and echocardiographic evaluation by a pediatric cardiologist. The postnatal evaluations were performed within the first month of life in all included cases. The presence of extracardiac abnormalities was noted from prenatal or postnatal records. Genetic studies were performed pre or postnatally only in patients with clinically suspected findings. Patients with isomerism (either asplenia or polysplenia) were not included given the peculiar systemic and pulmonary venous connections inherent to lateralization abnormalities.

Results

For the investigational period, we identified 84 patients with situs solitus and persistent LSVC that were prenatally detected and confirmed postnatally. During the same period, 37 patients were prenatally diagnosed with situs inversus, and all had usual systemic venous return for situs inversus, excluding them from this study. The 84 patients were initially prenatally diagnosed at an average gestational age of 27 weeks (range 19–35 weeks) from studies performed on 19,712 pregnant women referred to maternal-fetal medicine specialists. All postnatal confirmatory echocardiograms were performed within the first month of age.

In the population of women undergoing fetal echocardiography, the prevalence of persistent LSVC in situs solitus was 0.43% (84/19,712). For the 84 identified patients and for the entire population respectively, 14/84 (17%) and 14/19,712 (0.07%) had a single LSVC (absent RSVC). Of 14 patients with a single LSVC, 8 (57%) were male. For the 84 identified patients and for the entire population respectively, 70/84 (83%) and 70/19,712 (0.36%) had bilateral SVCs. We had no patients with bilaterally absent SVCs.

Table 1 list the referral indications for fetal echocardiography, with a dilated coronary sinus being the most common reason for referral. Table 2 describes the cardiac, extracardiac, and syndromic findings in 70 of 84 patients with bilateral SVCs. Of the 14 of the 84 patients with a single LSVC (absent RSVC), 11/14 (79%) had no associated cardiac, extracardiac, or syndromic abnormalities. Only 3/14 (21%) had cardiovascular anomalies: 1 patient with a sinus venosus ASD requiring surgical repair, and 2 patients with a small muscular ventricular septal defect. All 14 single LSVC patients had normal heart rate and rhythm in the early neonatal period. One patient was lost to follow-up after neonatal discharge. The other 13 patients remained in normal sinus rhythm in the latest outpatient follow-up at 1–99 months of age (average 24 months). None of the 14 with single LSVC had extracardiac abnormalities.

Table 1 Reasons for referral

Reasons for referral in 14 patients with single LSVC	
Dilated coronary sinus, n (%)	7/14 (50)
Difficult imaging, n (%)	3/70 (22)
Ventricular asymmetry, n (%)	2/14 (14)
Mono twins, n (%)	1/14 (7)
In vitro fertilization, n (%)	1/14(7)
Reasons for referral in 70 patients with bilateral SVCs	
Dilated coronary sinus, n (%)	25/70 (36)
Suspected cardiac abnormality unsp., n (%)	9/70 (13)
Ventricular asymmetry, n (%)	7/70 (10)
In vitro fertilization, n (%)	4/70 (6)
Extracardiac abnormalities, n (%)	3/70 (4)
Other miscellaneous reasons, n (%)	22/70 (31)

LSVC left superior vena cava, *mono* monochorionic, *SVC* superior vena cava, *unsp* unspecified

Table 2 Cardiovascular and extracardiac abnormalities in 70 patients with bilateral SVCs

Cardiovascular significant	
Tetralogy of fallot	5
Perimembranous VSD moderate-large	4
Hypoplastic aortic arch	3
Complete balanced AVSD	2
Secundum ASD	2
Unbalanced AVSD	1
Hypoplastic left heart syndrome	1
Tricuspid atresia	1
Severe valvular pulmonary stenosis	1
Pathologic PDA	1
Total, n (%)	21/70 (30)
Cardiovascular mild	
Mild arch hypoplasia, eventually resolved	8
Small muscular VSD	3
Persistent right umbilical vein	2
Bicuspid aortic valve	1
Low atrial rhythm	1
Two vessel umbilical cord	1
Total, n (%)	16/70 (23)
Extracardiac	
Tracheoesophageal fistula	2
Pentalogy of cantrell	1
Biliary atresia	1
Alagille	1
CPAM	1
Anal stenosis	1
Total, n (%)	7/70 (10)
Syndromes	
Trisomy 21	6
Trisomy 18	1
Turner syndrome	1
DiGeorge SYNDROME	1
VACTERL	1
Total, n (%)	10/70 (14)

ASD atrial septal defect, *AVSD* atrioventricular septal defect, *CPAM* congenital pulmonary airway malformation, *PDA* patent ductus arteriosus, *SVC* superior vena cava, *VSD* ventricular septal defect

Discussion

A persistent LSVC is best detected by fetal echocardiography using the three-vessel view (3VV). In cases with a single LSVC (absent RSVC), the innominate vein may be seen just cephalad to the 3VV plane connecting to the single LSVC, coupled with color-flow Doppler demonstrating flow towards the single LSVC. For the general obstetric sonographers, the imaging of a dilated coronary sinus from the four-chamber view raises the suspicion of a persistent LSVC and possible associated cardiovascular malformations. However, the identification of a persistent LSVC from the 3VV may require an experienced sonographer. In our series, referrals that led to identifying a persistent LSVC included those with a dilated coronary sinus or ventricular asymmetry found at the time of routine, general obstetric ultrasound (Table 1). The high number of referrals with dilated coronary sinus may be partly due to our fetal cardiac program community-wide education efforts to improve prenatal detection of cardiovascular abnormalities [11, 12].

Minsart and colleagues reported that only 17% of their 238 patients with a prenatal diagnosis of a persistent LSVC were unassociated with other cardiovascular or extracardiac malformations [4]. Further, Gustapane and colleagues, in a systematic review and meta-analysis of 501 high-risk pregnancy patients diagnosed with persistent LSVC on prenatal ultrasound, found that 37% were unassociated with other cardiovascular or extracardiac malformations [5]. However, in our series, we found 51% of those with a prenatally detected persistent LSVC was unassociated with other cardiovascular or extracardiac malformations, likely because most of the referrals were for a dilated coronary sinus rather than for other congenital heart risk factors (Table 1).

A single LSVC indicates the presence of a persistent LSVC and the absence of the RSVC. In our opinion, the term “isolated LSVC” is confusing, as some authors use it with or without associated cardiovascular malformations [4, 13]. Additionally, isolated LSVC is a poor synonym for a single LSVC. Thus, we prefer the terminology: bilateral SVCs (persistent LSVC implied) or single LSVC (absent RSVC implied) either with or without associated cardiovascular malformations.

Prenatal detection of a single LSVC has been rare, and previous publications are limited to case reports of 1–5 patients [14, 17]. Özsürmeli reported a series of 32 cases of prenatal diagnosis of persistent LSVC, all but one had bilateral SVCs [18]. Three other series include 325 combined patients with a prenatal diagnosis of persistent LSVC with no cases of absent RSVC noted [4, 19, 20]. Reports of postnatal diagnosis of single LSVC suggest a significant association with cardiac electrophysiologic and structural abnormalities [7, 10]. Lenox and colleagues reported an abnormal sinus node in 3 of 4 heart specimens with absent RSVC, speculating that abnormal development of the RSVC-right atrial junction area may compromise the sinus node [9].

It is difficult to estimate the occurrence of abnormalities associated with the prenatal diagnosis of single LSVC (absent RSVC) from isolated case reports, some describing association with significant abnormalities and others with

single LSVCs [14–18]. In this small series, 14 cases of prenatal detection of a single LSVC correspond to 0.07% of patients undergoing fetal echocardiography. The very low association with other intra or extracardiac abnormalities contrasts with the findings in our own and a previous series of bilateral SVCs [4]. Additionally, bilateral absence of the SVC has been described in a handful of case reports, mainly in adults, but including at least 3 cases of prenatal diagnosis [21–23]. We did not encounter any such cases.

A major limitation of this analysis is the small number of patients, inherent in studying rare conditions. The major strength of this report is our approach to prenatal congenital heart disease detection that results in a high population-wide detection of congenital heart disease, coupled with robust internal data management that simultaneously tracks maternal, fetal, and neonatal information for a region-wide population, rather than relying on third-party data, such as hospital discharge coding, insurance claims, or other administrative information.

A prenatally detected or suspected persistent LSVC may herald associated fetal cardiovascular malformations, findings that have relevancy for both general obstetricians and maternal-fetal medicine specialists. In this series, an abnormal 4-chamber view was the most frequent reason for fetal echocardiography referral due to the presence of a dilated coronary sinus. Postnatally, the knowledge of a persistent LSVC may be important for future interventions, including indwelling catheters and cardiac catheterization and cardiovascular surgery. Further, a single LSVC (absent RSVC) may be associated with both cardiac structural and electrophysical abnormalities, requiring long-term postnatal follow-up for the potential development of late arrhythmias. Finally, to the best of our knowledge, this study reports the largest series of patients with a prenatal diagnosis of an absent RSVC with mid-term follow-up.

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Compliance with ethical standards

Conflict of interest The authors declared that there is no conflict of interest.

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