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Original Article

Assessment of P-wave dispersion in children with atrial septal aneurysm

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Abstract *Background:* This was a prospective controlled study to determine the P-wave duration and P-wave dispersion in patients with atrial septal aneurysm. *Methods:* A total of 41 children with atrial septal aneurysm, including 21 boys and 20 girls (mean age 11.85 ± 3.8 years), and 32 controls, including 17 boys and 15 girls (mean age 12.3 ± 2.9 years), were included. P-wave dispersion was calculated from the 12-lead electrocardiogram. Cardiac functions, morphology of the aneurysm, and left atrial diameter were measured using conventional echocardiography. The diagnosis of atrial septal aneurysm was made when the base of the aneurysms with an excursion ratio ≥25% was found on echocardiography. *Results:* There was no significant difference between the patient and control groups in demographic, clinical findings, and M-mode echocardiographic parameters. The P-wave dispersion in patients with atrial septal aneurysm was significantly longer compared with the control group (64.4 ± 13.4 ms; $p < 0.0001$). Similarly, the the maximum duration of the P wave in the patient group was significantly longer compared with the control group (106.1 ± 13.3 ms; $p < 0.001$). The P-wave duration and dispersion were not correlated with age, gender, systolic and diastolic blood pressure, or m-mode echocardiographic parameters. *Conclusions:* This study shows that P-wave dispersion is delayed in atrial septal aneurysm patients. Prolonged P-wave dispersion was determined to indicate electrical disturbance, and therefore it has an increased electrocardiographic risk of atrial arrhythmia in children with atrial septal aneurysm.

Keywords: Atrial septal aneurysm; P-wave dispersion; child

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ATRIAL SEPTAL ANEURYSM IS A WELL-RECOGNISED cardiac anomaly. The incidence of atrial septal aneurysm is 0.9–1.7% by transthoracic echocardiography in children. It has been reported to be associated with congenital heart diseases, including atrial septal defects, ventricular septal defects, mitral valve prolapses, patent ductus arteriosus, Ebstein's anomaly, and tricuspid and pulmonary atresia.[1,2] The clinical significance of atrial septal aneurysm has not yet been fully elucidated. Atrial arrhythmia might represent in patients with atrial septal aneurysm.[3]

Some parameters obtained from surface electrocardiogram recordings are used for determining patients at risk for the development of atrial arrhythmias. P-wave dispersion is a specific and sensitive marker in various clinical settings. It is a non-invasive indicator of cardiac arrhythmogenicity calculated from a surface electrocardiogram by subtracting the smallest P-wave length from the largest P-wave length and recorded from multiple surface electrocardiographic leads. An increase in P-wave dispersion is assumed to be associated with heterogeneity in atrial conduction and therefore increases a risk of occurrence and recurrence of atrial arrhythmias.[4] Therefore, it may be interesting to evaluate the presence of atrial arrhythmias in patients with atrial septal aneurysm. To the best of our knowledge, there is no analysis of these parameters in children with atrial septal aneurysm. The purpose of this study was to evaluate electrocardiographic markers of electrical conduction in children with atrial septal aneurysm.

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Methods

Design and subjects

The study included 41 patients, including 20 girls and 21 boys, who had been diagnosed with atrial septal aneurysm. Patients were in the age group of 5–17 years (mean 11.85 ± 3.8 years). We chose 32 healthy children, including 17 boys and 15 girls, matched for sex and age, as the control group. The healthy children were in the age group of 5–16 years (mean 12.3 ± 2.9 years). All healthy subjects were interviewed as to their health status. No one was using medications or had been previously hospitalised. Working individuals with a history of arterial hypertension, left ventricular wall motion abnormality, primary cardiomyopathy, major congenital or rheumatic cardiac disease, valvular cardiac diseases, electrolyte imbalance, diabetes mellitus, and any systemic disease were excluded from the study. However, individuals with a history of any clinical evidence of cardiac manifestations or arrhythmia were also excluded. In addition, no patient had accompanying clinical disorders or was taking drugs known to influence the electrocardiogram or heart rate. Informed permission was obtained from the parents of all children before the study. The study protocol was approved by the Selcuk University ethics committee.

Echocardiographic examination

All echocardiographic examinations were performed with a commercially available echocardiographic machine (Toshiba, Aplio 50, Japan) equipped with 3–5 MHz transducers. The patients were made to rest for 5 minutes before the measurements and breathe slowly throughout the procedure. Recordings were performed with subjects in the supine or left lateral positions. All children underwent a detailed echocardiography, which contained an M-mode, two-dimensional, colour, Doppler-continuous, and pulse wave-examination. M-mode tracings were supplied at the level of the tips of mitral leaflets in the parasternal long-axis position, and measurements of the left ventricular end-systolic and end-diastolic dimension were performed according to the recommendations of the American Society of Echocardiography. Left atrial dimension, aortic dimension, interventricular septum and posterior wall thickness, left ventricular end-diastolic dimension, and left ventricular end-systolic dimension were measured from the parasternal long-axis window in M-mode echocardiography. Left ventricular ejection fraction and fractional shortening were provided using Teichholtz in M-mode echocardiography.[5] The interatrial septum was examined mainly in subcostal positions. The existence of aneurysmatic excursion of the interatrial septum and the presence of other associated cardiac lesions were evaluated. The maximum aneurysmatic excursion length from the interatrial septum and the base length of the aneurysm were measured in the subcostal four-chamber view. The proportion of the excursion length of the atrial septal aneurysm to the width of the related atrium, which is the maximum excursion seen through it (excursion ratio), and the ratio of the base length of the atrial septal aneurysm to the length of the interatrial septum were calculated. If the excursion ratio was $\geq 25\%$, the lesion was diagnosed as an atrial septal aneurysm.[6] The direction and shape of motion of the aneurysm were noted.

Electrocardiogram analysis

Electrodes were inserted in anatomical positions according to routine procedure and electrocardiography strips were recorded for 10 seconds with a standard device. The 12-lead electrocardiography was saved at a paper speed of 50 mm/hour and gain of 10 mm/mV (Cardiofax V; Nihon Kohden Corporation, Tokyo, Japan) in the supine position. The patient was allowed to breathe spontaneously but was not permitted to speak during the electrocardiographic recording. Electrocardiographies of poor quality were repeated, and to improve accuracy measurements were performed with the custom-made computer software. All the electrocardiogram traces were blindly analysed by two investigators. The measurements of the two investigators showed no inconsistencies. The arithmetic mean of these two measurements was taken.

The onset of the P wave was identified as the point of first upward departure from baseline for positive waveforms, or as the point of first downward departure from baseline for negative waveforms. The return to the initial was accepted as the end of the P wave.[7,8] P-wave length was determined from all leads. The maximal, minimal, average lengths, and P-wave dispersion were computed from one randomly selected beat in a steady state by subtracting the minimal from the maximal P-wave length in 12 leads. At the same time, 7–12 beats were averaged during 10s of ECG measurements. P-wave lengths and P-wave dispersion were calculated in a similar manner (P-wave dispersion = maximum P-wave duration-minimum P-wave duration).[7,9] To prevent diurnal variations, we took the electrocardiography recordings of all working groups at the same time interval (10–12 hours).

Data analysis

Statistical analysis was carried out with SPSS for Windows version 16.0 (SPSS Inc., Chicago, Illinois, United States of America). All the values are expressed as mean ± standard deviation and

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median (minimum–maximum) values. One sample Kolmogorov–Smirnov test was performed to determine the normal distribution of data of statistical analysis. $p < 0.05$ indicates that the distribution is not normal. The obtained results were assessed accordingly using independent samples t-test and Mann–Whitney U test. Correlations for P-wave dispersion were calculated using the Pearson test; $p < 0.05$ was considered significant.

Results

The demographic and clinical findings of the patients and control subjects are shown in Table 1. No difference was found between the patient and the control groups for age, gender, height, weight, systolic blood pressure, diastolic blood pressure, and heart rate. In addition, there was no difference between M-mode measurements in both groups. The all atrial septal aneurysm was moving (56.8% into the left atrium, 3.7% into the right atrium, and 39.5% into both atrium). The M-mode echocardiographic parameters and calculations related to the size of the atrial septal aneurysm are shown in Table 2. The P-wave dispersion was significantly higher for the patients with atrial septal aneurysm ($p < 0.001$) than for the healthy children. However, the minimum and maximum duration of the P wave were significantly higher for the patients with atrial septal aneurysm than for the healthy children ($p = 0.001$, $p < 0.001$, respectively) (Table 3). The P-wave duration and dispersion were not correlated with age, gender, systolic and diastolic blood pressure, or M-mode echocardiographic parameters.

Discussion

The relationship between arrhythmias and atrial septal aneurysm was analysed in the present study. Therefore, P-wave dispersion analysis was performed in patients with atrial septal aneurysm. P-wave dispersion is a non-invasive technique providing an estimated risk of atrial arrhythmias. There are many studies on the relationship between atrial septal aneurysm and cardiac arrhythmias in adult patients. To the best of our knowledge, the present study is the first in children with atrial septal aneurysm.

The atrial septal aneurysm is a saccular deformity located in the atrial septum and it is can be easily diagnosed by cross-sectional echocardiography. The pathogenesis of atrial septal aneurysm is not well known. Diverse prevalence of atrial septal aneurysm has been reported for different age groups in various studies. However, the accurate prevalence of atrial septal aneurysm in the population is not well defined.

Table 1. The demographic and clinical findings of the study population.

	Patients (n = 41) (mean ± SD)	Controls (n = 32) (mean ± SD)	p-value
Age (years)	11.85 ± 3.8	12.3 ± 2.9	ns
Male/female	21/20	17/15	ns
Height (cm)	144.42 ± 20.16	142.76 ± 21.5	ns
Weight (kg)	43.05 ± 17.08	42.78 ± 16.57	ns
Systolic blood pressure (mmHg)	100.96 ± 9.05	102 ± 10.7	ns
Diastolic blood pressure (mmHg)	63.27 ± 8.47	63.20 ± 7.89	ns
Heart rate (beats/minute)	90.94 ± 16.16	89.16 ± 15.75	ns

Table 2. The M-mode echocardiographic parameters of the study groups and size of ASA of patients.

Echocardiographic measurement	Patients (n = 41) (mean ± SD)	Controls (n = 32) (mean ± SD)	p-value
LVEDD (mm)	36.42 ± 7.07	38.12 ± 5.98	ns
LVESD (mm)	21.81 ± 3.61	21.36 ± 3.55	ns
IVS thickness (mm)	6.96 ± 1.42	7.16 ± 1.22	ns
Posterior wall thickness(mm)	6.78 ± 1.61	6.93 ± 1.33	ns
EF (%)	70.65 ± 6.13	70.96 ± 5.54	ns
FS (%)	39.42 ± 5.53	39.96 ± 5.07	ns
Aortic dimension (mm)	21.81 ± 3.61	21.36 ± 3.55	ns
Left atrial dimension (mm)	25.5 ± 4.26	25.40 ± 3.14	ns
Excursion length of ASA (mm)	10.3 ± 1.1	–	–
Excursion ratio of ASA (%)	41.3 ± 7.2	–	–

ASA = atrial septal aneurysm; EF = ejection fraction; FS = fractional shortening; IVS = interventricular septum; LVEDD = left ventricular end-diastolic dimension; LVESD = left ventricular end-systolic dimension.

Table 3. Electrocardiographic parameters in study population.

	Patients (n = 41) (mean ± SD)	Controls (n = 32) (mean ± SD)	p-value
P-wave dispersion (ms)	64.4 ± 13.4	39.2 ± 10.2	<0.0001
Minimum P-wave duration (ms)	42.6 ± 7.8	50.7 ± 6.1	0.001
Maximum P-wave duration (ms)	106.1 ± 13.3	82 ± 12.1	<0.0001

The frequency has been notified to be 0.2–0.5%, 0.9%, 7.6%, and 26–64% for adults, children, neonates, and foetuses, respectively.[2,6] The clinical significance of atrial septal aneurysm has not yet been fully elucidated. There are different complications related to atrial septal aneurysm, and it is still debated as to whether or not the lesion is benign. However, atrial arrhythmias are pervasive in patients with atrial septal aneurysm. The relationship between cardiac arrhythmias and atrial septal aneurysm has been evaluated in many retrospective studies and case reports. The prevalence of supraventricular arrhythmia has been reported to be 40%, atrial fibrillation (18%), atrial flutter (4%), atrioventricular nodal re-entrant tachycardia (8%), and miscellaneous (18%) in adult patients with atrial septal aneurysm.[10] In a study, abnormal electrocardiography findings were found to be 36.17% in children with an atrial septal aneurysm. These findings have been reported to be low atrial rhythm (2.13%), first-degree atrioventricular block (8.51%), right atrial enlargement (2.13%), incomplete right bundle branch block (19.14%), right bundle branch block (2.13%), and superior axis (2.13%).[2]

The same parameters obtained from surface electrocardiography recordings are used for determining patients at risk for the development of atrial arrhythmias. Among these parameters, P-wave dispersion is the most frequently used parameter in clinical cardiology. P-wave dispersion is a marker of interatrial and intra-atrial conduction disorders of sinus impulses and inhomogeneous atrial conduction.[11] Increased P-wave dispersion has been reported in various clinical settings, including coronary artery disease, hypertension, rheumatic mitral stenosis, mitral annular calcification, hypertrophic cardiomyopathy, obstructive sleep apnoea, and obesity. However, it is associated with a higher risk of paroxysmal atrial tachyarrhythmias and it can be used to diagnose patients with a high risk of atrial fibrillation.[12] It has also been shown that P-wave dispersion was higher in atrial septal aneurysm patients than in the control subjects.[13–15] It is believed that this may be related to atrial arrhythmia more common in those patients. In our study, P-wave dispersion and P_{max} duration were found to be higher in the patient group. These results suggested that the heterogeneity of atrial macro- and microgeometry caused by atrial septal aneurysm may lead to changes in the electrophysiological dynamics of the atrial myocardium. The prolongation of conduction has been documented by 12-lead surface electrocardiography recordings to have a longer P-wave dispersion. It has been shown in several studies that sinus impulses are conducted in a heterogeneous and anisotropic manner within the atrial tissue because of an irregular physical structure and differentiated microstructure of the atrial myocardium.[10] The increased P-wave dispersion indicates heterogeneous and discontinuous conduction of sinus impulses within the atrial myocardium and is an electrocardiographic marker reflecting intra- and interatrial conduction delay in many clinical studies to date.[16]

Some intra- and intercellular factors may also lead to conduction disorders, such as specific conduction delays in several regions within the atrial tissue. P-wave dispersion is currently considered a suitable method for assessing global atrial conduction. The sinus rhythm using a signal-averaged electrocardiography has demonstrated that prolongation in the P-wave dispersion is a risk factor for the development of atrial arrhythmia independent from the presence of structural heart disease.[17] In a patient population with paroxysmal atrial fibrillation, a P-wave dispersion threshold value with a sensitivity of 83% and a specificity of 72% has been reported to differentiate patients from controls.[11]

The invasive electrophysiological studies definitely provide the most valuable data for evaluating atrial electrophysiological characteristics. However, electrophysiological studies are exceedingly complex, expensive, and time-consuming procedures that are not suitable for screening the general population. P-wave dispersion is currently considered a suitable method for assessing global atrial conduction. In our comprehensive study, we have demonstrated that P-wave dispersion, which is a non-invasive technique providing an estimated risk of atrial arrhythmias, was significantly longer in atrial septal aneurysm patients than the control subjects. This study is the first to compare the Pd in children with atrial septal aneurysm. In the present study, it was found that the P-wave dispersion was significantly increased in patients with atrial septal aneurysm compared with the control group.

Conclusion

This study demonstrated that the P-wave dispersion and max P-wave duration were prolonged in children with atrial septal aneurysm. These results are consistent with a few studies indicating an association between atrial septal aneurysm and arrhythmias. The prolonged P-wave dispersion, which is a non-invasive, inexpensive, and simple technique, was determined to indicate electrical disturbances in the atrial myocardium and to predict the increase in the prevalence of atrial arrhythmias in patients with atrial septal aneurysm. It is clear that further comprehensive studies are needed with regard to this issue.

Study limitations

The most important limitation of our study was the insufficient number of patients. The other limitations are that our study was prospective but the patients were not followed up for arrhythmias.

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Conflicts of Interest

None.

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