The Poor Performance of RSR′ Pattern on Electrocardiogram Lead V1 for Detection of Secundum Atrial Septal Defects in Children

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Objective To assess the accuracy of RSR′ patterns in lead V1 (RSR′-V1) in diagnosing atrial septal defects (ASDs) in children.

Study design Children who underwent an electrocardiogram (ECG) during 2010 were divided into 2 ECG groups: RSR′-V1 and normal (no RSR′-V1). Children who underwent an echocardiogram during 2010 were also divided into an ASD group and a normal echocardiogram group. The 4 groups were matched in a 2 × 2 table format where the RSR′-V1 was the "test" and ASD was the "disease." Sensitivity, specificity, positive/negative predictive values, and pre/post-test probabilities were calculated.

Results There were 4658 ECG studies included in the analysis: 836 had RSR′-V1 and 3822 were normal without RSR′-V1. Of 4935 echocardiographic studies analyzed, 329 had an ASD and 4606 were normal; 1363 patients had both studies done during the study period. The ECG sensitivity for diagnosing an ASD was 36.1%, specificity was 80%, positive predictive value was 14.7%, and negative predictive value was 92.9% with an overall accuracy of 76.2%. Patients with ASD and RSR′-V1 were significantly older than patients with ASD and no RSR′-V1 pattern.

Conclusion RSR′-V1 is a poor screening test for the detection of ASD. It should not change the clinical suspicion or the decision to obtain an echocardiogram. Older children without RSR′-V1 on ECG are unlikely to have an ASD. *(J Pediatr 2013;162:308-12)*.

Atrial septal defects (ASDs) are among the most common congenital heart defects (CHD) and comprise ~6%-10% of all CHDs.[1] Recent general population-based studies have documented an incidence of 0.15%-0.39%.[2,3]

Most children with an ASD are asymptomatic throughout childhood and young adulthood.[4] Although some studies have documented that a significant proportion of the ASDs will become smaller with time and some will spontaneously close,[5] others have argued that the majority of secundum ASDs become larger over time.[6] Patients with an ASD may have subtle findings on physical examination, including flow-related systolic ejection murmurs, hyperactive precordium, or fixed splitting of the second heart sound. A similar pulmonary flow murmur is, however, often heard in children without an ASD or any CHD and is frequently referred to as an innocent murmur.[7]

The diagnostic challenge of differentiating an innocent murmur from an ASD-related flow murmur prompted clinicians to look at electrocardiographic (ECG) criteria for adjunctive data in diagnosing ASDs. A number of studies from the 1950s-1960s associated certain ECG patterns with the presence of hemodynamically significant ASDs.[8-10] Most of the patients in these classic studies were adults who became symptomatic over time. One of the most studied ECG patterns that has been associated with the presence of an ASD is the RSR′ complex in lead V1 (RSR′-V1), with or without mild QRS complex prolongation (incomplete right bundle branch block).[9-11] The RSR′-V1 complex has also been observed in the normal healthy pediatric population[12] and has been speculated to be a mere expression of individual differences in the rate of depolarization of the crista supraventricularis[9] or a physiologic variability in intraventricular conduction. The aim of the present study was to evaluate the predictive value of RSR′-V1 pattern in the diagnosis of ASDs in children with an otherwise structurally normal heart.

Methods

This is a retrospective chart review that was conducted in a large, university-affiliated pediatric hospital. The institutional review board approved the study and waived the need for written informed consent.

The ECG acquisition and management system (MUSE ECG Management; GE Healthcare, Waukesha, Wisconsin) has a set of predefined diagnoses from which

ASD	Atrial septal defect
CHD	Congenital heart defects
ECG	Electrocardiogram
RSR′-V1	RSR′ pattern in lead V1
RVH	Right ventricular hypertrophy

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the reading physician can choose. All ECGs are read by a pediatric cardiologist, with many of them interpreted by a pediatric electrophysiologist. The system was queried for the diagnoses as listed later.

The echocardiographic system (Xcelera System, Philips, Amsterdam, The Netherlands) also uses predefined diagnoses. All of the echocardiographic studies are read by a pediatric cardiologist, with the vast majority of them interpreted by a specialist in pediatric noninvasive cardiac imaging. The system was queried for the diagnoses as listed later.

The reading physicians for both the ECGs and the echocardiograms were blinded to the present study.

The study group included patients who had an echocardiographic and/or ECG study in our institution between January 1, 2010, and December 31, 2010. Exclusion criteria were age <30 days or >18 years on the day of the ECG or echocardiogram study. In our center, most new patients referred with a diagnosis of heart murmur undergo an ECG study before being evaluated by the pediatric cardiologist. An echocardiogram is performed after the initial evaluation only if deemed clinically indicated.

The patients who had an ECG study were divided into 2 groups: (1) the RSR′-V1 group included all children with the following ECG diagnoses: "right ventricular conduction delay," "incomplete right bundle branch block," "RSR′ in V1," "RSR or QR in V1 suggests right ventricular conduction delay," "RSR′ pattern," "RSR pattern in V1," "RSR in V1," or "RSR′ pattern in V1;" (2) The normal ECG group included all children with the following ECG diagnoses: "normal ECG," "within normal limits," "within normal limits for age," "normal for age," or "normal variant."

ECGs with preexcitation, poor acquisition quality, or pacing or those obtained during pharmacologic challenge testing were excluded. Patients who appeared in both groups 1 and 2 during the study period were excluded from the study.

The patients who had an echocardiographic study were similarly divided into 2 groups: (3) The ASD group included all children with the following echocardiographic diagnoses: "small ASD, secundum type," "small secundum ASD vs. patent foramen ovale," "moderate ASD, secundum type," "large ASD, secundum type," or "ASD, fenestrated septum primum." Those with minor findings such as physiologic branch pulmonary artery stenosis, mild pulmonary valve gradient (without evidence of obstruction or stenosis), bicuspid aortic valve, trivial tricuspid regurgitation or mitral regurgitation small aortopulmonary collaterals, dilated right ventricle, or enlarged right atrium were included in the study. Echocardiographic studies with all other diagnoses, including patent foramen ovale, were excluded; (4) The normal echocardiography group included all the children with the following echocardiographic diagnoses: "no cardiac disease identified," "normal echo for age," or "no structural cardiac disease identified." Fetal studies were excluded.

Patients who appeared in both groups 3 and 4 were excluded from the study.

Statistical Analyses

The query results were exported to an Excel spreadsheet (Microsoft Corporation, Redmond, Washington). The 4 groups were matched by medical record number, and the numbers of matched records were entered into a 2 × 2 contingency table for analysis where the ECG is the "test" and the echocardiogram is the "gold standard." Sensitivity, specificity, positive and negative predictive values, and accuracy were calculated. Comparison of the mean age across the 4 groups was performed with 1-way ANOVA. Comparison of the mean age of patients with different ASD sizes was performed with the Student t test. The 95% CIs were calculated using the Clopper-Pearson exact CI method with aid of R and PropCIs package. Correlation of ASD size with RSR presence was tested with Pearson χ^2 test, and the trend was tested with the Cochran-Armitage test.

Results

A total of 6198 ECGs were retrieved from the ECG management using the query terms as listed earlier, of which 1540 were excluded (due to preexcitation, poor acquisition quality, pacing, or pharmacologic challenge), yielding 4658 ECG studies. Of those, 836 had RSR′-V1 variants and 3822 were interpreted as normal. There were 7852 echocardiographic studies retrieved, of which 2717 studies were excluded (most due to major cardiac defects, other than secundum ASD), yielding 4935 echocardiographic studies; of those, 329 had secundum ASD and 4606 were normal. Therefore, the ASD prevalence in our cohort of children who underwent echocardiography during calendar year 2010 (excluding children with other cardiac defects) was 6.7%. The prevalence of RSR′-V1 patterns was 17.9%.

A total of 1363 patients matched between the ECG and echocardiogram groups during the study period and met the inclusion criteria. A 2 × 2 contingency table (**Table I**) revealed a sensitivity of 36%, specificity of 80%, positive predictive value of 14.7%, and negative predictive value of 92.9%. The false-discovery rate was 85.3% and the overall accuracy of ECG for detection of ASDs was 76.2%. Pre- and post-test probabilities were also calculated (**Table II**). Representative ECGs from the 4 groups are shown in the **Figure**.

Forty children had a large ASD, 52 had a moderate ASD, and 224 had a small ASD. Children with a large ASD were significantly older (mean age of 6 years) than children with

Table I. Contingency table showing the ECG and echocardiography results of 1363 children who underwent both studies

		Echocardiography		
		ASD	Normal	Total
ECG	RSR′-V1	43	249	292
	Normal	76	995	1071
Total		119	1244	1363