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Value of P wave dispersion in pediatric patients with secundum atrial septal defect

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ABSTRACT

Objective: Ostium secundum defect is the common cause of RA enlargement. The aim in this study is to evaluate P wave dispersion in children to the size of atrial septal defect.

Method: Forty–one children with isolated secundum atrial septal defect (and 41 age-matched controls evaluated. Using the same 12 lead ECG device in resting position, P maximum and P dispersion measured.

Results: Mean P dispersion in atrial septal defect children is prolonged compare to the controls (P dispersion: 29.1±10.1 vs. 25.3±5.5 ms, P=0.009). And children with right atrial dilation had significantly longer P maximum (101.2±14.1 vs. 81.7±12.3 ms, P<0.001) and larger P dispersion (35.0±11.4 vs. 26.5±8.3 ms, P=0.003) compared to those without right atrial dilation.

Conclusion: Children with moderate to large sized ASD are valuable to have prolonged. Atrial conduction time in the form of P duration and P dispersion. Also, it's a good tool for diagnosing ASD in places where echocardiography imaging is not available. We can also differentiate between small ASD and large one based on P dispersion.

Keywords: P wave dispersion, pediatric patients, secundum atrial septal defect

INTRODUCTION

Definition and Epidemiology

Atrial septal defects (ASD) are common form of congenital heart disease, accounting for about 10% of all congenital heart defect in children (1) through an ASD result in chronic volume overload of the right heart and, if untreated , may lead to atrial arrhythmias (2) , right heart failure (3,4), pulmonary hypertension (5), and/or systemic embolism (6).

An ECG demonstrates sinus rhythm, often with evidence of right atrial enlargement manifested by tall, peaked P waves (usually best seen in leads II and V2) and prolongation of the PR interval. The QRS axis is slightly directed to the right (+100º), and the precordial leads reveal right ventricular enlargement of the so-called volume overload type that is characterized by an rSR′ pattern in leads V3 R and V1with normal T waves. The QRS duration may be mildly prolonged because of right ventricular dilation. These mimics the finding in right ventricular conduction delay. A significant proportion (20-40%) of children with secundum atrial septal defect may not have abnormal ECG findings (7). Uncommonly, a patient with a secundum atrial septal defect may demonstrate a superior QRS axis with right ventricular enlargement, mimicking findings observed in the ECG of a patient with an ostium primum atrial septal defect.

Signal-averaged P waves have been evaluated in various clinical situations (8-13). More recently, simple electrocardiographic markers using P wave, P maximum, and P dispersion have been proposed for evaluation of patients at risk of paroxysmal atrial fibrillation or to predict recurrent atrial fibrillation (14,15).

Prolongation of P wave is thought to be an indicator of interatrial conduction disturbance (16) and is often used to predict paroxysmal atrial fibrillation (PAF) (8-10,17). Maximum P wave (at a value of ≥110 ms) derived from a 12-lead surface electrocardiogram (ECG) had a good sensitivity and specificity for the separation of patients with idiopathic PAF from controls (18). P-wave dispersion (P dispersion) is proposed to quantify the heterogeneity of atrial conduction that

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can result in variable P-wave duration measured from the different surface electrocardiographic leads. A P dispersion value of 40 ms also separated patients with idiopathic PAF from controls with good sensitivity, specificity and positive predictive accuracy (18). The combined use of both P maximum and P dispersion appeared to strengthen and complement their roles in this respect (18).

Left-to-right shunts across the atrial septum in patients with isolated secundum atrial septal defects (ASD) tend to increase with age in many patients (19). This can cause stretching of the atria which predisposes these patients to atrial flutter, fibrillation, and tachycardia. While only a small percentage of patients below 18 years of age develop atrial arrhythmias, the proportion may increase to significant magnitude in older adults (10,20,21). Chen (18) had suggested that atrial electrophysiological characteristics of a dilated atrium differ from that of a normal atrium.

Aim of the Study

Our objective is to evaluate maximum P-wave duration and P dispersion in children with isolate ASD in comparison with that of controls and to relate these variables to the size of ASD as well as the presence or absence of right atrial dilation.

METHODS

Study Population

A total of 41 children (11 boys, 30 girls) with isolated ASD and 41 age-matched controls (18 boys, 23 girls) participated in this study. The ages of patients (at time of diagnosis) and controls were 1.8 to 4.2 years and 2.4 to 4.3 years, respectively. The mean was 3.1 years for patients and 3.3 years for the control.

Diagnosis of ASD was confirmed by cross-sectional and Doppler echocardiography done by the same Pediatric echo cardiologist. The ASD children had no other cardiovascular defects. Echocardiographic measurement of atrial size and presence of atrial dilation were noted. Children with ASD were further sub grouped into those with small (1-3 mm), moderate (4-7 mm) and large (≥8 mm) ASD. These children were also classified into those with or without right atrial (RA) dilation (1,11).

Measurement of ECG

All patients and controls had resting 12-lead surface ECGs measured while in a supine position in the ICU of Sulaimai pediatric hospital using the same device (Mortara instrument –MILWAUKEE USA- model UTK). Each ECG was measured in 3-lead sets, at a paper speed of 50 mm/sec and with 10 mm/mV standardization. The ECG recordings were magnified using handheld mangier brand (HDIUK) for manual and accurate measurement of P-wave durations from each of the 12 leads, and all the results were divided later on by 2 to match the reading of the standard 25mm/sec paper speed. The onset of P wave was defined as the junction between the isoelectric line and the beginning of P-wave deflection. The offset of P wave was taken at the junction between the end of the P-wave deflection and the isoelectric line. The average P wave of three consecutive beats from each lead was determined. Three variables determined from the P wave measurements were:

(1) P-wave duration defined as the average P-wave duration from lead II

(2) P maximum defined as the longest P-wave duration among the 12 leads

(3) P dispersion defined as the difference between the maximum and minimum P-wave durations from the 12 leads.

Measurement of P waves was done all by two observers separately, and both readings were assessed using the method described by Bland and Altman (23) (repeatability option) to compare the repeated measurement of the same method.

Statistical Analysis

All variables were presented as means and standard deviation (SD). Statistical calculations were performed using SPSS 10 for Windows (SPSSInc. IL, USA). Independent –simplest- tests were used to compare the differences between ASD patients and controls, as well as between those patients with and without RA dilation. One-way ANOVA was used to assess the differences between the ASD subgroups and between the various follow-up intervals in patients who had surgical repair of ASD. Statistical significance was defined as a P value of < 0.05.

Table 1: *Mean P Wave duration, P Maximum, and P Dispersion of controls and Children with ASD*

	Control	ASD	P-vaule
Number	41	41	
P wave duration (msec) Range	78.1±13.1 44-105	78.5±17.1 40-115	0.863
P maximum (msec) Range	86.2±11.0 60-108	88.6±16.5 60-135	0.267
P dispersion (mesc) Range	25.3±5.5 15-42	29.1±10.1 8-62	0.009

Table 2: *Mean P Wave duration, P Maximum, and P Dispersion of controls and children with different size ASD*

	ASD size			
	Small 1-3mm	Moderate 4-7 mm	Large ≥ 8mm	P
Number	12 (29%)	13 (32%)	16 (39%)	< 0.001
P wave duration (msec) Range	61.4±11.0 40-83	77.1±10.6 56-104	92.5±12.8 52-115	< 0.001
P maximum (msec) Range	72.8±5.7 60-85	83.7±7.7 72-104	104.7±13.1 80-135	< 0.001
P dispersion (mesc) Range	25.6±7.0 14-43	26.3±10.2 8-48	36.8±11.2 18-62	< 0.001

Table 3: *Mean P Wave duration, P Maximum, and P dispersion of ASD children with and without Right Atrial (RA) Dilation*

	Without RA dilation	With RA dilation	P value
Number (percentage)	29 (71%)	12 (29%)	
P wave duration (msec) Range	73.5±16.7 40-109	90.4±11.4 65-115	< 0.001
P maximum (msec) Range	81.7±12.3 60-120	101.2±14.1 75-135	< 0.001
P dispersion (mesc) Range	26.5±8.3 8-49	35.0±11.4 8-62	0.003

RESULTS

Children with ASD were distributed according to size of ASD: 29.2% (12 patients) had small ASD, 31.7% (13 patients) had moderate sized ASD, and 39.1% (16 patients) had large ASD. Mean ±SD size of ASD was 13.6±5.3 mm. None of the children had any history of atrial arrhythmias.

ASD Children versus Controls

Table 1 shows the mean ±SD P-wave duration (lead II), P maximum, and P dispersion of ASD patients and controls. The upper limits (mean + 2SD) of P-wave duration, P maximum, and P dispersion for controls were 104.3 ms, 108.2 ms, and 39.6 ms, respectively. Children with ASD had significantly longer mean P dispersion compared to controls (30.2±11.1 vs 26.4±6.6 ms, P=0.008).

ASD Subgroups According to Size

The proportions of children with small, moderate, and large size ASD were 29, 32, and 39% respectively. It was noted that mean P-wave duration, P maximum, and P dispersion increased significantly with increasing sizes of ASD (P<0.0001).

ASD With and Without RA Dilation

Of the ASD children, 29.2% had RA dilation while 70.8% did not have dilation of RA. Of those with RA dilation, 89.3% had large ASD, 10.7% had moderate ASD, and none had small ASD. Those who had right atrial dilation had significantly longer mean P-wave duration (90.4±11.4 vs 73.5±16.7 ms, P<0.001) and P maximum (101.2±14.1 vs 81.7±12.3 ms, P<0.001) than those without RA dilation. Mean P dispersion of patients with RA dilation was also significantly higher (35.0±11.4 vs 26.5±8.3 ms, P=0.003) than those without RA dilation.

DISCUSSION

The mechanism for atrial fibrillation is believed to be intra-atrial conduction abnormalities resulting in fragmentation and prolongation of atrial activation (24-26). While the simple P-wave duration may represent duration of atrial activation, it cannot reflect regional differences in atrial activation and dispersion in refractoriness. The heterogeneity of atrial conduction plays an important role in the initiation of re-entry circuits (24-26), which may predispose the atria to arrhythmias. Nonuniform electrophysiological characteristics, atrial size (surface area), morphology and anatomic obstacles may contribute to the heterogeneity of atrial conduction and vulnerability to atrial fibrillation (27).

Inhomogeneous atrial conduction may result in highly variable P-wave duration measured from different oriented surface ECG leads (18).

In this study P-wave duration and P maximum are used to quantify atrial conduction time while P dispersion is used as a marker of regional differences in P- wave durations. These variables were found to have a significant positive relation to size of the atrial septa1 defect and to the presence of atrial dilation. Left-to-right shunting across the atrial septum commonly occurs in ASD. The development and magnitude of the shunt depends on pressure differences between the right and left atria and the relative compliance of the right and left ventricles rather than on the size of the interatrial communication (19). Large shunts may cause stretching of the atria which may then predispose them to atrial arrhythmias. Large left-to-right shunts have been found to be associated with increased incidence of atrial arrhythmias. (19). The incidence of atrial arrhythmias was also much higher in older patients, particularly in adults. While there is no documentation of atrial arrhythmias in our study cohort, there are already significant increases in P-wave duration, P maximum, and P dispersion in those with right atrial dilation and large ASD sizes. In one study done in National University of Singapore by Ting Fei Ho et al. (28) they measured the P wave and P dispersion on 94 patients with ostium secundum ASD and compare them to 64 control of the same age group, and their result was almost the same of the result that we achieved in our study as the children in their study with the ASD had significantly longer mean P dispersion compared to controls (P dispersion: 30.2±11.1 vs 26.4±6.6 ms, P=0.008).

In adult studies, both P maximum and P dispersion were found to be significantly higher in patients with PAF (18,29). A P maximum value of 110ms and P dispersion value of 40 ms separated patients with PAF from controls with a sensitivity of 88% and 83%, a specificity of 75 and 85%, respectively (19). However, multivariate analysis of several variables revealed that only P maximum and not P dispersion was a significant independent predictor of recurrent PAF (15). The study of Chang et al. (14) supported the above opinion that prolongation of P-wave duration (≥100 ms) was an independent predictor of postoperative AF while P dispersion did not prove to be a predictor of postoperative AF in patients after coronary artery bypass surgery.

In this study, the children with ASD had no history of atrial arrhythmias. However increased values of P maximum and P dispersion to as high as 135ms and 62ms, respectively, particularly in those with large ASD or dilated RA are indicative of prolongation and heterogeneity of atrial conduction which may predispose these children to PAF. The mechanism(s) for such conduction defects maybe a combination of anatomic, morphologic, and possibly electrophysiological factors that are related to the structural and hemodynamic features of ASD. Although size of ASD does not directly influence the magnitude of left-to-right shunt, their likely association is indicated by the fact that almost 90% of the ASD children with dilated RA have large ASD.

This study revealed that children with ASD had significantly prolonged P dispersion in comparison with normal controls. P maximum and P dispersion which were indicative of atrial conduction time and in homogeneity of atrial conduction, respectively, were more severe with increase in size of ASD and in the presence of right atrial dilation. Whether such changes in atrial conduction predispose the children to PAF is yet to be proved.

A big limitation of this study is the lack of prior research studies of the same topic done in children, except for only one study mentioned above that been done in Singapore (28) and other one done on adult (29). So there is limited data to compare with , maybe the fact that there is only paper on evaluation the P wave on pediatric ASD patients is that the current availability and the easy accessibility for the doctors to use the Echocardiograph for such patient is eliminating its need.

CONCLUSION

Children with moderate to large sized ASD are valuable to have prolonged atrial conduction time in the form of P duration and P dispersion.

Also it's a good tool for diagnosing ASD in places where echocardiography imaging is not available. We can also differentiate between small ASD and large one based on P dispersion.

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