Differentiating fasciculoventricular pathway from Wolff-Parkinson-White syndrome by electrocardiography

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BACKGROUND In school-based cardiovascular screening programs in Japan, Wolff-Parkinson-White (WPW) syndrome is diagnosed based on the presence of an electrocardiographic (ECG) delta wave without differentiation from the fasciculoventricular pathway (FVP), although the risk of sudden death is associated only with the former.

OBJECTIVE The purpose of this study was to differentiate FVP patients among children diagnosed with WPW syndrome by ECG.

METHODS Children who were diagnosed with WPW syndrome through school screening between April 2006 and March 2008 and had QRS width $\leq$120 ms were included. Patients with asthma and/or coronary heart disease were excluded. FVP and WPW syndrome were differentiated based on ECG responses to adenosine triphosphate (ATP) injection. Age, PR interval, QRS width, and Rosenbaum classification were compared among patients.

RESULTS Thirty patients (median age 12.7 years, range 6.5–15.7 years) participated in the study. FVP was diagnosed in 23 patients (76.7%), and WPW syndrome in 7 (23.3%). In Rosenbaum type A patients, all six patients had WPW syndrome, whereas FVP was diagnosed in 23 of 24 and WPW syndrome was diagnosed in 1 of 24 of type B patients. Age, PR interval, and QRS width were not significantly different between the two conditions.

CONCLUSION ATP stress test was reliable in differentiating FVP from WPW syndrome. Although FVP is considered rare, the results of our study indicate that many WPW syndrome patients with QRS width $\leq$120 ms may actually have FVP. Patients categorized as type B are more likely to have FVP, whereas type A patients are most likely to have WPW syndrome.

KEYWORDS ATP stress testing; Atrioventricular pathway; Delta wave; Electrocardiogram; Fasciculoventricular pathway; Preexcitation syndrome; Wolff-Parkinson-White syndrome

ABBREVIATIONS **ATP** = adenosine triphosphate; **AV** = atrioventricular; **ECG** = electrocardiogram; **FVP** = fasciculoventricular pathway; **HCM** = hypertrophic cardiomyopathy; **VAT** = ventricular activation time; **WPW** = Wolff-Parkinson-White syndrome

(Heart Rhythm 2014;11:686–690)

Introduction

In Japan, first- and seventh-grade children are screened at school for heart disease based on electrocardiographic (ECG) findings. Wolff-Parkinson-White (WPW) syndrome, characterized by the presence of an extra atrioventricular (AV) pathway, is one of several conditions that are frequently detected through school-based cardiovascular screening programs. WPW syndrome is diagnosed based on the detection of a delta wave on ECG and is associated with a risk of sudden cardiac death due to AV reentrant tachycardia and atrial fibrillation.[1] However, delta waves are also present in patients with a fasciculoventricular pathway (FVP), but these patients are not at risk for tachycardiac episodes or sudden death.[2,3] To accurately differentiate FVP, additional testing is required. Although electrophysiologic examination is the gold standard, adenosine stress testing is a noninvasive alternative that also provides an accurate differential diagnosis.[4,5] FVP is reportedly a rare condition accounting for 1.2% to 5.1% of preexcitation syndrome,[4,6–8] but these percentages are based on electrophysiologic studies in patients presenting with palpitations or some other symptoms. To date, the prevalence of FVP among patients with asymptomatic preexcitation has not been reported. The purpose of this study was to differentiate FVP by using adenosine stress test among children who were diagnosed with WPW syndrome through school-based cardiovascular screening programs and had QRS width $\leq$120 ms.

Methods

The study consisted of two sets of pediatric patients: one from Osaka City in Osaka Prefecture, Japan, and the second from other cities in Osaka Prefecture. Both sets of patients were diagnosed with WPW syndrome through school-based cardiovascular screening between April 2006 and March

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1547-5271/$-see front matter http://dx.doi.org/10.1016/j.hrthm.2013.11.018

Table 1 Study population

	In Osaka City	In other cities
No. of children screened in 2 years	41,576	N/A
Diagnosed with Wolff-Parkinson-White syndrome	32	N/A
QRS >120 ms	12	N/A
QRS ≤120 ms	20	N/A
Presented to our hospital	19	N/A
QRS >120 ms	8	N/A
QRS ≤120 ms*	11	19

*These cases were included in the study (n = 30 in total).

2009 and presented to our hospital. After review of their ECGs, only patients with QRS width ≤120 ms were included in the study. Patients with coronary heart disease and/or a history of asthma were excluded. In their school health screening programs, the diagnosis of WPW syndrome was made based solely on detection of a delta wave.

We performed screening echocardiography and adenosine and procainamide tests in all cases. For adenosine stress test, adenosine triphosphate (ATP) was rapidly infused intravenously at 0.3 to 0.4 mg/kg during sinus rhythm under continuous ECG monitoring in leads I, II, aVL, V_1, V_4, and V_6. Diagnosis of WPW syndrome was made if there was a change of QRS morphology to full excitation without alteration in the PR interval and if AV block did not occur in response to rapid ATP infusion. Diagnosis of FVP was made if AV block, defined as any nonconducted P wave, occurred without a change in QRS waveform or if the PR interval was prolonged by ≥40 ms without a change in QRS morphology in response to the ATP stress. After the patient's condition was stabilized, procainamide was infused at 10 mg/kg over 5 minutes to determine whether accessory pathway conduction was blocked based on the presence or absence of the delta wave.

According to Rosenbaum WPW syndrome classification, all patients were divided into two groups: type A with R/S ratio >1 in lead V_1 indicating a left-sided accessory pathway, and type B with R/S ratio <1 in lead V_1 indicating a right-sided pathway.[9] Age, PR interval, and QRS width were also compared between the FVP and WPW syndrome patient populations. QRS and PR durations were measured using an ECG automatic analyzer (Nihon Kohden, Tokyo, Japan). Statistical analysis was performed by the Wilcoxon/Kruskal-Wallis test using JMP software (SAS Institute, Cary, NC).

The study was reviewed and approved by the ethics committee at our hospital. Written consent was obtained from all patients after they were provided with information on the disease, study methods, and risks.

Results

Characteristics of the study population is summarized in Table 1. During the 2 years from April 2006 to March 2008, 41,576 first- and seventh-grade children underwent school cardiovascular screening in Osaka City, and 32 children (0.08%) were diagnosed with WPW syndrome, with QRS width >120 ms in 12 (37%) and ≤120 ms in 20 (62%). Of these 32 patients, 19 presented to our hospital; 11 (57.9%) had QRS width ≤120 ms and were included in the present study. In addition to these patients, 19 patients from outside Osaka City who presented to our hospital after also being diagnosed with WPW syndrome through school screening and had QRS width ≤120 ms were included in the study. Of the total of 30 subjects, 14 were male and 16 were female (median age 12.7 years, range 6.5–15.7 years; Table 2). Screening echocardiography indicated normal cardiac functions in all cases, with no abnormal findings, such as hypertrophic cardiomyopathy (HCM) or and Ebstein anomaly, in any of the cases. No patient had coronary heart disease and/or asthma.

Table 2 Characteristics of the 30 patients*

	Median	Range
Age (years)	12.7	6.5–15.7
QRS width (ms)	95	68–116
PR interval (ms)	120	100–148

*14 males and 16 females; 6 type A and 24 type B.

By the Rosenbaum classification, 6 patients were type A and 24 were type B. Based on ATP stress test results, FVP was diagnosed in 23 patients (76.7%) and WPW syndrome in 7 patients (23.3%) (Figure 1). All 6 type A patients were classified as having WPW syndrome based on ATP stress test results, whereas in type B patients, FVP was diagnosed in 23 patients and WPW syndrome in 1 (Figure 2). On procainamide tests, accessory pathway block, as indicated by the loss of delta wave, occurred in 3 of 7 WPW patients and in 3 of 23 FVP patients. Accessory pathway conduction was not blocked by procainamide in the remaining patients.

Example ECGs of a type B patient diagnosed with FVP are shown in Figure 3. The patient was a 13-year-old girl with a distinct delta wave, QRS width of 108 ms, and PR interval of 114 ms (Figure 3A). This patient showed transient complete AV block in response to ATP stress (Figure 3B) and therefore was diagnosed with FVP. The diagnosis was further supported by the administration of

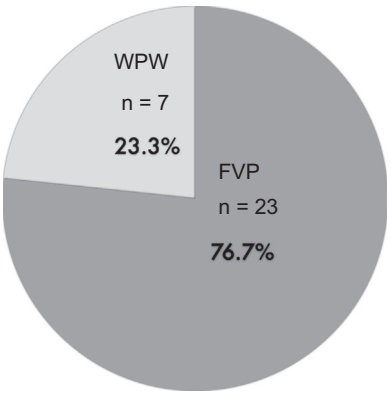

Figure 1 Percentage of Wolff-Parkinson-White (WPW) syndrome and fasciculoventricular pathway (FVP) based on ECG profiles by adenosine stress tests. Among the pediatric patients who were diagnosed with WPW syndrome and had QRS width ≤120 ms, 76.7% actually had FVP.