Risk Stratification of Patients With Syncope

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See related editorial, p 540.

Study objective: To develop and validate a risk classification system for patients presenting to emergency departments with syncope.

Methods: Two prospective studies were carried out at a large urban teaching hospital ED. One cohort of 252 patients with syncope who reported to the ED was used to develop the risk classification system; a second cohort of 374 patients with syncope was used to validate the system. Data from the patient's history, physical examination, and ED ECG were used to identify predictors of arrhythmias or mortality within the first year. Arrhythmias were detected by cardiac monitoring or electrophysiologic studies. Logistic regression and Cox proportional hazards models were used to identify the important risk factors for the classification system. Performance of the system was measured by comparing the proportion of patients with arrhythmias or death at various levels of the risk and receiver operating characteristic curves.

Results: Multivariate predictors of arrhythmia or 1-year mortality were an abnormal ED ECG (odds ratio [OR], 3.2; 95% confidence interval [CI], 1.6 to 6.4); history of ventricular arrhythmia (OR, 4.8; 95% CI, 1.7 to 13.9); history of congestive heart failure (OR, 3.1; 95% CI, 1.3 to 7.4); and age greater than 45 years (OR, 3.2; 95% CI, 1.3 to 8.1). Arrhythmias or death within 1 year occurred in 7.3% (derivation cohort) to 4.4% (validation cohort) of patients without any risk factors and in 80.4% (derivation) to 57.6% (validation) of patients with three or four risk factors.

Conclusion: Historical and ECG factors available at the time of presentation can be used to stratify risk of arrhythmias or mortality within 1 year in ED patients presenting with syncope.

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INTRODUCTION

Syncope is a common medical problem accounting for 1% to 6% of medical admissions and up to 3% of emergency department visits.[1-5] This symptom is often difficult to evaluate because of a broad differential diagnosis and the low yield of many diagnostic studies.[1-5] Further, patients presenting with syncope represent a heterogeneous population with respect to demographic and clinical characteristics. In patients with a definite cause of syncope, management depends on the cause identified. However, because the cause frequently is not certain when the patient is seen in the ED, hospital admission is often necessary. A major reason for admission in syncope patients is concern about arrhythmias and sudden death. Identification of patients who are at low risk for arrhythmias and sudden death could help ED personnel make informed decisions about safe discharges for outpatient diagnostic evaluation and treatment.

The primary goals of this study were (1) to identify predictors of arrhythmias and mortality within the first year for patients presenting to the ED with syncope and (2) to develop and validate clinical prediction rules that can be used to separate ED patients into low- and high-risk groups.

METHODS

Syncope was defined as a sudden transient loss of consciousness associated with an inability to maintain postural tone that was not compatible with a seizure disorder, vertigo, dizziness (lightheadedness without loss of consciousness), coma, shock, or other states of altered consciousness. Patients must have regained consciousness spontaneously; those who required pharmacologic or electrical treatment at initial presentation were excluded.

Two cohorts of patients with syncope were evaluated and followed prospectively. One group (derivation cohort) was enrolled between March 1981 and February 1984; the second group (validation cohort) was enrolled between August 1987 and February 1991. The study methodology for the two cohorts was similar. Patients were accrued from an exhaustive search at the University of Pittsburgh Medical Center ED, a teaching, tertiary and primary care hospital-associated department that had an average annual census of 36,000 visits during the study periods. Patients presenting to the ED with symptoms possibly compatible with syncope were identified from daily review of ED visits and contacted. If these patients met the criteria for having had a syncopal episode, they were asked to participate in this study.

There were two differences between the protocols for patients in the two cohorts. First, in the validation cohort, end points in addition to mortality and arrhythmias were collected, including stroke and myocardial infarction. Second, patients in the validation cohort underwent additional diagnostic testing systematically for orthostatic hypotension and psychiatric disorders. A few patients in the validation cohort underwent tilt-table testing when it became available in late 1980s.

All patients enrolled in the study underwent a standardized assessment. Patients were interviewed and previous medical charts were reviewed. Assessment consisted of a complete history and physical examination; a baseline laboratory evaluation including a complete blood count, urinalysis, electrolytes, blood urea nitrogen, creatinine, and glucose; a 12-lead ECG; prolonged ECG monitoring of at least 24 hours' duration, by either ambulatory Holter monitoring or bedside monitoring in a CCU; and definitive evaluation of any clinical or historical findings suggestive of a cause of syncope. For example, cerebral angiography was required to establish a diagnosis of subclavian steal when clinical findings compatible with that entity were present. Other diagnostic studies, such as EEG, head computed tomography scans, and glucose tolerance tests were not routinely performed because previous studies have documented a low yield for these tests.[1-5] These studies were used selectively for consideration of specific diagnoses based on data from the initial history, physical examination, and ECG. Electrophysiologic studies were performed at the discretion of the patient's attending physician or on the recommendation of a consulting cardiologist. Upright tilt testing was not available for the derivation cohort and during the developmental phases in the validation cohort; therefore, few patients underwent tilt testing.

Patients were monitored by their personal physicians. Follow-up information regarding recurrence of syncope, new cardiovascular events, subsequent diagnoses of significant arrhythmias, and mortality were obtained from patients, their personal physicians, family, or caregivers. Follow-up information was obtained at 3-month intervals for 3 years. All attempts were made to obtain records of subsequent evaluations, hospital admissions, and other events.

A cause of death was assigned on the basis of information obtained from the family, patients' physicians, records from the Bureau of Vital Statistics, and autopsy reports if available. Death was classified as sudden or nonsudden by specific criteria.[6] Sudden death was defined as unexpected death occurring within 1 hour after onset of acute symptoms. Death was also classified as sudden if it occurred in a person known to be alive and functioning in his or her usual health within 24 hours of an unwitnessed death. This category included patients who were found dead or died during sleep. In addition, deaths were classified as sudden if unexpected

cardiac arrest occurred and resuscitation was successful but the cardiac arrest initiated a chain of events that led to death.

Causes of syncope were assigned based on strict adherence to previously reported diagnostic criteria.[4]

ECG reports and tracings (from ED ECG, Holter monitoring, or bedside ECG monitoring in the CCU) were reviewed for identification and verification of arrhythmias. Two definitions of clinically important arrhythmias were considered. It was not required that these arrhythmias were the cause of the syncope.

A broad definition, designed to be inclusive, included the following: ventricular tachycardia (VT) of three or more beats; sinus pauses of 2 seconds or longer and those pauses that were symptomatic; symptomatic sinus bradycardia ("symptomatic" for the purposes of this study refers to the simultaneous occurrence of dizziness, lightheadedness, or syncope and an arrhythmia on ECG monitoring); supraventricular tachycardia (SVT) with symptoms or associated with hypotension (systolic blood pressure less than 90 mm Hg); atrial fibrillation with slow ventricular response (RR interval longer than 3 seconds); complete atrioventricular block; Mobitz II atrioventricular block; and evidence of pacemaker malfunction. Isolated, asymptomatic premature ventricular contractions (PVCs), couplets, asymptomatic premature atrial contractions, brief asymptomatic runs of SVT, chronic atrial fibrillation, and atrial flutter were not included in our definition of arrhythmias unless they were associated with symptoms (dizziness, lightheadedness, or syncope).

In addition, findings at the time of electrophysiologic studies of prolonged corrected sinus node recovery time; inducible, sustained monomorphic VT; HV intervals longer than 100 msec; symptomatic SVT or SVT associated with hypotension; and carotid sinus hypersensitivity were also considered evidence for clinically important arrhythmias.

Table 1.
Demographic and clinical characteristics of derivation and validation cohorts.

Characteristic	Derivation Cohort (n=252)	Validation Cohort (n=374)
Age (years)		
Mean	57.3	56.1
Range	15–90	18–94
No. >45 (%)	183 (73)	262 (70)
No. female (%)	139 (55)	199 (53)
No. nonwhite (%)*	63 (25)	79 (21)
No. with prior syncope (%)		
Any previous episode	157 (62)	197† (55)
>1 Episode in preceding year	107 (42)	92‡ (26)
No. with comorbid conditions (%)		
High blood pressure	77 (31)	121 (32)
Diabetes mellitus	33 (13)	37 (10)
Ventricular arrhythmias	32 (13)	10 (3)
Coronary artery disease	71 (28)	72 (19)
Congestive heart failure	42 (17)	34 (9)
Cerebrovascular disease	34 (14)	37 (10)
ECG results (%)		
Normal	70 (28)	154 (41)
NST only	44 (18)	32 (9)
Abnormal§	138 (55)	188 (50)
Conduction disorders	68 (27)	104 (28)
Old myocardial infarction	40 (16)	36 (10)
Ventricular hypertrophy‖	29 (12)	30 (8)
Rhythm abnormalities	30 (12)	29 (8)
Other	25 (10)	22 (6)

NST, nonspecific ST- and T- wave abnormalities.
*Patients in the derivation cohort were either white or black; in the validation cohort there were four patients of Asian/Pacific Islander ancestry.
†Only 356 patients had data available for this variable.
‡Only 360 patients had data available for this variable.
§Some patients had more than one abnormality.
‖One patient in the derivation cohort and five patients in the validation cohort had right ventricular hypertrophy; the remainder had left ventricular hypertrophy.

Table 2.
Clinically important arrhythmias identified in study populations in the year after presentation.

Characteristic	No. in Derivation Cohort (%) [n=252]	No. in Validation Cohort (%) [n=374]
Any arrhythmia		
Broad definition*	65 (26)	49 (13)
Strict definition	43 (17)	29 (8)
Ventricular tachycardia		
Broad definition†	41 (16)	32 (9)
Strict definition‡	15 (6)	10 (3)
Sinus pause		
Broad definition (≥2.0 seconds)	13 (5)	9 (2)
Strict definition (≥3.0 seconds)	5 (2)	2 (.5)
Pacemaker malfunction	6 (2)	5 (1)
Sinus bradycardia with symptoms	6 (2)	4 (1)
Atrioventricular block§	6‖ (2)	7 (2)
Supraventricular tachycardia with symptoms	4 (2)	3 (1)
Atrial fibrillation with slow ventricular response	1¶ (.4)	1# (.3)

*Seven patients in the derivation cohort and 11 patients in the validation cohort had more than one arrhythmia.
†In the derivation cohort, diagnosis in one patient was made on the basis of electrophysiologic findings only and three by ECG findings only; in the validation cohort, diagnosis was made in two patients by electrophysiologic findings only and one by ECG findings only.
‡Strict definition: duration >100 beats or >30 sec, or with symptoms.
§Includes complete heart block, Mobitz II on ECG, and prolonged ECG monitoring.
‖Five patients had complete heart block on Holter, 1 had Mobitz II, seven had complete heart block on prolonged ECG monitoring.
¶Atrial fibrillation with pauses of 4.5 sec; also prolonged HV interval on electrophysiologic studies.
#Atrial fibrillation with pauses of 3 seconds.

The strict definition for clinically important arrhythmias included symptomatic or sustained VT (duration longer than 30 seconds or 100 beats), symptomatic SVT, symptomatic bradycardia, pauses of longer than 3.0 seconds, atrial fibrillation with slow ventricular response (RR interval longer than 3.0 seconds), complete atrioventricular block, Mobitz II atrioventricular block, and pacemaker malfunction. The electrophysiologic abnormalities defined previously were maintained.

Results are reported for all-cause mortality and, in a more focused analysis, for cardiac causes of mortality. Cardiac mortality included deaths resulting from atherosclerotic heart disease (eg, myocardial infarction, coronary artery disease); myocardial, pericardial, or valvular heart disease; congestive heart failure (CHF); congenital heart disease; restrictive cardiomyopathy; and cardiac arrhythmias. All sudden deaths were classified as cardiac deaths.

Potential predictor variables included demographic information (ie, age, sex, race), comorbid conditions, history of prior syncope, and ED ECGs. This information was obtainable from the patients or from medical records at the time of presentation for the index episode. The comorbid conditions considered were current or past history of high blood pressure, diabetes mellitus, cerebrovascular disease, coronary artery disease, CHF, or ventricular arrhythmias (VA). VA included past history of frequent (more than 10 per hour), repetitive (two or more consecutive), or multifocal PVCs.

ED ECGs were classified into three groups: normal (including patients with only sinus bradycardia or sinus tachycardia); nonspecific ST- and T-wave abnormalities (NST) for patients with NST as the only abnormality; and abnormal. The abnormal group included rhythm abnormalities (eg, atrial fibrillation or flutter, multifocal atrial tachycardia, junctional or paced rhythms); frequent or repetitive PVCs (including VT), conduction disorders (ie, left axis deviation, bundle branch block, intraventricular conduction delay), left or right ventricular hypertrophy (LVH or RVH), short PR interval (less than .10 sec), old myocardial infarction, and atrioventricular block (ie, complete atrioventricular block, Mobitz II, or Mobitz I with other abnormalities present).

Univariate predictors of clinically important arrhythmias were identified using χ^2 analysis for categorical data and Student's *t* test for continuous data. Univariate predictors of death within 1 year of study enrollment were identified with Kaplan-Meier methods and the Wilcoxon statistics. Those variables with probability values lower than .10 were entered in a multivariate logistic regression model to identify predictors of important arrhythmias and in a Cox proportional hazards model to identify multivariate predictors of 1-year mortality.

After multivariate models were identified for each study end point, a joint logistic regression model was developed by using the multivariate predictors of either arrhythmias or death in the first year. For this model, death in the first year was coded as "yes" or "no." Significant multivariate predictors were then identified as risks for arrhythmias or death.

Predictors identified by the final logistic regression model were used to define a risk index for either arrhythmias or mortality within 1 year based on the number of risk factors present. The usefulness of the risk index was measured by comparing the proportion of death or arrhythmias across the risk index in the derivation and validation cohorts. In addition, its usefulness for identifying patients with the more strictly defined arrhythmias or cardiac deaths was measured. Performance of the risk index in all analyses was also evaluated by comparison of areas under receiver operating

Table 3.
*Significant multivariate predictors of arrhythmias and death within 1 year.**

	Broad-Definition Arrhythmias		Mortality		Combined Arrhythmias or Mortality	
Predictor	**OR**	**95% CI**	**RR**	**95% CI**	**OR**	**95% CI**
Abnormal ECG	2.5	1.1–5.6	3.5	1.3–9.6	3.2	1.6–6.4
History of ventricular arrhythmia	5.4	2.1–14.2	1.0	.4–2.3	4.8	1.7–13.9
History of congestive heart failure	2.5	1.03–5.9	2.6	1.3–4.9	3.1	1.3–7.4
Age >45 years	2.8	1.00–7.8	3.3	.7–15.0	3.2	1.3–8.1
Nonwhite race	2.7	1.1–6.7	—	—	—	—
No prior history of syncope	—	—	2.0	1.03–3.8	—	—

*Logistic regression models result in OR estimates, and Cox proportional hazards models result in RR estimates. OR compares the odds of occurrence of an event when a risk factor is present with the odds of occurrence when the risk factor is not present. RR compares the proportion of those with a risk factor who have an event to the proportion of those without the risk factor who have the event. If the occurrence of the event is rare, the RR is estimated by the OR. The 95% CI of the OR or RR is shown in each instance.

characteristic (ROC) curves. BMDP Statistical Software[7] was used for logistic regression and survival analyses; ROCFIT software[8] was used for the ROC analysis.

RESULTS

In the derivation cohort, 253 patients with syncope presented to the ED. One patient did not have an ED ECG, leaving 252 patients in the derivation cohort. In the validation cohort, 378 patients were seen in the ED, and 4 did not have an ED ECG, leaving 374 patients in the validation cohort. No patients in the derivation cohort were lost to follow-up at 1 year; three patients (.8%) in the validation cohort were lost to follow-up in the first year.

As shown in Table 1, patients in the derivation cohort had greater cardiac comorbidity (ie, more coronary artery disease, CHF, and history of VA) and were less likely to have a normal ED ECG ($P<.01$ for all comparisons). A larger proportion of patients in the derivation cohort had had more than one episode of syncope within the last year. Results from ED ECGs indicated that the most frequent abnormalities in both cohorts were conduction disorders, old myocardial infarction, and LVH or RVH.

In the derivation cohort, there were 65 patients with arrhythmias (broad definition) and 39 deaths within the first year. Descriptions of the arrhythmias are presented in Table 2. Significant univariate predictors of arrhythmias were an abnormal ECG, male sex, age greater than 45 years, nonwhite race, history of CHF, history of myocardial infarction, and history of VA. As displayed in Table 3, multivariate predictors of arrhythmia were an abnormal ECG, history of VA, history of CHF, age greater than 45 years, and nonwhite race.

Univariate predictors of death in the first year were abnormal ECG, NST on ECG, LVH on ECG, age greater than 45 years, history of CHF, history of VA, and having no prior history of syncope. LVH on ECG was not included in the multivariate modeling because it was a type of abnormality on the ECG. As displayed in Table 3, the multivariate predictors of death were an abnormal ECG, history of CHF, age greater than 45 years, and having no prior history of syncope.

The combined multivariate model for arrhythmia or death showed four significant factors (Table 3). These included an abnormal ECG, age greater than 45 years, history of VA, and history of CHF. The odds ratios of these factors ranged from 3.1 to 4.8, but, for simplicity, they were treated as equivalent in the identification of risk groups. Four groups were identified, defined by the number of risk factors present (none, one, two, and three or four). The validation cohort had a smaller proportion of patients with three or four risk factors than the derivation cohort ($P=.007$).

In the derivation cohort, the incidence of arrhythmias (broad definition) identified in the first year ranged from 5.5% in patients with no risk factors to 63.0% in patients with three or four risk factors (Figure, A). In the validation cohort, the model identified similar proportions of patients with arrhythmias in each risk group, ranging from 3.3% in those patients with no risk factors to 45.5% in patients with three or four risk factors.

When the more strict definition of arrhythmia was employed, rates of arrhythmias decreased in all risk categories (Figure, B). However, in both the derivation and validation cohorts, the proportion of patients with arrhythmias increased as the number of risk factors increased. There were 1.8% and 0% in the lowest risk group and 43.5% to 18.2% in the highest risk group of the derivation and validation cohorts, respectively.

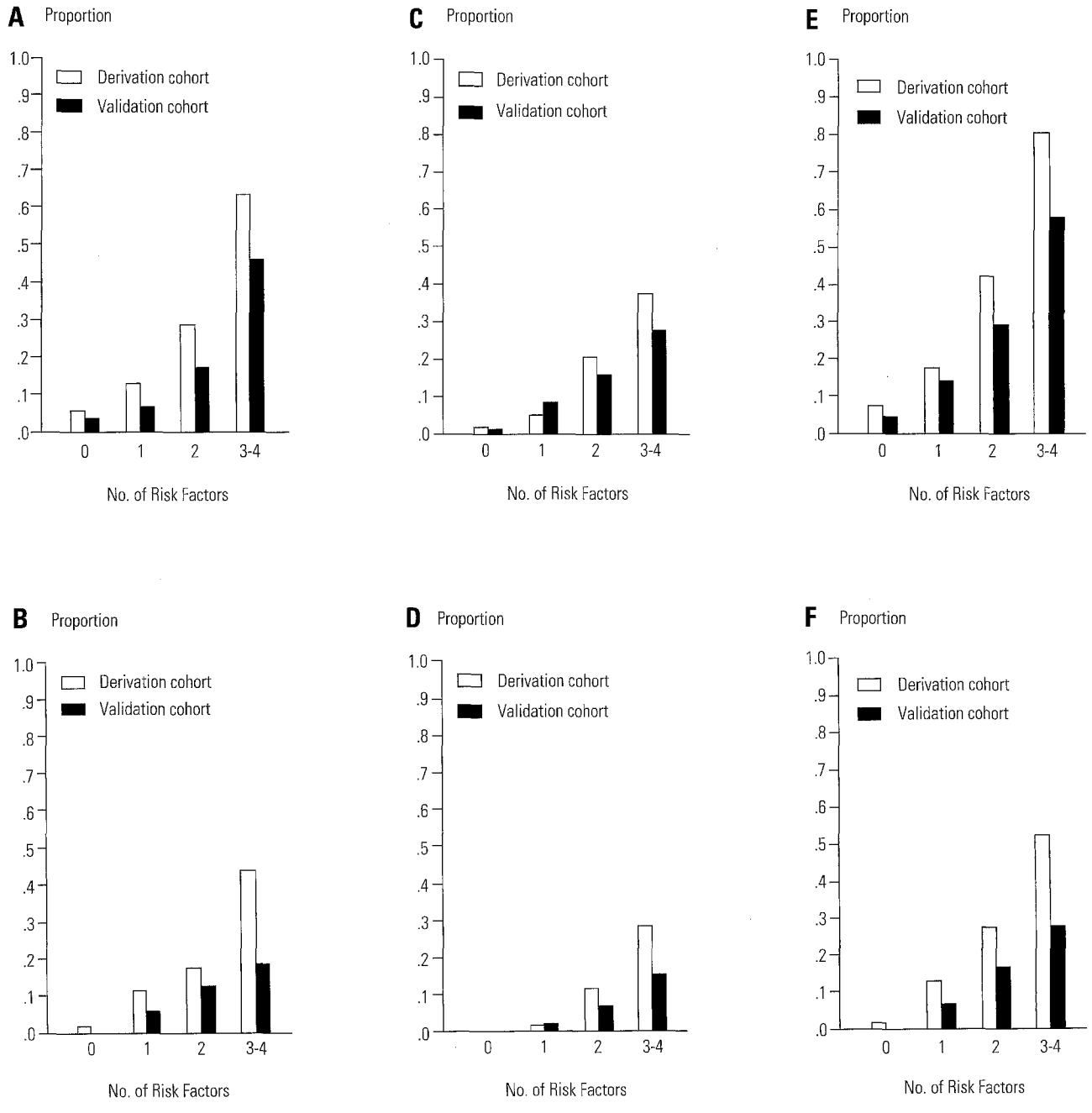
One-year mortality rates in the derivation cohort ranged from 1.8% in patients with no risk factors to 37.0% in patients with three or four risk factors (Figure, C). In the validation cohort, mortality ranged from 1.1% in the lowest risk category to 27.3% in patients with three or four risk factors. When only cardiac causes of mortality were considered (Figure, D), mortality rates decreased in all risk groups. Cardiac mortality rates ranged from 0% to 28.3% in the derivation cohort and from 0% to 15.1% in the validation cohort.

Figure part E displays the number of arrhythmias (broad definition) and deaths in the first year in the derivation and validation cohorts. In the derivation cohort, these ranged from 7.3% in patients with no risk factors to 80.4% in patients with three or four risk factors. In the validation cohort, they ranged from 4.4% in the lowest risk category to 57.6% in patients with three or four risk factors. When only strict-definition arrhythmias or cardiac causes of mortality were considered (Figure, F), the rates ranged from 1.8%

Table 4.
Distribution of patients across risk strata.

No. of Risk Factors	No. From Derivation Cohort (%) [n=252]	No. From Validation Cohort (%) [n=374]
0	55 (22)	91 (24)
1	63 (25)	108 (29)
2	88 (35)	142 (38)
3 or 4	46 (18)	33 (9)

Figure.
Performance of the syncope risk classification system. Graphs show the proportion of patients at each number of risk factors who **A,** *had broadly defined cardiac arrhythmias;* **B,** *strictly defined cardiac arrhythmias;* **C,** *died within a year of the enrolling episode;* **D,** *died of a cardiac cause in the year after the enrolling episode;* **E,** *had broadly defined arrhythmias or died within the first year; and* **F,** *had strictly defined arrhythmias or died of a cardiac cause in the first year.*



to 52.2% in the derivation cohort and from 0% to 27.3% in the validation cohort.

Areas under the ROC curves range from .77 to .83 for the derivation cohort and from .73 to .80 for the validation cohort. All 12 ROC curves had areas significantly greater than .5. There were no significant differences in areas under the ROC curves in any comparison between derivation and validation cohorts; probability values ranged from .2 to .8.

DISCUSSION

This study showed that information available at the time of presentation to the ED can be used to stratify the risk of arrhythmias and death within 1 year in patients with syncope. We found four factors useful for risk stratification: age greater than 45 years, history of VA, history of CHF, and abnormal ECG. Our model performed well whether a broadly inclusive definition of arrhythmias or a strict definition was used. Furthermore, when only cardiac death was considered, the mortality rates in the lower-risk strata approached zero.

Our results apply to patients presenting with syncope to an ED. The proportions of patients with cardiac syncope (31% in the derivation cohort and 17% in the validation cohort) in this study were similar to or higher than those reported in unselected populations in other studies (approximately 16%).[1-3] Studies of syncope patients referred to electrophysiology practices report a higher proportion of patients with cardiac syncope (arrhythmias)[9-16]; our results may not be entirely applicable to these selected populations.

Syncope is often difficult to evaluate in the ED. Patients are usually free of symptoms when they are seen after an episode, and the clinical assessment and initial ECG may be unremarkable. If a cause of syncope can be determined on the basis of initial clinical assessment (eg, symptomatic orthostatic hypotension), management decisions are relatively straightforward. However, in approximately 60% of patients a cause is not apparent on initial history, physical examination, and ECG.[4] Under these circumstances, the focus of evaluation is directed toward finding serious and life-threatening arrhythmias that may be inapparent on initial clinical assessment. The concerns for arrhythmias and sudden death frequently lead to hospital admission and performance of many diagnostic tests.

There are no published studies of stratification of risk of arrhythmias and death in patients with syncope using clinical and ECG data available at the time of initial presentation. Studies of risk stratification are important in devising more cost-effective management strategies for subgroups of patients. Previous prognostic studies of syncope have identified high-risk causes, mainly cardiac causes[1-5], as being associated with high risk of mortality and sudden death. Although these studies have been important for determining prognosis, they are not applicable to patients presenting to the ED, because assignment of a cause of syncope often requires extensive diagnostic testing that cannot be performed in the ED.

The factors used in risk stratification in this study are consistent with those reported in previous clinical and epidemiologic studies of risk of arrhythmias and mortality in patients with syncope. A recent study showed that syncope in patients with left ventricular dysfunction was associated with a particularly poor prognosis.[17] In addition, studies of the natural history of CHF showed 5-year survival rates of 25% in men and 38% in women[18], clearly identifying this condition as a determinant of poor outcome. The history of CHF undoubtedly represented left ventricular dysfunction in most of our patients. Previous studies have correlated both a risk of sudden death and inducibility of sustained monomorphic VT at the time of electrophysiologic studies with left ventricular dysfunction in patients presenting with syncope.[9-17]

Our finding that a history of VA identified patients at risk for arrhythmias and death is consistent with results of studies documenting higher rates of sudden death and all-cause mortality in syncope patients with VT.[11,12,14,19] It is also clinically plausible that a history of VA in a patient with syncope implies a high likelihood that VT was the cause of patient's symptoms.

Other studies have shown that negative predictors of abnormal electrophysiologic studies are the absence of structural heart disease and normal ECG.[15,16] These findings are consistent with our results, which showed CHF and abnormal ECG to be predictors of arrhythmias. An abnormal resting ECG may serve as a marker for underlying structural heart disease, explaining its correlation with mortality and arrhythmias.

Finally, although no previous study has identified age alone as an independent risk factor for adverse outcome after a syncopal episode, data from the Framingham Heart Study documented increasing rates of sudden death in males as age increased, after controlling for cardiac risk factors.[18] Further, age may serve as a marker for the presence of comorbid disease processes that may affect the likelihood of arrhythmias and mortality.

We acknowledge several limitations of this study. First, the derivation and validation phases of the study were performed at a single institution which serves as a tertiary referral center for a large patient population. The generalizability of our findings needs to be tested in other clinical

settings. Second, electrophysiologic testing was not performed in a large fraction of patients. Although we might have diagnosed more arrhythmias by wider use of electrophysiologic testing, our findings that structural heart disease, particularly CHF, and abnormal ECG are predictors of arrhythmias probably would not have changed, because previous studies have shown these to be predictors of abnormal electrophysiologic results.[15,16] Similarly, wider use of tilt testing would not have altered the results of our study, because patients with positive tilt-test results are at low risk for arrhythmias and death.[12,20-22]

REFERENCES

1. Day SC, Cook EF, Funkenstein H, et al: Evaluation and outcome of emergency room patients with transient loss of consciousness. *Am J Med* 1982;73:15-23.

2. Silverstein MD, Singer DE, Mulley A, et al: Patients with syncope admitted to medical intensive care units. *JAMA* 1982;248:1185-1189.

3. Martin GJ, Adams SL, Martin HG, et al: Prospective evaluation of syncope. *Ann Emerg Med* 1984;13:499-504.

4. Kapoor WN, Karpf M, Wieand S, et al: A prospective evaluation and follow-up of patients with syncope. *N Engl J Med* 1983;309:197-204.

5. Kapoor W: Evaluation and outcome of patients with syncope. *Medicine (Baltimore)* 1990;69:160-175.

6. Cupples LA, Gagnon DR, Kannel WB: Long- and short-term risk of sudden coronary death. *Circulation* 1992;85 (suppl):I11-I18.

7. Dickson WJ (ed): *BMDP Statistical Software Manual.* Berkeley: University of California Press, 1990.

8. Metz CE, Shen JH, Wang PL, et al: *ROCFIT.* Chicago: University of Chicago, 1988.

9. Bachinsky WB, Linzer M, Weld L, et al: Usefulness of clinical characteristics in predicting the outcome of electrophysiologic studies in unexplained syncope. *Am J Cardiol* 1992;69:1044-1049.

10. Teichman SL, Felder SD, Matos JA, et al: The value of electrophysiologic studies in syncope of undetermined origin: Report of 150 cases. *Am Heart J* 1988;110:469-479.

11. Doherty JU, Pembrook-Rogers D, Grogan EW, et al: Electrophysiologic evaluation and follow-up characteristics of patients with recurrent unexplained syncope and presyncope. *Am J Cardiol* 1985;55:703-708.

12. Sra JS, Anderson AJ, Sheikh SH, et al: Unexplained syncope evaluated by electrophysiologic studies and head-up tilt testing. *Ann Intern Med* 1991;114:1013-1019.

13. Moazez F, Peter T, Simonson J, et al: Syncope of unknown origin: Clinical noninvasive and electrophysiologic determinants of arrhythmia induction and symptom recurrence during long-term follow-up. *Am Heart J* 1991;121:81-88.

14. Bass EB, Elson JJ, Fogoros RN, et al: Long-term prognosis of patients undergoing electrophysiologic studies for syncope of unknown origin. *Am J Cardiol* 1988;62:1186-1191.

15. Krol RB, Morady F, Flaker GC, et al: Electrophysiologic testing in patients with unexplained syncope: Clinical and noninvasive predictors of outcome. *J Am Coll Cardiol* 1987;10:358- 363.

16. Denes P, Vretz E, Ezr MD, et L: Clinical predictors of electrophysiologic findings in patients with syncope of unknown origin. *Arch Intern Med* 1988;148:1922-1928.

17. Middlekauff HR, Stevenson WG, Stevenson LW, et al: Syncope in advanced heart failure: High risk of sudden death regardless of origin of syncope. *J Am Coll Cardiol* 1993;21:110-116.

18. Ho KK, Anderson KM, Kannel WB, et al: Survival after the onset of congestive heart failure in Framingham Heart Study subjects. *Circulation* 1993;88:107-115.

19. Kapoor WN, Cha R, Peterson J, et al: Prolonged electrocardiographic monitoring in patients with syncope: Importance of frequent or repetitive ventricular ectopy. *Am J Med* 1987;82:20-28.

20. Almquist A, Goldenberg IF, Milstein S, et al: Provocation of bradycardia and hypotension by isoproterenol and upright posture in patients with unexplained syncope. *N Engl J Med* 1989;320:346- 351.

21. Grubb BP, Temesy-Armos P, Hahn H, et al: Utility of upright tilt-table testing in the evaluation and management of syncope of unknown origin. *Am J Med* 1991;90:6-10.

22. Kapoor WN, Smith M, Miller NL: Upright tilt testing in evaluating syncope: A comprehensive literature review. *Am J Med* 1994;97:78-88.

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