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Surgical management of children and young adults with the Wolff-Parkinson-White syndrome

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Summary. The Wolff-Parkinson-White syndrome, as originally described, includes palpitations, tachycardia, and an abnormal electrocardiogram (short PR interval and wide QRS complex). The clinical manifestations are dependent upon a reentrant tachycardia supported by an accessory connection bridging the atrioventricular junction and frequently appear during the first two decades of life. Palpitations are the usual symptoms; less frequently, severe symptoms, such as syncope and sudden death, may result from very rapid atrioventricular conduction across the accessory connection during atrial fibrillation. We report the surgical management of 30 young patients with this syndrome, including 6 with life-threatening tachycardia. Surgical interruption of the accessory connection(s) was curative in 90% (27/30) of the patients; life-threatening symptoms were eliminated in the other three. Based on the limited knowledge of the natural history of the Wolff-Parkinson-White syndrome, the individual patient symptoms, and the electrophysiologic properties of each patient's accessory pathway(s), an algorithm is presented outlining the treatment options. This experience strongly suggests that surgical treatment of the Wolff-Parkinson-White syndrome is safe, effective, and possibly the preferred treatment for this disorder in selected young symptomatic patients.

Key words: Wolff-Parkinson-White – Surgery – Supraventricular tachycardia – Sudden death – Electrophysiology

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In 1930, Wolff, Parkinson, and White described 11 patients with palpitations and a short PR interval, wide QRS complex [QRS], and tachycardia on the electrocardiogram (WPW syndrome [WPW], preexcitation) [1]. Nine had the onset of symptoms during childhood or adolescence. The mechanisms proposed to explain the paroxysmal tachycardia and electrocardiographic findings included bundle-branch block and accelerated conduction through either the atrioventricular node or an accessory pathway [2]. The accessory atrioventricular connection, first proposed by Holzmann and Scherf [3], explained all the important features of the syndrome [4], including the atrioventricular reentrant tachycardia (ART), and was subsequently demonstrated [5] to be histologically similar to the earlier-described Kent bundle [6]. The symptoms of the WPW syndrome range from palpitations to syncope and, rarely, sudden death. Prophylaxis for the paroxysmal ART was initially directed toward pharmacologic alteration of conduction within either the atrioventricular node, the accessory connection, or both. However, division of the anomalous pathway can alleviate all symptoms of the syndrome. The surgical division of an accessory conduction pathway (Kent bundle) was first achieved in 1968 by Cobb and associates [7]. Since then, a number of reports have described the technique and results in adults [8–11]. However, only three other groups have reported surgical treatment of WPW in children [12–14]. This report examines the surgical management of WPW in children and young adults at our institution, outlines their clinical and electrophysiological characteristics and outcome, and discusses indications for surgery in this age group.

Patients and methods

Patients

During the past nine years, 24 children (age $\leq$ 18 years) and 6 young adults (age 19–25 years) followed at our institution un-

derwent surgical division of anomalous pathways (patients #3 and #4 at a different institution). The clinical, electrocardiographic, electrophysiologic, and surgical data are outlined in Table 1. There were 9 females and 19 males. Two of the patients had other cardiac abnormalities: one (patient #13) had mild supravalvular aortic stenosis (25 mmHg peak systolic gradient), and the other (patient #2), tricuspid atresia, which was corrected (Fontan procedure) during the same operation [15].

Clinical presentation

Twenty-nine of the patients had the onset of palpitations associated with chest pain, faintness, and anxiety during childhood or adolescence as well as electrocardiographic changes consistent with preexcitation. One infant (#1) presented in severe congestive heart failure [16]. Twenty-nine of the patients had multiple episodes of sustained symptomatic ART. The remaining patient (#16) presented with a single episode of palpitations and a very rapid, wide QRS tachycardia on the electrocardiogram. Atrial fibrillation with anterograde conduction through the accessory connection was observed in the emergency room, followed by deterioration into ventricular fibrillation, requiring emergency defibrillation. Five additional patients had documented spontaneous atrial fibrillation; this rhythm deteriorated in three of these patients to documented ventricular fibrillation. Seven patients experienced syncope or presyncope.

Drug therapy

Twenty-three of the 30 patients with ART received empiric prophylactic drug therapy prior to referral to our institution. Seventeen (57%) received a trial of digoxin (10–15 mcg/kg daily), and 14 (47%), a trial of quinidine (20–65 mg/kg daily). Beta blockers (propranolol 2–4 mg/kg daily; 12/30, 40%), verapamil (5–9 mg/kg daily; 8/30, 27%), disopyramide (2 mg/kg daily; 4/30, 13%), and procainamide (10–40 mg/kg daily; 2/20) were also tried. Nineteen (63%) patients were treated with several different drug regimens, whereas four received only single drug therapy. Seven patients, all among the most recent 10 patients seen, elected surgical treatment.

Electrophysiologic evaluation

Preoperative electrophysiologic studies were performed in all 30 patients (patients #16 and #29 were studied at other institutions); all medications had been withdrawn at least 5 half-lives of the respective drug(s) before the study. Electrode catheters were placed in the coronary sinus (or through a patent foramen ovale into the left atrium), right atrium, and across the tricuspid valve (except patient #2) for recording of intracardiac electrograms and delivery of programmed extrastimuli. The effective refractory period (ERP) of the accessory connection in the anterograde direction was determined by introducing an extrastimulus coupled to a constant drive cycle length (500 or 600 ms) at progressively more premature intervals during diastole, until there was loss of preexcitation. Rapid atrial pacing was performed and/or atrial fibrillation was induced to determine the shortest RR interval (RR) with 1 : 1 conduction through the accessory connection to the ventricles. To locate the accessory connection within the atrioventricular ring, the earliest site of retrograde atrial activation recorded through bipolar pairs of electrodes (10 mm inter-electrode distance) during supraventricular tachycardia (SVT) was identified.

Surgical management

In the 28 patients operated on at our institution, the surgical approach consisted of either sternotomy (25 patients) or right thoracotomy (3 patients). Intraoperative electrophysiologic study using a hand-held electrode probe was performed to localize the accessory pathway. During atrial pacing at a rate that maximized preexcitation, the ventricular epicardium was mapped by comparing the measured local activation times near the atrioventricular groove. The area of earliest excitation on the ventricle corresponded to the ventricular insertion of the accessory pathway. The atrium was mapped in an analogous manner during ART (or ventricular pacing when ART was not sustained). Thus, the anomalous connection was localized to a specific site (approx. 5 mm) along the atrioventricular ring.

Standard bicaval cardiopulmonary bypass with moderate systemic hypothermia and cold cardioplegic arrest was used. Right free wall and posterior septal pathways were approached from the right atrium, whereas the left free wall pathways were divided through a left atriotomy. The atrial endocardium was incised 2 mm above the atrioventricular valve annulus and continued 1–2 cm to either side of the accessory connection location. In the last 15 patients in this series, the dissection was extended to include the entire anatomic space containing the accessory connection. The plane between the atrioventricular groove fat pad and the ventricular myocardium was separated until the epicardial reflection was reached throughout the entire length of the dissection. In patients with a posterior septal accessory connection, the fat pad in the pyramidal space bounded by the right fibrous trigone anteriorly, the mitral and tricuspid annuli laterally, and the epicardial reflection posteriorly was completely dissected. Each dissection was designed to interrupt any accessory fibers spanning the atrioventricular junction within the area of dissection.

After cardiopulmonary bypass was discontinued and sinus rhythm restored, atrial burst pacing was performed to assess both normal and persistently anomalous (if present) anterograde conduction. If preexcitation persisted, ventricular epicardial mapping was repeated to identify additional or incompletely divided accessory connections. If present (and after localization), division of the additional pathway(s) was performed. Anomalous ventriculo-atrial (retrograde) conduction was also examined by ventricular pacing and atrial mapping.

Postoperative studies and follow-up

All the patients had exteriorized atrial and ventricular electrode wires placed at the end of surgery; electrophysiologic studies using the same protocol employed preoperatively were performed through these wire electrodes. Four of the patients received postoperative electrophysiologic study 6–24 months after surgery. Information regarding follow-up, including electrocardiograms, was available from all 30 patients.

Statistical analysis

All electrophysiologic data are presented as the mean and one standard deviation. For purposes of analysis the patients were assigned to two groups: those with syncope and those without. Differences in the mean between groups were assessed using analysis of variance as well as the Kruskal-Wallis test for continuous variables and the Fisher exact test for categorical variables. Differences were considered significant if the P value was equal to or less than 0.05.

Table 1. Data on patients who underwent surgical division of anomalous pathways

Patient	Sex	Arrhythmias	Life-threatening tachycardia	Drug therapy	Age at surgery (years)	Accessory connection	ERP (ms)	RR interval (AF/pace) (ms)	Postoperative status
#1	M	AF, VF, CHF	Yes	DIG, Q, V, P, DISO	3 (month)	Multiple, left Free wall	NA	240/NA	WPW. SVT Sick sinus
#2	F	Palpitations, faintness	No	DIG, Q, P	18	Right free wall	450	NA/500	No WPW No SVT, AF
#3	M	Palpitations, chest pain	No	DIG, Q, P	17	Right anterior septal	300	500/NA	No WPW No SVT
#4	F	Palpitations, syncope, AF	Yes	DIG, Q, DISO	16	Left free wall	260	180/250	No WPW No SVT
#5	F	Palpitations, chest pain	No	DIG, Q, DISO	25	Posterior septal	322	NA/355	No WPW No SVT
#6	M	Palpitations, syncope, AF	Yes	DIG, P, DISO	24	Left free wall, multiple	270	180/180	WPW SVT
#7	M	Palpitations,	No	DIG, Q	17	Left free wall	240	370/400	No WPW No SVT
#8	M	Palpitations, syncope, VF	Yes	DIG, P. PR, V	15	Right and left free wall	Right 295, Left 295	240/245	No WPW No SVT
#9	M	Palpitations, faintness	No	Q, P	16	Left free wall	375	300/240	No WPW No SVT
#10	M	Palpitations, chest pain, syncope	Yes	DIG	16	Posterior septal	255	300/290	No WPW SVT
#11	F	Palpitations	No	DIG	15	Left free wall	290	350/280	No WPW No SVT
#12	F	Palpitations	No	DIG, P	15	Left free wall	210	210/230	No WPW No SVT
#13	F	Palpitations	No	DIG, V	17	Left free wall	220	NA/280	No WPW No SVT
#14	F	Palpitations	No	DIG, Q, P, V	10	Right and left free wall	Right 330, Left 280	NA/310	No WPW No SVT
#15	M	Palpitations	No	Q, P	4	Right free wall	320	NA/600	No WPW No SVT
#16	M	Syncope, AF, VF	Yes	Q, P	14	Left free wall	220	170/NA	No WPW No SVT
#17	F	Palpitations	No	DIG, Q, P, V	18	Left free wall	460	350/310	No WPW No SVT
#18	M	Palpitations, faintness	No	DIG, P, Q, V	7	Left free wall, multiple	200	300/240	No WPW No SVT
#19	F	Palpitations, faintness	No	None	17	Left free wall	210	280/NA	No WPW No SVT
#20	F	Palpitations, faintness	No	None	11	Right free wall	240	240/240	No WPW No SVT
#21	M	Palpitations associated with exercise	No	None	15	Right free wall	600	No preexcitation with AF or pace	No WPW No SVT
#22	F	Palpitations	No	DIG, P	11	Right free wall, Post septal	Right 370, Left 600	No preexcitation	No WPW No SVT
#23	M	Palpitations, AF, VF	No	P, V, PR	20	Post septal left	<220	160/250	WPW SVT
#24	M	Palpitations	No	None	19	Post septal	290	230/290	No WPW No SVT
#25	M	Palpitations	No	Q, V	21	Post septal left	190	230/400	No WPW No SVT
#26	M	Palpitations	No	Q	17	Left free wall	290	NA/400	No WPW No SVT
#27	M	Palpitations	No	None	18	Post septal left	<260	380/280	No WPW No SVT
#28	M	Palpitations	No	None	21	Left free wall	250	280/300	No WPW SVT
#29	M	Palpitations	No	DIG	17	Right free wall	NA	NA/NA	No WPW No SVT
#30	M	Palpitations, hypotension, dizzness, counter-shock	No	None	18	Right free wall	Right 250, Left 600	190/300	No WPW No SVT

Abbreviations: AF, atrial fibrillation; CHF, congestive heart failure; DIG, Digoxin; DISO, Disopyramide; ERP, effective refractory period; NA, not available; P, propranolol; PR, procainamide; Q, quinidine; SVT, Supraventricular tachycardia; V, verapamil; VF, ventricular fibrillation; WPW, Wolff-Parkinson-White syndrome

Results

Although trends were noted suggesting differences in the electrophysiologic properties of the accessory connection between the patients whose symptoms included syncope and those whose symptoms did not, most of these differences did not reach significance; this was, in part, due to the small number of patients along with the wider range of values in the non-syncopal group. The preoperative electrophysiologic studies demonstrated a mean antegrade ERP in the accessory connection of 251 ± 27 ms (range, 220–295 ms) in those patients with syncope compared to 300 ± 100 ms (range, 190–600 ms) among those without syncope (P = ns). Likewise, the mean RR interval with preexcitation during rapid atrial pacing ipsilateral to the accessory connection (243 ± 40 ms [range, 180–290 ms] versus 327 ± 99 ms [range, 230–600 ms]; $P = 0.08$, $n = 22$) tended to be shorter in those patients with syncope compared to those without syncope, but not to a significant degree. In contrast, the shortest RR interval obtained during induced or spontaneous atrial fibrillation (205 ± 54 ms [range, 160–300 ms] versus 300 ± 84 ms [range, 190–500 ms]; $P = .02$, $n = 20$) was significantly shorter in those patients with syncope compared to those without. A similar trend that did not reach significance was found in these values between patients with either single or multiple accessory connections.

The transcatheter and intraoperative mapping procedures located 36 accessory pathways in the 30 patients. A single left-sided free wall pathway occurred in 11 (37%) of the patients. An isolated right free wall pathway was found in 6 patients. Two patients had both a right and left free wall pathway; six had pathways located in the posterior septum, and in one the pathway was found in the anterior septum. Six patients had more than one pathway—the two mentioned above, three with multiple left-sided tracts, and one with a tract in both the right free wall and the posterior septum. The anatomic distribution of the anomalous pathways in this group of children was similar to that found in other series [12, 17]. Four of the six patients with multiple pathways experienced either syncope or spontaneous atrial fibrillation/ventricular fibrillation; these associations did reach significance ($P = 0.02$ and $P = 0.01$, respectively) by the Fisher exact test.

Twenty-seven of the 30 patients (90%) have had no further symptoms of WPW syndrome following surgery; all 30 have intact atrioventricular conduction, postoperatively. To avoid the more visible scar of a median sternotomy, three adolescent girls with left lateral pathways elected a right thoracotomy; their early postoperative course was not different in duration or outcome from those patients approached through a median sternotomy. However, one girl has had persistent pain along the incision line, compatible with a surgically induced peripheral neutopathy. Two other patients have experienced surgical complications, for a total of three (10%). One patient developed the post-pericardiotomy syndrome which responded to anti-inflammatory therapy without residua. Another patient experienced postoperative hemorrhage into the right pleural cavity, resulting in cardiac arrest, followed by successful resuscitation.

Three patients represent a failure of the technique. Our first patient, an infant, experienced recurrent ART three days after surgery, and at 22 months of age he developed sick sinus syndrome requiring a pacemaker. Two other patients developed recurrent preexcitation and ART 4–12 weeks after surgery. In one, mitral regurgitation and a left posterior-lateral wall motion abnormality were noted at postoperative catheterization, suggesting an intraoperative injury to that segment of the left ventricular wall; he has no symptoms related to this finding. Patient #1 had one-to-one atrioventricular conduction blocks at atrial rates above 200 bpm. In patient #6, the shortest preexcited RR interval during atrial fibrillation was 210 ms before the operation and 310 ms after the operation (both after procainamide infusion). The third patient has refused further evaluation. All three have been clinically free of rapid anterograde conduction across the atrioventricular junction 1–9 years following surgery.

Three patients have developed a later, different form of supraventricular tachycardia. Patient #2 developed atrial fibrillation related to her congenital heart disease; postoperative electrophysiologic study excluded persistence of an accessory pathway. Patients #10 and #28 developed a slower, non-sustained, narrow QRS SVT 3 years and 6 months later, respectively. Electrophysiologic study demonstrated atriventricular nodal tachycardia and no evidence of an accessory pathway in patient #28. Patient #10 has declined further study. All three patients have no preexcitation on the electrocardiogram.

Discussion

Although the reported incidence of SVT in children is reported to be low (1/25,000), more recent experience suggests a higher frequency [18]. At our institution, 3.5% of patients referred for cardiac evaluation (10,500 patients) have SVT. Approximately 50% of these patients have either manifest (i.e., WPW syndrome) or concealed accessory pathways supporting the tachycardia (ART) [19]. Although ART and WPW are both well known in infants

[20–25] and are usually, but not always [16], benign, especially in the absence of structural heart disease, the tachycardia may either first occur or even reappear in the older child and adolescent. Thus WPW, as first described by Wolff, Parkinson, and White, is often a problem of the young. Possible factors which may have militated against definitive surgical treatment in this age group in the past are the favorable natural history of this disorder, particularly in the infant, the paroxysmal character of the disorder making the definitive diagnosis elusive, an incomplete understanding of the tachycardia, infrequency of atrial fibrillation in the young, the absence of associated heart disease in the young, empiric drug therapy, the invasive as well as the time-, labor-, and technology-intensive character of the arrhythmia analysis, both in the laboratory and the operating room, and the attendant surgical morbidity and potential mortality. The experience of 90% freedom from SVT and preexcitation among our patients receiving operations, along with both the similar surgical (86%–98%) experience of others [8–14] and the recognized problems of side-effects and compliance in the use of anti-arrhythmic medications [17, 26–28], in large part, overcomes these reservations and argues strongly for surgical treatment of this disorder in the young.

Surgery was unsuccessful in 3 patients. Left-sided pathways were identified at two sites along the left atrioventricular groove in 2 patients; even after extensive dissection through the left atrium, preexcitation and ART returned. The third patient had a pathway located deep(leftward) in the posterior septum. We have extended the surgical approach to this accessory connection location to include a right atrial approach to the posterior left aspect of the pyramidal space. Postoperatively, patients #1 and #5 have undergone electrophysiologic study. Both had much slower anterograde conduction across the accessory connection, and neither has had a recurrence of ventricular fibrillation. Therefore, of the seven patients with syncope and potentially fatal arrhythmias, 6 of the 7 are known to be free of their life-threatening arrhythmias.

The appearance of late arrhythmias in 3 patients which were not directly related to the WPW syndrome is unexpected, especially in the two patients without associated structural heart disease. Although neither patient had evidence of another form of tachycardia at electrophysiologic study, it is well known that more than one form of SVT can occur in a single patient with WPW [29]. Whether the appearance of these late arrhythmias is related to potential surgical alteration in the electrophysiologic properties of the atrioventricular conduction system, or to the aforementioned association of several forms of tachycardia, is unknown.

The comparison of the electrophysiologic data between the children with syncope and those without was similar to those reported in older patients by Klein [30] and relates to the important question of risk for sudden death. Although the mean anterograde effective refractory period of the accessory pathway of our patients with syncope tended to be shorter than that in patients without syncope, 9 of the 23 patients without syncope exhibited short ($\leq$250 ms) anterograde effective refractory periods. Further, and more importantly, 5 non-syncopal patients exhibited a consecutive preexcited RR interval $\leq$250 ms during induced atrial fibrillation, clearly identifying a group of young patients at theoretical risk for sudden death if clinical atrial fibrillation should appear. Several investigators have noted increased atrial vulnerability or susceptibility to atrial fibrillation in older patients with frequent episodes of ART [31, 32]. On the other hand, in part because of the smaller atria, atrial fibrillation occurs infrequently in infants with WPW [16, 33]. Our 7 patients with syncope represent those individuals at greatest risk for sudden death. Four of our five patients with syncope and spontaneous atrial fibrillation had fast anterograde conduction across the accessory connection; the patients with only induced, but not spontaneous, atrial fibrillation and fast conduction are presumably at risk if spontaneous atrial fibrillation occurs. Importantly, as illustrated by patient #16 as well as by patients reported elsewhere [34, 35], the initial presentation of young people with the WPW syndrome can be a catastrophic event, enhanced, perhaps, by an exercise-related catecholamine surge. Rinne and associates [36] have reported that up to 50% of patients with unproven symptoms (undocumented palpitations) may have fast anterograde conduction properties (RR interval during atrial fibrillation $\leq$250 ms) in the accessory connection, whereas Milstein et al. [37] have noted that up to 17% of asymptomatic patients with WPW may exhibit fast anterograde conduction across the accessory connection.

Implications

Prospective management of patients with WPW syndrome would be improved by the definition of risk; Klein et al. [30, 38], Wellens et al. [39, 40], Rinne et al. [36], and Sharma et al. [41] have examined a number of factors that impact patient risk. The occurrence of a short anterograde effective refractory period in the accessory connection, frequent fast ART, the shortest consecutive preexcited RR interval during spontaneous atrial fibrillation, the individual autonomic state, and enhanced atrial vulnerability may contribute to risk in the individual

patient. However, the sensitivity of the shortest consecutive preexcited RR interval during spontaneous atrial fibrillation is only moderate (78%), whereas the correlation between the shortest preexcited RR interval during atrial fibrillation and the anterograde effective refractory period of the accessory connection is variable (r = .39-.7) [39, 41]. Furthermore, the specificity and accuracy of the shortest consecutive preexcited RR interval to predict who is at risk for sudden death is reported to be low (49% and 19%, respectively). An improved sensitivity (91%) is achieved by examining the response of preexcitation to both an exercise test and a type I anti-arrhythmic medication infusion; however, this combination does not improve specificity [41]. On the other hand, because slow conduction across the accessory pathway will prevent a rapid ventricular response to atrial fibrillation, should it develop, these variables do identify patients who are *not* at risk for sudden death.

Recognizing the incompleteness of information regarding the natural history of WPW as well as the infrequency of spontaneous atrial fibrillation in the young, we have developed an algorithm (Fig. 1) to assist in the management of WPW in our young population. If preexcitation is intermittent on the ECG or disappears with exercise or with procainamide or disopyramide infusion [26, 36, 41], one may conclude that the accessory connection is not a fast conductor. Further, if the patient's episodes of ART are brief ($\leq$5–10 min), occur infrequently ($\leq$3–4 times a year) and are self-limiting (terminated by a vagal maneuver) so as to be minimally symptomatic, the patient and family may choose to do nothing (Fig. 1A). If preexcitation is not intermittent and persists through exercise and high heart rates ($\geq$180 bpm), rapid atrial pacing and/or induction of atrial fibrillation through either the esophageal or intra-cardiac route should be considered to examine the conduction properties of the accessory connection. If rapid conduction is present during pacing or atrial fibrillation, treatment is then similar to that of more symptomatic patients (Fig. 1B). If conduction is slow during atrial fibrillation, either no treatment or empiric treatment with type I or type II anti-arrhythmic medications may be tried (digoxin should be used only after electrophysiologic study of its effect in this older group). If significant symptoms are present with or without persistence of preexcitation with exercise (Fig. 1B), the electrophysiologic characteristics of the accessory pathway should be determined and appropriate pharmacological or surgical therapy directed toward prophylaxis of both the ART and rapid

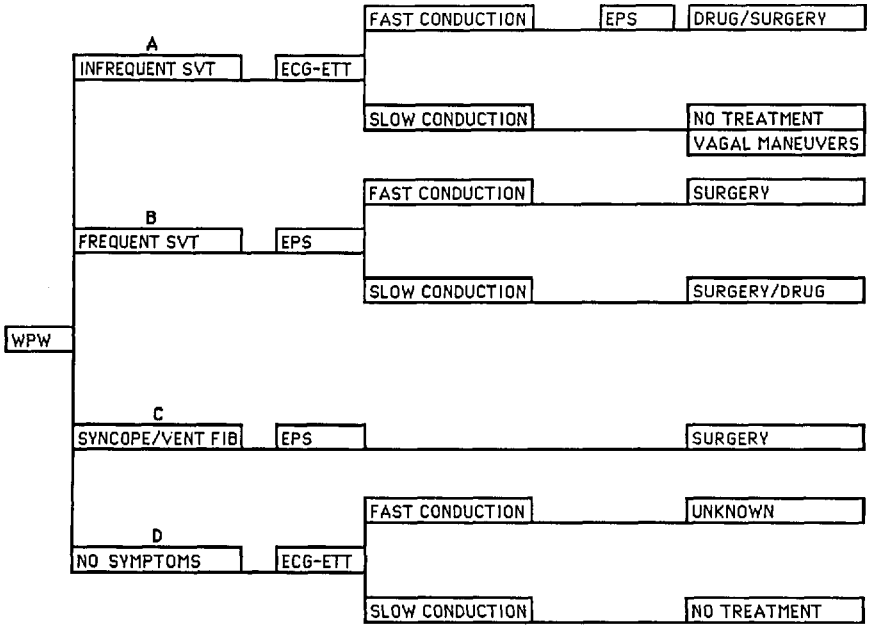

Fig. 1. This algorithm outlines a proposed course of action in children noted to exhibit preexcitation on the electrocardiogram. The initial branches of the decision tree are dependent upon symptoms and mode of presentation. As symptoms change or appear, patients may move from limb to limb until definitive treatment is determined and achieved. *ECG*, electrocardiogram; *EPS*, electrophysiologic study; *ETT*, exercise treadmill testing; *SVT*, supraventricular tachycardia; *VENT FIB*, ventricular fibrillation; *WPW*, Wolff-Parkinson-White

conduction across the accessory connection when present. If the patient has experienced documented atrial fibrillation with a rapid ventricular response across the accessory connection, ventricular fibrillation, or unexplained syncope (Figure 1C), surgery, preceded by electrophysiologic study, is indicated. It is important to note that these recommendations do not address the patient with fast conduction—determined by the measures outlined—but with no symptoms (Figure 1D). Owing to the rarity of sudden deaths (0%–4%) [35] in older individuals with WPW, the even lower probable risk below the teenage years in the absence of heart disease [20–24], and the lack of specificity in identifying patients at risk, decisions regarding evaluation and treatment in these unusual patients must at present be individualized and perhaps considered investigational [42]. Although asymptomatic (i.e., no tachycardia) patients with both the WPW syndrome and fast conducting accessory pathways appear to be at risk for sudden death, and thus would possibly benefit from surgery in a manner similar to patients with an atrial septal defect or aortic stenosis who undergo surgery for the prevention of pulmonary vascular obstructive disease or sudden death, respectively, the natural history of this subset of WPW patients is not sufficiently characterized to justify a recommendation of surgery at this time.

In conclusion, this experience along with that of others is sufficiently comprehensive to advise surgical treatment for all patients with WPW syndrome and unexplained syncope, atrial fibrillation with fast anterograde conduction across the accessory connection, and/or documented ventricular frbrillation, regardless of age. In addition, the frequency of SVT in the young, the low, unquantified but real risk of sudden death, and the proven effectiveness and safety of definitive treatment grounded in electrophysiologic principles argues persuasively that surgical division of the accessory connection is an acceptable, and perhaps the preferred, treatment for selected young patients with WPW and ART.

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