JOURNAL OF INSURANCE MEDICINE

J Insur Med 2015;45:48–57

REVIEW

The Wolf-Parkinson-White ECG Pattern – Assessing the Mortality Risk

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The presence of a Wolf-Parkinson-White (WPW) pattern is not uncommonly discovered on a life insurance applicant's ECG. How does one determine the appropriate mortality risk in this population? This article will discuss the risk of sudden cardiac death (SCD), the interpretation of electrophysiology testing results, and risk-stratification both for asymptomatic individuals and those who have had ablation treatment.

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Key words: WPW, preexcitation, accessory pathway, sudden cardiac death, mortality, life insurance.

Received: October 8, 2014

Accepted: November 10, 2014

TWO HYPOTHETICAL CASE SCENARIOS

While you are reading ECGs, you come across two tracings showing WPW patterns. The first ECG (Figure 1) is on a 23-year-old male client (case #1). The second ECG (Figure 2) is on a 45-year-old woman (case #2). Both individuals are applying for a million dollar life insurance policy.

Case #1

There is no disclosed medical history by the 23-year-old male client, who has a WPW pattern on his ECG (Figure 1). The ECG shows sinus rhythm at 60 bpm; the PR interval is short, and there is slurring of the upstroke of the QRS (delta wave) making the QRS wide. There are QS complexes in lead III and AVF. The QRS axis is leftward (approximately -50 degrees). The QRS and delta wave transition is between V1 and V2. Repolarization is basically normal.

Case #2

The 45-year-old woman disclosed a history of palpitations for which she was seen by a cardiologist 15 years ago. Her ECG (Figure 2) shows sinus rhythm at 94 bpm. There are 2 populations of QRS complexes. The narrow QRS complexes are preceded by a normal PR interval; repolarization is normal, and the QRS transition is in V3.

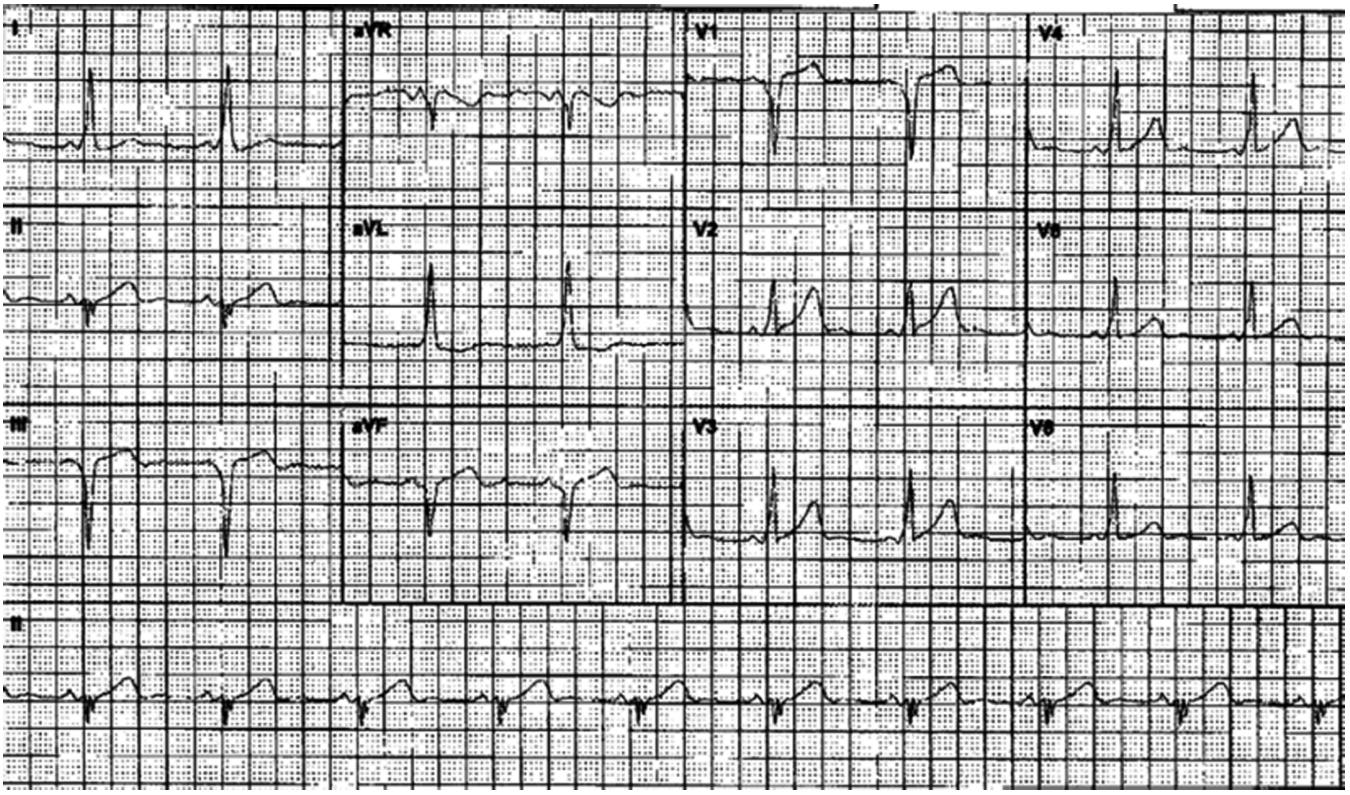

Figure 1. *ECG of a 23-year-old male with WPW pattern.*

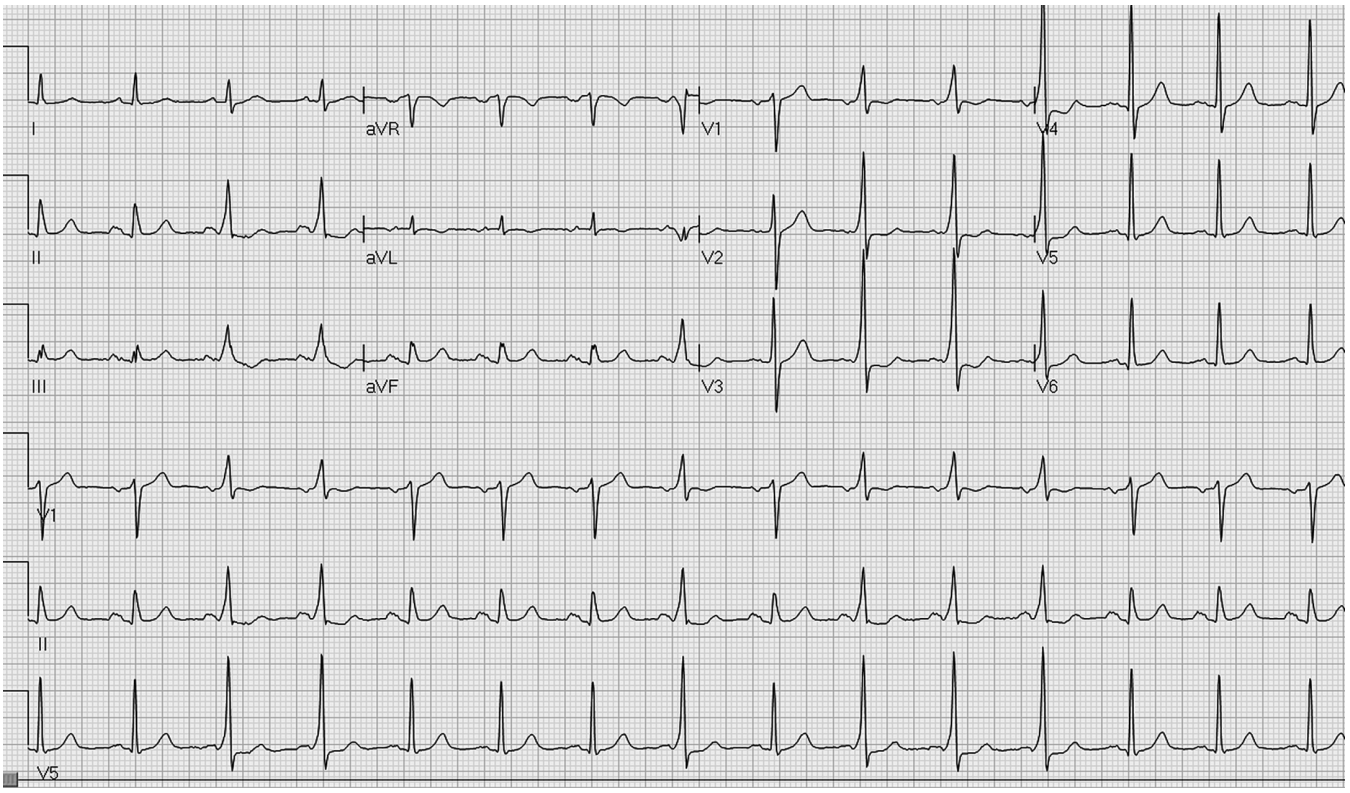

Figure 2. *ECG of a 45-year-old female with intermittent preexcitation.*

The wide QRS complexes are also preceded by sinus P waves at the same rate as those with narrow QRS complexes. There is slurring on the upstroke of the QRS, and there are minor repolarization abnormalities. The QRS complex in V1 is positive. The differential diagnosis for alternating wide and narrow QRS complexes is intermittent preexcitation or ventricular extrasystoles with long coupling intervals. This ECG is consistent with intermittent preexcitation, and the positive QRS complex in V1 suggests a left-sided accessory pathway.

Individuals who have a WPW pattern on their ECG have an abnormal accessory conduction connection between the atria and the ventricles, which bypasses the atrioventricular node (AV node). Histologically, this accessory pathway has a pattern consistent with normal working ventricular myocardium, not specialized conduction tissue. Importantly, it does not share the rate-slowing properties of the AV node. The accessory pathway (AP) is, therefore, capable of conducting antegradely to the ventricle with conduction faster than the AV node during sinus rhythm. Thus, the AV node and the accessory pathway are in competition to depolarize the ventricle when a supraventricular beat is initiated. The fusion of these competing paths results in the WPW pattern, consisting of a delta wave, which is the slurring of the initial upstroke of the QRS (also making the QRS wide) and a short PR interval (Figure 3). The accessory pathway can also predispose the patient to supraventricular tachycardia (SVT) – primarily AV reentry tachycardia (AVRT) – as well as very rapid ventricular rates during other supraventricular tachyarrhythmias such as atrial fibrillation (AF) (Figure 5).

The term *WPW syndrome* refers to preexcitation seen on an ECG associated with the clinical symptoms, ie, palpitations and tachyarrhythmias. Not all patients with the WPW pattern will develop clinical tachycardias and not all patients with AVRT tachycardia will have preexcitation apparent on the surface ECG. The terms preexcitation and Wolff-Parkinson-White syndrome are used interchangeably in this article, even though there are other forms of preexcitation.

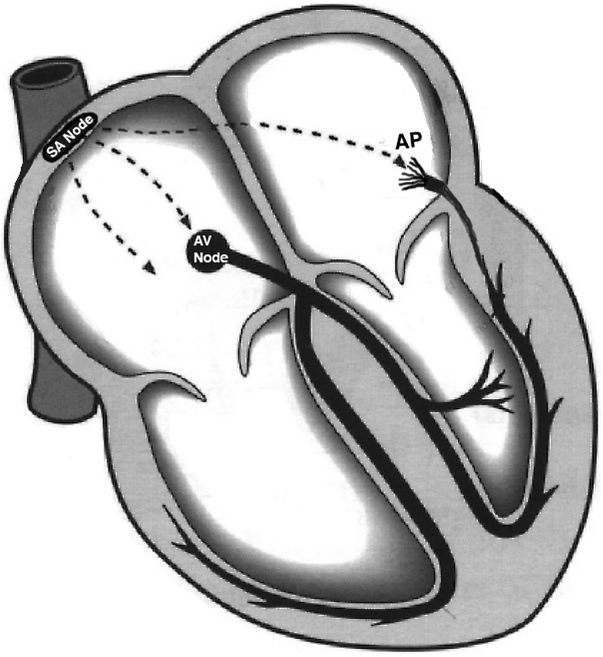

Figure 3. *Impulse from Sinus Node is conducted via AV node and Accessory pathway (in competition) to the ventricle.*

WPW ARRHYTHMIAS AND MECHANISM OF SUDDEN CARDIAC DEATH

Accessory pathways may conduct antegradely only, retrogradely only or may conduct bi-directionally (ie, both antegradely and retrogradely). Accessory pathways can be present without an obvious WPW pattern on the ECG. Supraventricular tachycardia is not uncommon in patients with WPW (~20%). Tachyarrhythmias associated with accessory pathways are most often a narrow complex AVRT regardless of the overt presence of preexcitation on the ECG. The antegrade limb of the tachycardia circuit is down the AV node and the retrograde limb is up the accessory pathway. The other form of AVRT is less common (wide QRS tachycardia) in which the antegrade limb of the

circuit is down the accessory pathway and the retrograde limb is up the AV node. Rarely the accessory pathway plays the role of a bystander only during other forms of SVTs (ie, atrial tachycardia, AVNRT, atrial flutter, atrial fibrillation).

The mortality concern with a Wolff-Parkinson-White ECG pattern is the risk for sudden cardiac death due to the development of rapidly conducting, preexcited atrial fibrillation that may degenerate into ventricular fibrillation (VF) and sudden cardiac death.[1-3] This life-threatening arrhythmia occurs when the accessory pathway has a short anterograde effective refractory period (ERP), resulting in a ''wide window'' allowing many atrial impulses during atrial fibrillation to be conducted to the ventricle. This will result in very high ventricular rates with possible deterioration into ventricular fibrillation and sudden cardiac death. A long antegrade effective refractory period of the accessory pathway does not exclude the possibility of a SVT, but the individual is not at risk of sudden death if atrial fibrillation occurs.

Epidemiological data indicates that the prevalence of a WPW pattern on a routine ECG is 0.1% to 0.3% in the general population[4,5] meaning that every year approximately 3 new cases are found in a population of 100,000. It is also known that there is a 4-fold increase of this finding in family members of WPW patients.[6] The risk of ventricular fibrillation and sudden death in *symptomatic* individuals with WPW syndrome is estimated to be approximately 0.25% per year or 3% to 4% over a lifetime.[2] However, sudden death rarely may be the first event in individuals with *asymptomatic* preexcitation.[3]

Recently there have been advocates for performing invasive electrophysiologic assessment and catheter ablation therapy in *asymptomatic* individuals with Wolff-Parkinson-White ECG patterns based on the finding by some investigators of higher mortality rates in these individuals.[7-9] This approach has triggered multiple publications with several rebuttals. Should life insurance medical directors reevaluate our approach to Wolff-Parkinson-White ECG findings? Well, first, let's leave this debate for the electrophysiologist community. Second, the risk of sudden cardiac death in a population with Wolff-Parkinson-White ECG pattern is exceedingly small.

All analyses except the recent Italian studies have shown very low event rates. Unfortunately, we do not get ECGs on all asymptomatic individuals, so we do not know the cause and the true incidence of sudden cardiac death. It is also known that many patients with Wolff-Parkinson-White tend to lose accessory pathway conduction over time.[10] A recent metaanalysis has shown that asymptomatic individuals have a low incidence of sudden cardiac death, and the risks associated with an invasive procedure such as ablation therapy are similar to the risk of sudden cardiac death in asymptomatic individuals. This argues against routine invasive management in most asymptomatic individuals with the Wolff-Parkinson-White ECG pattern.[11] The major conclusion of this meticulous review is that the available evidence is insufficient to justify the use of catheter ablation in the asymptomatic patient. ''The risk of sudden cardiac death was statistically significantly lower in the non-Italian compared to the Italian studies''.[11]

In summary: though some recent Italian studies had showed somewhat higher mortality rate in asymptomatic individuals, based on available evidence, the mortality risk in insured populations is no different than was believed in the past, and thus the approach should probably remain the same.

RISK STRATIFICATION OF INDIVIDUALS WITH WPW

In absence of any tests, important risk factors (''red flags'') are: younger age (<30y), male sex, history of palpitations, syncope or atrial fibrillation, history of congenital heart dis-

ease and family history of WPW.[12] The purpose of risk stratification is to identify individuals with a Wolff-Parkinson-White ECG pattern who are at risk for lethal arrhythmias. The obligatory condition for ventricular fibrillation is an accessory pathway with short antegrade refractory period (as reflected by the shortest R-R interval between preexcited QRS complexes during atrial fibrillation (Figure 5) or the effective refractory period measured during EP study). Non-invasive and invasive (electrophysiology) tests are used for risk assessment.

NONINVASIVE TESTING

In general, these tests look for evidence of an accessory pathway that fails to be able to conduct at rapid rates, either in sinus rhythm or during AF. These tests include resting ECGs, Holter monitoring, exercise testing and medication challenge to induce a block in the accessory pathway in sinus rhythm. These tests can reveal *intermittent preexcitation* during sinus rhythm. Intermittent preexcitation is present when 2 consecutive sinus beats show the presence and absence of preexcitation (Figure 2). This finding indicates a long antegrade refractory period of the accessory pathway resulting in very low risk of sudden cardiac death.[13,14]

During preexcited atrial fibrillation, the antegrade characteristics of the accessory pathway are assessed by the measurement of the *shortest preexcited R-R interval* (SPERRI) (Figures 4 and 5). A SPERRI of 220-250 ms, especially if <220 ms indicates high risk for ventricular fibrillation and cardiac arrest.[15-17]

The appearance of different preexcited morphologies on an ECG or serial monitoring is suggestive of *multiple* accessory pathways, which has been identified as a risk factor for ventricular fibrillation and sudden cardiac death.[9,16,18]

Serial monitoring also helps to find episodes of supraventricular tachycardia or atrial fibrillation in asymptomatic individuals. In a prospective study of 184 asymptomatic children with WPW followed for 5 years with 2 Holter monitor per year, 12% had paroxysmal atrial fibrillation, an incidence significantly higher than seen in asymptomatic adults with WPW.[15]

The best indicator of low risk is the *sudden* disappearance of pre-excitation during exercise, first described by Levy et al.[19] This indicates a long antegrade effective refractory period of the accessory pathway. Sympathetic stimulation occurring during exercise will shorten the duration of the effective refractory period of the accessory pathway.[20] When the effective refractory period of the accessory pathway is reached during exercise, as manifested by sudden block in the accessory pathway and normalization of the ECG, it is a good indicator that the patient is not at risk for ventricular fibrillation even during sympathetic stimulation.[21,22] One must be careful, however, to distinguish true block in the accessory pathway from diminution of the degree of preexcitation over that produced by sympathetic stimulation during exercise, which will shorten the trans-AV nodal conduction time. Therefore, several leads are taken simultaneously, and special attention is given to the *sudden* occurrence of block in the accessory pathway during exercise and to the ECG after exercise. This is because, in exercise-induced block in the accessory pathway, a sudden marked change in the ECG takes place since there is an exclusive conduction over the AV node (rather than fusion conduction over the AVN *and* the accessory pathway). The inability to clearly demonstrate the sudden and absolute loss of manifest PRX during exercise warrants invasive electrophysiology testing.

In the past, sodium channel blocking agents (ajmaline, procainamide, etc.) were used to determine properties of the accessory pathway.[23-25] The specificity of loss of preexcitation after drug administration was poor, and this technique is no longer utilized for risk assessment.

Figure 4. *Preexcited ECG; sinus rhythm with conduction competing over AP and AV node; all QRS complexes are preexcited (fused).*

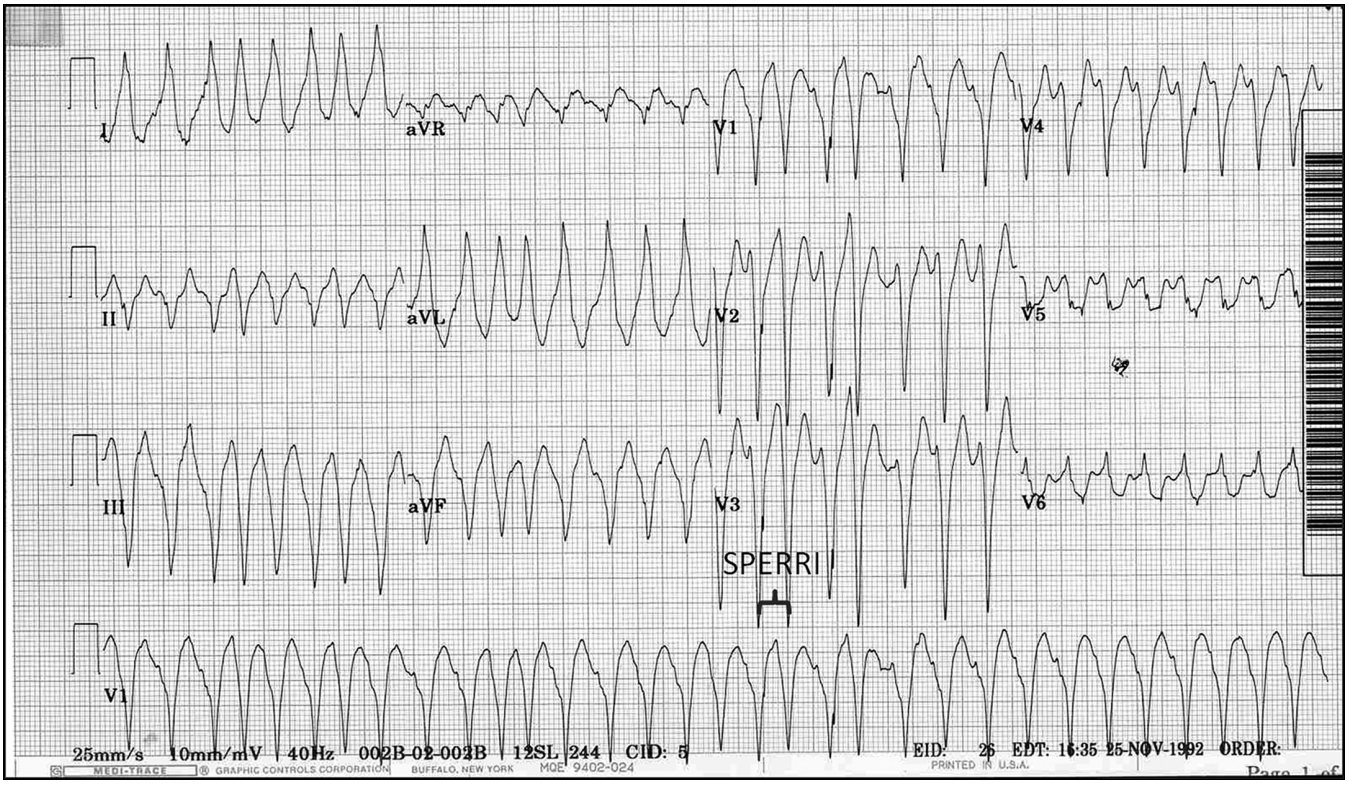

Figure 5. *Preexcited AF with rapid conduction over the AP. The Shortest preexcited R-R interval (SPERRI) is 240 ms.*

INVASIVE ELECTROPHYSIOLOGY TESTING

Invasive electrophysiology testing also can be used for risk stratification as an alternative approach to noninvasive risk stratification for asymptomatic patients. An electrophysiology study is recommended in asymptomatic patients when non-invasive testing is ambiguous or uncertain regarding the risk. When an electrophysiology study reveals high risk in an asymptomatic patient, mapping of the accessory pathway's location and ablation therapy are usually performed (as a potentially definitive treatment) of the accessory pathway. Invasive electrophysiology testing is also strongly indicated in certain asymptomatic patients with a WPW pattern when there is a coexistent cardiac abnormality. It is also recommended when multiple accessory pathways are suspected. For symptomatic patients with palpitations/tachycardia, an electrophysiology study with ablation is clearly recommended. Invasive electrophysiology testing is usually not recommended in an individual over age 40 to identify stratify risk.

During the electrophysiology study, the inducibility of tachycardias is assessed as well as the conduction characteristics of the accessory pathway. The antegrade conduction property is measured by the effective refractory period of the accessory pathway (or also defined by the shortest preexcited R-R interval [SPERRI], as discussed earlier). In children, SPERRI <220 ms carry a threefold increase in risk of sudden cardiac death compared to the general WPW population.[17] Long anterograde ERP/SPERRI (>250 ms) of the accessory pathway indicates limited capability of anterograde conduction via accessory pathway and indicates low risk for ventricular fibrillation and sudden cardiac death. The sensitivity and negative predictive value of SPERRI (≤ 220 ms) is high and well established,[26-29] but the specificity and positive predictive values of predicting sudden cardiac death are low.[30,31] The very low event rates of ventricular fibrillation challenge the accuracy of electrophysiology testing to predict sudden cardiac death.[32]

MANAGEMENT

Radiofrequency Ablation Therapy

In symptomatic WPW syndrome, radiofrequency (RF) ablation therapy is the well-established first line of therapy. It is also indicated in some occupations in which the development of symptoms would put themselves or others at risk (eg, truck drivers or airline pilots, some athletes).

In asymptomatic patients, ablation of the accessory pathway decreases the incidence of potential future symptomatic arrhythmias; however, studies are not powered to detect reduction in mortality.[22] A decision to proceed with ablation in asymptomatic cases is recommended when risk stratification reveals high risk features. It can be also considered when the WPW pattern is associated with structural heart disease. Otherwise it is made on a case-by-case basis with careful discussion between the clinician and the well-informed patient who balances a very small immediate ablation risk with a very small longer-term risk without ablation.[32] Low-risk patients with WPW on the ECG require reassurance.

For the procedure, 3-4 diagnostic catheters and 1 ablation catheter are inserted via the transvenous route and positioned at specific sites in cardiac chambers in order to record intracardiac electrograms during the pacing guided electrophysiology study. With pacing maneuvers, the accessory pathway properties are defined, potential tachycardias are induced, accurate mapping (localization) of the accessory pathway is achieved and radiofrequency ablation is employed. Under special circumstances other energy sources are used (ie, cryoablation). Permanent disappearance of the accessory pathway and non-inducibility of tachycardia define acute success.

The *success rate* with catheter-based ablation is approximately 90% to 95%, depending upon the location of the accessory pathway and the precision of pathway localization.[33,34] The

recurrence rate of the accessory pathway is around 8%. However, this depends on the location of the accessory pathway and the possibility of multiple accessory pathways. This can increase the recurrence rate to 21%. Recurrences are often seen within 12-24 hours, or rarely later, usually within 2-3 months.[35-37]

The procedure carries a small risk of complications. The incidence of major procedural complications associated with electrophysiology studies and ablations has been reported to be approximately 2%. Most common are cardiac perforation with tamponade, advanced AV block, coronary artery involvement and thromboembolic events. Other adverse events also can occur (hematoma at entry site, RBBB, LBBB, valvular regurgitations, etc.). Mortality rates are reported to be 0.07% - 0.19%.[35,38,39]

DRUG THERAPY

Less frequently *antiarrhythmic drugs* are used for preventing tachycardia (SVT/AVRT). Efficacy is related to their ability to alter the electrophysiologic properties of the circuit, rendering the circuit incapable of sustaining reentry. Some features and co-morbidities (ie, overt preexcitation, concomitant structural heart disease, ischemia, etc) need to be considered to choose the proper medication. Chronic and acute therapy for accessory pathway-related arrhythmia management and prevention requires careful decision making.

REVISITING THE CASES

Case # 1

The 23-year-old male client has no disclosed medical history. His ECG shows a WPW pattern, and the mortality risk is unclear at this point. In the absence of any tests, the ''red flags'' in his case are the younger age, male sex, and the lack of information about symptoms. Since this individual has persistent preexcitation on his ECG, clinical assessment will be helpful for him to be able to get insurance. We noticed QS complexes in lead III and AVF. Q waves/QS complexes can be seen on Wolff-Parkinson-White pattern ECGs. This pattern is a nonpathological cause of Q waves.

Case # 2

The 45-year-old woman has a clear history of palpitations. Her ECG reveals intermittent preexcitation. Without any tests, her risk can be considered low based on her age, sex and particularly based on the intermittent pattern of the preexcitation, which suggests poor anterograde conduction capability of the accessory pathway. In addition, she admitted cardiac investigations for palpitation in the past and was advised to undergo observation only. Her mortality risk is low, probably identical to the insured population risk. She doesn't require any further evidence to indicate that she is insurable.

SUMMARY

In summary, the Wolff-Parkinson-White syndrome requires an assessment, re the need for an electrophysiology study and possible ablation therapy. Asymptomatic patients need clinical assessment. If careful history taking reveals symptoms, noninvasive assessment is indicated and electrophysiology study may be indicated. In the case of truly asymptomatic patients with WPW pattern on their ECG, non-invasive testing may be considered. ''Low-risk'' individuals are usually followed without invasive testing as long as they remain asymptomatic. Intermittent preexcitation suggests low risk for life threatening events. High risk features or ambiguous findings require invasive assessment. Keep in mind that very low event rates of ventricular fibrillation challenge the accuracy of electrophysiology studies to predict sudden cardiac death. The negative predictive value of the SPERRI >250 ms is well established, but the positive predictive value of the SPERRI to predict sudden cardiac death remains low. For insurance purposes, patients over age 40

with an asymptomatic WPW pattern on their ECG have a minimal risk for serious events. Younger patients with WPW pattern on their ECG require assessment.

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