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Paroxysmal Supraventricular Tachycardia in the General Population

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Objectives. **We sought to determine the epidemiology and clinical significance of paroxysmal supraventricular tachycardia (PSVT) in the general population.**

Background. **Current knowledge of PSVT has been derived primarily from otherwise healthy patients referred to specialized centers.**

Methods. **We used the resources of the Marshfield Epidemiologic Study Area, a region covering practically all medical care received by its 50,000 residents. A review of 1,763 records identified prevalent cases as of July 1, 1991 and all new cases of PSVT diagnosed from that day until June 30, 1993. A mean follow-up period of 2 years was completed in all incident patients. Patients without other cardiovascular disease were labeled as having "lone PSVT."**

Results. **The prevalence was 2.25/1,000 persons and the incidence was 35/100,000 person-years (95% confidence interval, 23 to 47/100,000). Other cardiovascular disease was present in 90% of males and 48% of females ($p = 0.0495$). Compared with patients with other cardiovascular disease, those with lone PSVT were younger (mean 37 vs. 69 years, $p = 0.0002$), had a faster PSVT heart rate (mean 186 vs. 155 beats/min, $p = 0.0006$) and were more likely to have their condition first documented in the emergency room (69% vs. 30%, $p = 0.0377$). The onset of symptoms occurred during the childbearing years in 58% of females with lone PSVT versus 9% of females with other cardiovascular disease ($p = 0.0272$).**

Conclusions. **There are ~89,000 new cases/year and 570,000 persons with PSVT in the United States. In the general population, there are two distinct subsets of patients with PSVT: those with other cardiovascular disease and those with lone PSVT. Our data suggest etiologic heterogeneity in the pathogenesis of PSVT and the need for more population-based research on this common condition.**

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To date, there are no published reports of paroxysmal supraventricular tachycardia (PSVT) in the general population. PSVT is generally a regular, narrow complex tachyarrhythmia frequently encountered in clinical practice (1–6). It is the most common arrhythmia in the Wolff-Parkinson-White (WPW) syndrome. Even in the absence of overt pre-excitation, reentry through the atrioventricular (AV) node or a concealed bypass tract accounts for ~90% of all PSVT (1). The electrophysiologic-morphologic substrates responsible for both AV node reentry tachycardia (AVNRT) and AV reentry tachycardia (AVRT) are thought to be present from birth (1,7). This congenital defect theory is supported by the observation that most patients reported on (8–12) are young healthy persons referred to tertiary care centers for treatment of intractable PSVT. Despite the widespread utilization of radiofrequency ablation as a curative and cost-effective therapy for patients with refractory tachycardia (13–18), there are no data on its role in more typical cases.

The purpose of our investigation was to determine the epidemiology and clinical significance of PSVT in the general population. Population studies provide incidence, prevalence and demographic data on unselected cases and thus improve our understanding of associated conditions (19) and facilitate good clinical decisions (20).

Methods

Population-based epidemiologic research is feasible in central Wisconsin because almost all health care is provided by Marshfield Clinic or St. Joseph's Hospital. These institutions share a common system of medical records including information on all inpatient and outpatient medical care encounters. The Marshfield Epidemiologic Study Area (MESA) has been established to conduct epidemiologic studies and population-based health research. MESA is a zip code–defined region with ~50,000 residents in and around Marshfield, Wisconsin. Validation studies (21) have shown that MESA ascertains 100% of deaths, 94% of hospital discharges and 92% of outpatient medical visits among area residents. The population

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Abbreviations and Acronyms

AV	=	atrioventricular
AVNRT	=	atrioventricular node reentry
AVRT	=	atrioventricular reentry
CI	=	confidence interval
CVD	=	cardiovascular disease
ECG	=	electrocardiogram, electrocardiographic
ICD-9-CM	=	International Classification of Diseases, 9th Revision, Clinical Modification
MESA	=	Marshfield Epidemiologic Study Area
PSVT	=	paroxysmal supraventricular tachycardia
WPW	=	Wolff-Parkinson-White

data base is updated daily, allowing longitudinal follow-up of individual persons. The study protocol, including the abstraction form designed to obtain the pertinent information from the records, was approved by our Institutional Review Board.

Potential cases of PSVT occurring among MESA residents from January 1, 1979 through June 30, 1993 were initially identified by reviewing Marshfield Clinic's computerized diagnostic data base. Since 1979, the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) has been used to code diagnoses. A physician reviewed the records of all potential cases and completed a standard abstraction form. Standard ECG criteria for PSVT were employed: 1) paroxysmal occurrence, 2) normal QRS complex configuration or preexisting bundle branch block, 3) variation in successive RR intervals ≤40 ms, 4) ventricular rate ≥120 beats/min, 5) no evidence of AV dissociation, and 6) no identifiable P waves preceding the QRS complex during tachycardia (22–24). All ECG tracings identified as potentially eligible were confirmed by cardiac electrophysiologists. During the 100,000 person-years of observation, ~13,000 ECGs and rhythm strips, 500 Holter monitors and 250 ambulatory event recordings were obtained from the MESA residents. Incident and prevalent cases satisfying the ECG criteria were included in the study if the documented PSVT was clinically significant, defined as an event causing symptoms or requiring short- or long-term therapy.

Incidence. To identify newly diagnosed cases of PSVT, we reviewed the records of all MESA residents who had a first occurrence of any of the following ICD-9-CM codes from July 1, 1991 through June 30, 1993: 1) 426.7, anomalous AV excitation; 2) 427.0, PSVT; 3) 427.2, paroxysmal tachycardia, unspecified; 4) 427.6, premature beats, unspecified; 5) 427.89, other cardiac arrhythmias; 6) 427.9, cardiac arrhythmia, unspecified; 7) 785.0, tachycardia, unspecified; or 8) 785.1, palpitations. To ensure complete ascertainment, we also employed two codes of the Current Procedural Terminology (CPT) system: 1) 93620, comprehensive electrophysiologic evaluation; and 2) 93650, intracardiac catheterization-ablation of arrhythmogenic focus or tracts. However, these two codes identified no additional potential cases not identified by the eight ICD-9-CM codes.

Prevalence. A review of the incident cases indicated that 91% of PSVT cases could be identified by using four ICD-9-CM codes (426.7, 427.0, 427.89 and 427.9). Therefore, we used these codes to identify potential prevalent PSVT cases. Prevalence was determined as of July 1, 1991. We identified 2,223 persons living in the MESA on that date who had received one or more of the four codes between January 1, 1979 and June 30, 1991. To estimate the proportion of potential prevalent cases that could be confirmed by ECG review, we selected a stratified random sample of 600 potential prevalent cases for chart review. We randomly selected 150 persons in each of the following groups: 1) males <65 years, 2) females <65 years, 3) males ≥65 years, and 4) females ≥65 years.

Clinical course. A mean follow-up interval of 24 months (range 1 to 38) was achieved for all incident cases. For the 28 patients living at the time of last follow-up, the minimal and mean periods of observation were 12 and 26 months, respectively. Data collection was conducted by reviewing medical records of the incident patients who had been seen either as an inpatient or an outpatient at least once during 2 months before June 30, 1995. The four patients not seen during this period were contacted by telephone and asked to respond to a structured interview to complete a questionnaire specifically designed for this study.

Data analysis. The entire population of MESA, including persons of all ages, was considered at risk for development of PSVT. The number of verified incident cases was divided by the total number of person-years of observation for all MESA residents. Age- and gender-adjusted rates were calculated by using the 1990 U.S. census as the standard. We used Poisson regression to estimate relative risks and confidence intervals for PSVT according to age and gender. Prevalence was estimated by adjusting the number of potential prevalent cases identified through the computer data base by the proportion of confirmed cases in the chart review sample. The denominator for the prevalence proportion was the number of persons living in the MESA on July 1, 1991. Associations between gender and associated cardiovascular disease (CVD) were analyzed with the Fisher exact test. Univariate comparisons of heart rates and associated CVD were made with the Wilcoxon rank sum test. The Kaplan-Meier method was used to estimate the percent of patients remaining free of PSVT recurrence in each month of follow-up (25). A p value ≤ 0.05 was considered statistically significant. All statistical calculations were generated with SAS software (version 6.08) (SAS Institute, Inc.) and StatXact statistical software (STATXACT TURBO, 1992, CYTEL Software Corporation).

Results

Prevalence. A review of the computerized diagnoses data base identified 2,223 potential prevalent cases. Reviewing the records and electrocardiographic (ECG) tracings of a subsample of 600 patients confirmed 31 prevalent cases of PSVT. The verification proportion differed by age and gender. Accounting for the sampling design, we estimated that as of July

Table 1. Prevalence of Paroxysmal Supraventricular Tachycardia per 1,000 Persons by Age and Gender

Age	Males	Females	Total
<65 yr	0.95	2.37	1.65
≥65 yr	9.69	3.65	6.16
Total	1.94	2.56	2.25
Adjusted	2.05*	2.53*	2.29†

*Age adjusted to the 1990 U.S. census. †Age and gender adjusted to the 1990 U.S. census.

1, 1991, the crude proportion of MESA residents who had received a diagnosis of PSVT over the previous 12 years was 2.25/1,000 persons (Table 1).

Incidence. A total of 1,163 patients were classified as potential new cases of PSVT. A review of all records and ECGs of all 1,163 patients confirmed 33 incident cases of PSVT. Only 13 (39%) of the 33 incident cases would have been detected had we limited our screening to those identified by code 427.0, the specific ICD-9-CM code for PSVT. Overall, the incidence rate of documented PSVT in MESA was 35/100,000 person-years (Table 2).

Age, gender and other associated CVD. Table 3 shows the clinical characteristics and main features of the incident patients. The mean age at the time of initial PSVT documentation was 57 years (range: infancy to 90 years). Among the 33 incident patients, 23 (70%) were females. Females had a risk of development of PSVT two times greater than that of males (relative risk 2.0, 95% confidence interval [CI] 1.0 to 4.2). The risk of development of PSVT was more than five times greater in residents ≥65 years than in those <65 years old (relative risk 5.3, 95% CI 2.7 to 10.5).

Other CVD was considered present only if its existence before the initial diagnosis of PSVT could be established from chart abstraction. All patients had ECG tracings during tachycardia and sinus rhythm. In addition, 70% had other diagnostic cardiac studies, including two-dimensional echocardiogram and cardiac catheterization. CVD was considered present in those persons with a documented diagnosis of hypertension, coronary artery disease, congestive heart failure, valvular heart disease, atrial fibrillation/flutter, sick sinus syndrome, congenital heart disease or pericarditis. CVD was present in 20 (61%) of the 33 incident patients, occurring in 90% of males and 48% of females ($p = 0.0495$) (Table 4). Hypertension was present in 15 patients, coronary artery disease in 7, congestive heart failure in 6, atrial fibrillation in 6; ECG evidence of WPW syndrome was present in only 1 subject. Thirteen (39%) of patients with newly diagnosed PSVT had no CVD and were labeled as having "lone PSVT." Of the 23 female incident patients, 12 (52%) had lone PSVT, accounting for all but 1 of the 13 patients with lone PSVT. The onset of symptoms of PSVT occurred during the childbearing age (15 to 50 years) in 7 of 12 females with lone PSVT but in only 1 of 11 females with other associated CVD ($p = 0.0272$). All males with other CVD also had the onset of symptoms late in life, after the age of 50 years. Thus, in patients with CVD, gender did not influence the age of onset of symptoms. Subjects with associated CVD were older than those with lone PSVT (mean 69 vs. 37 years, $p = 0.0002$). For the 33 incident cases, the average heart rate during the initial documented episode of PSVT was 167 beats/min. As a group, patients with CVD had slower tachycardia rates than did those with lone PSVT (mean heart rate during PSVT, 155 vs. 186 beats/min, $p = 0.0006$).

Clinical characteristics. Twenty-one incident patients (64%) had symptoms suggestive of PSVT before initial ECG documentation, including 8 who had symptoms for <1 year and 13 who had symptoms for >1 year before diagnosis. In 8 of the remaining 12 patients (24% of all incident patients), PSVT was documented during their first symptomatic episode. Four asymptomatic incident patients satisfied our definition of clinically significant PSVT because they required treatment for their arrhythmia. At initial diagnosis, 6 (30%) of 20 patients with CVD had PSVT documented in the emergency room, compared with 9 (69%) of 13 patients with lone PSVT ($p = 0.0377$) (Table 4). At initial presentation, four patients (12%) were taking cardioactive drugs capable of slowing or preventing PSVT. Two patients presented with hemodynamic instability (hypotension, cardiovascular collapse or syncope) during the tachycardia. At last follow-up, 78% of incident patients had been referred to a cardiologist or electrophysiologist.

Electrophysiologic findings and long-term treatments. Electrophysiologic studies were performed in six patients, documenting AVNRT in five and orthodromic AVRT in the patient with the WPW syndrome. Radiofrequency ablation was performed in four patients: three with CVD and one with lone PSVT. At last follow-up, 67% of patients with CVD and 47% with lone PSVT were taking antiarrhythmic agents.

Table 2. Incidence Rates of Paroxysmal Supraventricular Tachycardia per 100,000 Person-Years by Age and Gender

Age (yr)	Males		Females		Total	
	No.	Rate	No.	Rate	No.	Rate (95% CI)
≤19	1	7	3	21	4	13 (0–27)
20–64	4	15	10	38	14	27 (13–40)
≥65	5	98	10	139	15	122 (60–184)
Total (95% CI)	10	21 (8–35)	23	48 (28–67)	33	35 (23–47)
Adjusted (95% CI)		24 (9–39)*		46 (27–65)*		36 (23–48)†

*Age adjusted to the 1990 U.S. census. †Age and gender adjusted to the 1990 U.S. census. CI = confidence interval.

Table 3. Clinical Characteristics of the 33 Incident Patients

Case No.	Age (yr)/ Gender	PSVT Rate (beats/min)	Initial Documentation	Long-Term Therapy		Duration of Symptoms	Associated CVD
				Medical	RFA		
1	83/F	157	Office	None		None	HTN
2	73/F	148	Office		Yes	≥1 yr	HTN
3	75/F	138	Office	Yes		None	HTN
4	56/M	152	Wards	Yes		1st episode	CHF, CAD, HTN
5	90/F	158	Wards	Yes		None	CAD, HTN, AFib
6	60/M	152	Wards	Yes		≥1st yr	CHF, HTN, AFl
7	78/M	140	Wards	Yes		1st episode	CHF, CAD, VSD
8	68/F	150	Wards	Yes		1st episode	CHF, HTN, AI, MR, AFib, SSS
9	69/F	167	Wards	Yes		1st episode	AS, AFib
10	53/M	158	Holter monitor	None		≥1 yr	Pericarditis, MVP
11	43/F	170	Holter monitor	Yes		<1 yr	HTN, AFib
12	65/F	170	Holter monitor	None		≥1 yr	HTN
13	66/M	178	Holter monitor	Yes		≥1 yr	HTN
14	68/M	207	Holter monitor	Yes		≥1 yr	HTN
15	69/M	140	ER	Yes		<1 yr	HTN, SSS
16	63/M	130	ER	Yes		None	CHF, HTN
17	82/F	130	ER		Yes	≥1 yr	CAD, HTN, AFib
18	82/F	146	ER	Yes		1st episode	CHF, CAD, HTN, MR
19	69/M	143	ER	Yes		<1 yr	CAD, AFib, AFl
20	60/F	164	ER		Yes	<1 yr	WPW, CAD, Ebstein
21	14/M	230	Holter monitor	None		≥1 yr	—
22	8/F	200	Holter monitor	None		<1 yr	—
23	20/F	167	EP lab	Yes		<1 yr	—
24	50/F	200	EP lab	Yes		≥1 yr	—
25	26/F	172	ER	Yes		≥1 yr	—
26	71/F	200	ER	Yes		≥1 yr	—
27	36/F	168	ER	None		1st episode	—
28	62/F	190	ER	Yes		≥1 yr	—
29	0.3/F	240	ER	None		<1 yr	—
30	39/F	135	ER	None		<1 yr	—
31	76/F	182	ER	Yes		1st episode	—
32	46/F	160	ER	Yes		1st episode	—
33	39/F	180	ER		Yes	≥1 yr	—

AFib = atrial fibrillation; AFl = atrial flutter; AI = aortic insufficiency; AS = aortic stenosis; CAD = coronary artery disease; CHF = congestive heart failure; CVD = cardiovascular disease; Ebstein = Ebstein's anomaly; EP lab = electrophysiology laboratory; ER = emergency room; F = female; HTN = hypertension; M = male; MR = mitral regurgitation; MVP = mitral valve prolapse; PSVT = paroxysmal supraventricular tachycardia; RFA = radiofrequency ablation; SSS = sick sinus syndrome; VSD = ventricular septal defect; WPW = Wolff-Parkinson-White syndrome.

Clinical course. Based on a mean follow-up interval of 24 months for the 33 incident cases, the cumulative observation period was 771 person-months. During that time, six patients (four females) had a total of eight documented recurrences. The probability of experiencing a recurrence by the end of year 2 of follow-up was 0.20 (95% CI 0.06 to 0.35) (Fig. 1). No predictors of recurrence were identified. Among patients with a recurrence, all but one experienced their first recurrence within 12 months of diagnosis and one presented with hemodynamic instability. Five patients died during follow-up, none secondary to PSVT. All deaths occurred in subjects with other CVD (mortality rate in that group 25% at 2 years). Specific causes of death included intracranial hemorrhage in an 84-year old woman, congestive heart failure in a 56-year old man, pneumonia in a 90-year old woman, stage IV non-Hodgkin's lymphoma in a 54-year old man and pancreatic cancer in a 70-year old man.

Table 4. Comparison of Incident Patients With Lone Paroxysmal Supraventricular Tachycardia and With Paroxysmal Supraventricular Tachycardia and Cardiovascular Disease

	PSVT and CVD	Lone PSVT	p Value
Patients (no.)	20	13	
Females (%)	55%	92%	0.0495
Mean age (yr)	69	37	0.0002
Mean PSVT rate (beats/min)	155	186	0.0006
Initial PSVT in ER	30%	69%	0.0377
Onset of symptoms in females at age 15–50 years (%)	9%	58%	0.0272

Abbreviations as in Table 3.

Discussion

This study, the first population-based investigation of PSVT, challenges many existing beliefs regarding this common

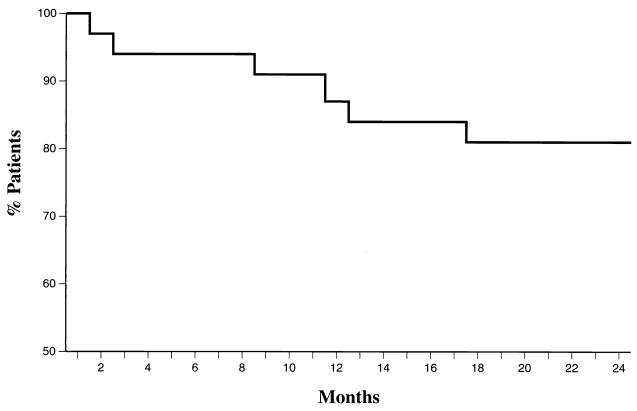

Figure 1. Cumulative percent of patients free of documented recurrence of PSVT during follow-up.

arrhythmia. Our findings show that patients with PSVT and the condition itself are different in the general population than in tertiary care centers. We believe that our study has identified important but previously unrecognized features of this common entity. This undistorted view of PSVT has changed our perception of typical patients and their expected course.

Epidemiology. There are no previous studies on the incidence and prevalence of PSVT in the general population. When our rates are adjusted by age and gender to the population of the U.S., the incidence of PSVT is estimated to be 36/100,000 persons per year, and the prevalence is 2.29/1,000 persons. If our results could be extrapolated to the entire U.S. population, we estimate there would be nearly 89,000 new cases/year and ~570,000 persons with PSVT in this country. In the Manitoba follow-up study (26), healthy males selected for aircrew training had an incidence rate of regular narrow QRS complex tachycardias of 17/100,000 persons per year. In our series, males in the age group 20 to 64 years had a similar incidence of 15/100,000 persons per year. The observation that our overall incidence is more than twofold greater than that reported in the Manitoba study can be explained by differences in the populations studied. Our design identified subsets of patients at a significantly greater risk of PSVT than that of healthy young males. Females had a risk of development of PSVT two times greater than that of males. Residents 65 years or older had more than five times the risk of development of PSVT than that of younger residents.

By identifying virtually all persons with PSVT in the area, we avoided errors of selection bias. In contrast to patients with PSVT reported from specialized arrhythmia centers, the unselected persons in our study were more likely to be older, to be female and to have other CVD, and they were at lower risk of experiencing refractory PSVT (Table 5). Subjects in our series had a mean age of 57 years, whereas the subjects studied by Jackman et al. (28) and Sintetos et al. (38) had a mean age of 41 and 42 years, respectively. Associated CVD was found in 61% of our subjects with newly diagnosed PSVT. CVD has

Table 5. Demographic Features of Patients With Paroxysmal Supraventricular Tachycardia in Present and Previous Studies

	Patients	Mean Age (yr)	Male/Female	CVD Other Than WPW	Recurrence Rate (%)
Calkins et al. (9)	106	43	49/57	10 (1%)	N/A
Kay et al. (12)	608	40	302/306	N/A	N/A
Lindsay et al. (27)	59	44	18/41	8 (14%)	N/A
Jackman et al. (28)*	80	42	24/56	14 (18%)	81% at 1 mo
Chen et al. (29)	408	47	264/144	56 (14%)	N/A
Rodriguez et al. (30)	574	36	325/249	N/A	N/A
Wu et al. (31)	100	48	37/63	6 (6%)	N/A
Clair et al. (32)*	113	40	56/57	35 (31%)	75% at 3 mo
Wu et al. (33)	79	52	45/34	31 (39%)	N/A
DiMarco et al. (34)	359	47	186/173	0	N/A
Bhandari et al. (35)	49	50	15/34	27 (55%)	N/A
den Dulk et al. (36)	40	49	17/23	9 (22%)	N/A
Giraudon et al. (37)	32	30	3/29	0	N/A
Sintetos et al. (38)*	34	42	23/11	10 (30%)	83% at 3 mo
Henthorn et al. (39)*	34	50	11/23	16 (47%)	25% at 2 mo
Dorian et al. (40)	121	51	35/86	N/A	N/A
Hopson et al. (41)	67	41	33/34	33 (39%)	N/A
Total (referral centers)	2,863	44	1,443/1,420 (females, 50%)	(16%)	71% at 3 mo
Present study (population based)	33	57	10/23 (Females, 70%)	20 (61%)	6% at 3 mo, 20% at 24 mo

*Studies used to calculate minimal recurrence rates at 3 months. Unless otherwise indicated, data are presented as number (%) of patients. CVD = cardiovascular disease; EPS = electrophysiologic study; N/A = not available; RFA = radiofrequency ablation; WPW = Wolff-Parkinson-White syndrome.

been reported in 1% to 25% of patients undergoing radiofrequency ablation for PSVT (27–29,42).

Unlike the more homogeneous group of mostly young healthy patients reported from referral centers, we have found that persons with PSVT in the general population fall into at least two distinct clinical subsets: those with other CVD and those without CVD (lone PSVT). Patients with lone PSVT are more likely to be females, to be younger at the time of diagnosis, to have had earlier onset of symptoms, to have faster PSVT rates, to be identified in the emergency room setting and to have a longer survival time. Among the estimated 89,000 subjects with new PSVT per year in the U.S., our data suggest that ~54,000 probably have other CVD and 35,000 have lone PSVT.

Clinical course. In the general population, frequently recurring, drug-refractory or hemodynamically destabilizing PSVT is uncommon. During ~800 person-months of observation, our patients had eight documented recurrences of PSVT, and only one of these was associated with symptoms suggestive of hemodynamic instability. Documented recurrences occurred in two patients (6%) at 3 months and in six patients (20%) at 2 years. In four previous studies reporting on early recurrences, 71% of patients had one or more recurrences at 3 months (Table 5). Whereas only one of our patients (3%) had more than one recurrence in >2 years, Jackman et al. (28) reported that 81% of their patients experienced at least one episode every 30 days before radiofrequency ablation, and Kalbfleisch et al. (15) described a frequency of 4.5 episodes/month. Owing to the small number of patients and their benign course, we were unable to identify predictors associated with recurrence of PSVT.

Assuming that accessory AV connections and WPW syndrome were the most common morphologic substrates responsible for PSVT, most of the early work on its mechanism (43,44) excluded patients with overt pre-excitation. In one study that did not exclude patients with overt pre-excitation (45), WPW syndrome was found in 68 (57%) of 120 consecutive patients admitted to the hospital for PSVT. Of the 45 patients in that series in whom the first attack occurred before the age of 21, 73% had pre-excitation. Only one patient (3%) in our series had WPW syndrome. We believe that the misconception that this syndrome is the most common cause of PSVT resulted from a systematic referral bias that preferentially selected patients for hospital admission if they could be identified and treated surgically, the only curative treatment modality at the time. Patients with a delta wave during sinus rhythm (WPW syndrome) or very fast PSVT (more frequently seen in PSVT with retrograde conduction over an accessory pathway) are more likely to be admitted to the hospital than are those with a normal ECG during sinus rhythm and slower heart rates during PSVT. The recent ability to perform curative radiofrequency ablation for almost all patients with PSVT has shown that AVNRT, not WPW syndrome, is the most common mechanism of PSVT.

Although AVNRT accounts for >60% of patients with PSVT undergoing invasive testing, these patients rarely require immediate hospital admission. AVRT, either in the setting of WPW syndrome with overt pre-excitation or occurring by means of retrograde conduction over a concealed accessory pathway, is now known to account for only ~30% of PSVT. Just as recent technologic advances have clarified the frequency of the different underlying electrophysiologic mechanisms in PSVT, we believe that epidemiologic studies can dispel and challenge clinical misconceptions (46).

Severely affected patients are more likely to be referred to tertiary care centers and to benefit from invasive procedures (47). Medical decisions appropriate for such patients may not be applicable to less seriously affected patients in the general population. Cost-effectiveness analysis of competing therapeutic strategies formulated for referral patients with incapacitating, drug-refractory PSVT may not be generalizable to persons with the "same illness" in the general population (14). Recent reviews (48,49) and the 1995 guidelines of the American Heart Association/American College of Cardiology/North American Society of Pacing and Electrophysiology (16) advocate invasive electrophysiologic evaluation and radiofrequency ablation for patients with symptomatic PSVT who prefer ablative therapy over pharmacologic treatment. These guidelines have not addressed how to best manage patients after their first documented episode of well tolerated PSVT. Our study findings suggest the need for further investigation in the assessment of optimal utilization of each of the therapeutic modalities available for PSVT. Given an average charge of $15,000/radiofrequency ablation procedure (11), performing this procedure on the ~90,000 patients with *new* cases of clinically significant PSVT each year in the U.S. would result in charges of well over $1 billion/year. However, this investigation shows that >60% of patients with PSVT in the general population have other associated CVD, such as hypertension, coronary artery disease or atrial fibrillation, for which chronic treatment will be needed. These clinical conditions are frequently treated with medications also used for PSVT, such as beta-adrenergic blocking agents, calcium channel blocking agents or digoxin. Given that three of four patients with PSVT in the general population require long-term medical therapy or radiofrequency ablation, and given the potential increased risk of PSVT in these patients, it may well be that the increased utilization of ablation in the elderly is appropriate. Our group (50) recently reported data quantitating the dramatic increase in the use of radiofrequency ablation in the U.S. Medicare population over the last few years. Only well designed prospective outcome studies will answer this important question.

Heterogeneity of PSVT. Our findings suggest the possibility of etiologic heterogeneity in the pathogenesis of PSVT. As previously noted, it is now well established that >90% of patients with PSVT have AVNRT or AVRT as the mechanism of PSVT. Both of these arrhythmias require the AV node for their maintenance. Both of these conditions have been viewed as congenital anomalies because it was believed that the required substrate was present from birth (7). Our study, in contrast, suggests that PSVT may be a heterogeneous disease with different underlying mechanisms. This assertion is sup-

ported by our finding that 91% of males, but only 50% of females, with PSVT have associated CVD. Additional evidence for a yet unrecognized etiologic mechanism of PSVT comes from the 12 females in our study with lone PSVT. In seven (58%) of these females the onset of symptoms occurred during childbearing age, an infrequent occurrence (9%) among females with underlying CVD ($p = 0.0272$). Rosano et al. (51) recently reported a strong correlation between episodes of PSVT and plasma concentration of ovarian hormones. Thus, hormonal effects experienced after menarche may contribute to the increased risk of PSVT observed in young healthy women. The possibility that PSVT has a heterogeneous etiology is also supported by recent reports (52) documenting that different molecular abnormalities are responsible for the condition currently labeled the familial long QT syndrome.

Limitations of the study. We minimized selection bias by identifying practically all cases occurring in the entire population of a defined geographic region. Although ICD-9-CM coding of medical conditions may not be completely accurate, we used a large set of codes to try to identify all possible PSVT cases. Using eight ICD-9-CM and two CPT codes, we reviewed nearly 1,200 charts to identify 33 incident cases of PSVT; thus, it is unlikely that we missed many, if any, incident cases of clinically significant PSVT during the study period. It is possible, however, that we might have missed a small number of cases, including atrial tachycardia, by using the ECG criteria we adopted (22–24). In our review of *all* MESA residents who underwent invasive electrophysiologic testing during the 100,000 person-years of observation, there were no cases of unexplained wide complex tachycardia that presented exclusively as rate-related bundle branch block. Given the limitations in current technology and the nature of this intermittent condition, complete ascertainment of PSVT in any population would require continuous and long-term ECG monitoring of all persons in the area, a study that is not likely to be feasible. Diagnostic bias was minimized by having electrophysiologists review the ECG tracings in all suspected cases to verify the diagnosis according to standard criteria. For the incidence study, the starting date coincided with the introduction of radiofrequency ablation at our institutions. The 2-year time interval, however, constrained the number of cases and limited the statistical power. The MESA population is predominantly white and rural. Although we are not aware of studies establishing racial, ethnic or residential predisposition to PSVT, our results should be used cautiously to project to other population groups.

More population-based studies are needed to enhance our understanding of the epidemiology and health care resource needs of patients with this and other common arrhythmias.

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