Factors Associated With Pulseless Electric Activity Versus Ventricular Fibrillation

The Oregon Sudden Unexpected Death Study

Carmen Teodorescu, MD, PhD; Kyndaron Reinier, PhD; Celia Dervan, MD; Audrey Uy-Evanado, MD; Mershed Samara, MD; Ronald Mariani, EMT-P; Karen Gunson, MD; Jonathan Jui, MD, MPH; Sumeet S. Chugh, MD

Background—Corresponding with a continuing decline in the prevalence of sudden cardiac arrest cases presenting with ventricular fibrillation (VF), there has been a significant rise in the prevalence of pulseless electrical activity (PEA). Given significantly lower survival from PEA versus VF, we comprehensively investigated PEA correlates by incorporating first-responder data with lifetime clinical history information.

Methods and Results—In the Portland, Ore, metropolitan area (population ~1 million), cases of out-of-hospital sudden cardiac arrest who underwent attempted resuscitation were identified prospectively (2002–2007). Those presenting with PEA versus VF and asystole were compared with \( \chi^2 \) tests, ANOVA, and logistic regression. A total of 1277 cases aged \( \geq 18 \) years underwent resuscitation by first responders (mean age, 65±16 years; 67% male). Presenting arrhythmia was VF in 48%, PEA in 25%, and asystole/other in the remainder. Compared with VF cases, PEA cases were older (mean age, 68 versus 63 years; \( P=0.0002 \)), more likely to be female (37% versus 26%; \( P=0.0008 \)), and less likely to survive to hospital discharge (6% versus 25%; \( P<0.0001 \)). A history of syncope was strongly associated with PEA (odds ratio, 2.6; confidence interval, 1.3 to 5.3) after adjustment for age, gender, response time, and arrest circumstances. Black race was also independently associated with PEA (odds ratio, 2.6; confidence interval, 1.3 to 5.4). Pulmonary disease and female gender were significant factors associated with PEA (\( P \) for interaction=0.04). In a subgroup analysis of resting ECGs (n=391), there were no differences in cardiac clinical history or prevalence of cardiac conduction system disease (PEA, 31.6% versus VF, 32.2%; \( P=0.48 \)).

Conclusions—PEA cases had a significantly higher prevalence of syncope in their lifetime, with other correlates, including black race, that were distinct from VF cases. Potential mechanistic links between syncope and future manifestation with PEA warrant further exploration. (Circulation. 2010;122:2116-2122.)

Key Words: death, sudden ♦ population ♦ resuscitation ♦ syncope

There has been a progressive increase in the proportion of sudden cardiac arrest (SCA) cases presenting with pulseless electrical activity (PEA), due in large part, to a decrease in the prevalence of ventricular fibrillation (VF). Among residents of Seattle, Wash, aged \( \geq 20 \) years, there was a 56% decrease in VF from 1980 to 2000.\(^1\) In Goteborg, Sweden, the proportion of VF cases decreased from 39% in 1981 to 32% in 1997, whereas PEA cases increased from 6% to 26% in the same time period.\(^2\) Similarly, in Helsinki, Finland, the prevalence of VF decreased by 48% from 1994 to 1999.\(^3\) Another consistent finding is that success rates of resuscitation from SCA are a function of the presenting arrhythmia. There is a stark contrast between success rates for PEA (\( \leq 6\% \))\(^4\) compared with VF/VT (as high as 40%).\(^5\) Therefore, the rising prevalence of PEA has significant public health implications.

Clinical Perspective on p 2122

What are the causes of these altered trends? If VF were more likely to manifest among patients with coronary artery disease (CAD), the significant drop in mortality from CAD might explain the decline in VF cases. Published studies suggest that the rise in PEA prevalence, on the other hand, could be related to a variety of tissue hypoxic/anoxic insults.\(^6\) However, there is a need for comprehensive studies that extend beyond first-responder analysis and evaluate detailed lifetime clinical history and characteristics of patients. An improved understanding of factors associated with PEA could enhance the current understanding of mechanisms. We hypothesized that both the type as well as number of associated disease conditions (the “disease burden”) may also influence
presenting arrhythmia. We evaluated correlates of PEA compared with VF/VT in a large, ongoing, community-based study of SCA in the Portland, Ore, metropolitan region.

Methods

Study Population

The Oregon Sudden Unexpected Death Study (Oregon-SUDS) is an ongoing prospective study of out-of-hospital SCA in the Portland, Ore, metropolitan region (population ~1 million). Detailed methods have been published earlier. Briefly, emergency medical services (EMS) for the metropolitan area are provided by a 2-tier, advanced life support first-response system. Cases were identified through EMS, the Medical Examiner’s office, or 16 local hospitals, and all available medical records were obtained for each subject. Subjects with resuscitation attempted who were enrolled from February 1, 2002, to January 31, 2007, and were at least 18 years of age were included in this analysis. Cases with noncardiac cause of SCA, trauma, terminal illness (such as malignancy not in remission), or drug overdose were excluded. A detailed comparison of patient demographics, arrest circumstances, and lifetime clinical history was performed between those presenting with VF/VT, PEA, and asystole. This study was approved by the institutional review boards of Cedars-Sinai Medical Center, Oregon Health and Science University, and all participating hospitals and health systems.

Definitions

SCA was defined as a sudden unexpected pulseless condition of likely cardiac cause. If unwitnessed, the subject should have last been seen alive within 24 hours. The presenting arrhythmia was defined as the initial recorded rhythm and was identified from review of the actual presenting ECG rhythm strip in 64% of the study population presenting with VF/VT or PEA. When the rhythm strip was not available, the presenting arrhythmia was identified from the EMS report. VF was defined as a pulseless condition with characteristic features on the cardiac recording performed by EMS. PEA was defined as the absence of a palpable pulse with the appearance of an organized electric rhythm on cardiac monitoring. Asystole was defined as the absence of electric activity on cardiac monitoring. Response time was calculated as the time from dispatch of emergency medical personnel to their arrival on the scene in contact with the patient and was treated as a continuous variable as well as categorized according to the Utstein criteria as >4 minutes versus ≤4 minutes. Return of spontaneous circulation was defined as return of a palpable pulse in conjunction with a systolic blood pressure of ≥60 mm Hg.

Established CAD was defined as history of myocardial infarction, coronary revascularization, or at least 50% stenosis on coronary angiography. Hyperlipidemia was identified by documentation in the clinical history or by use of a lipid-lowering drug. Diabetes mellitus was defined as a clinical history of diabetes mellitus or use of insulin or oral hypoglycemic agent; liver disease as clinical history of cirrhosis or end-stage liver disease; chronic kidney disease as clinical history of chronic renal insufficiency or dialysis; and pulmonary disease as clinical history of asthma or chronic obstructive lung disease or use of medical therapy for these disorders (such as inhaled bronchodilators) or use of home oxygen. Hypertension, congestive heart failure, cerebral vascular accident, peripheral vascular disease, syncope, seizure, and sleep apnea were also identified from the lifetime clinical history.

The “disease burden” was calculated as a simple sum of all preexisting clinical conditions listed above. The prevalence of conduction system disease was determined from an available resting 12-lead ECG obtained previously that was closest to and unrelated to the cardiac arrest (median of 14 months before the cardiac event). Conduction system findings from the ECG were classified as follows: no conduction system abnormality; low-grade conduction abnormality (first-degree atrioventricular block; type I, second-degree atrioventricular block; left anterior or posterior fascicular block; and incomplete bundle-branch block); and high-grade conduction abnormality (left or right bundle-branch block; intraventricular conduction delay; bifascicular block; type II, second-degree or third-degree atrioventricular block).

Statistical Analysis

For all individuals with attempted resuscitation, differences in demographics, arrest circumstances, and resuscitation outcomes by presenting arrhythmia were examined with the use of ANOVA with Tukey-Kramer post hoc tests for continuous variables and Pearson χ² tests for categorical variables. Continuous variables were expressed as mean±SD. In the subset of individuals with detailed medical records available before arrest, the clinical history of individuals presenting with PEA versus VF/VT and asystole was compared by Pearson χ² test or Fisher exact test, when appropriate, and the Wilcoxon rank sum test for the disease burden. Clinical characteristics were also evaluated by adjusting for age with the Cochran-Mantel-Haenszel test. Significant variables from univariate analysis were entered in a full multiple logistic regression model to identify significant factors associated with PEA versus VF/VT and PEA versus asystole. Variables that reached a P value of ≤0.1 were retained in the 2 final logistic regression models. To adjust for arrest circumstances, witnessed status, arrest location, and response time were retained in the final model regardless of their significance level. Likelihood ratio tests (LRT) were used to compare each full model to each final model to verify that the variables excluded from the final models did not significantly affect model fit. Two-way interactions were evaluated between age and gender and between both age and gender and significant clinical factors such as CAD, hyperlipidemia, syncope, and pulmonary disease. Interaction terms found to be significant with the use of LRT were retained in the final model. Because of the age differences between patients presenting with PEA versus VF/VT, a logistic regression model restricted to patients aged <75 years was also run to evaluate the consistency of multivariable results. Because of the limitations of estimating the pre-911 times and because of differences in the witnessed status and arrest location by presenting arrhythmia, a subgroup analysis was also performed among witnessed cases. For all analyses, P<0.05 was considered statistically significant. All statistical analyses were performed with the use of SAS 9.1 (SAS Institute Inc, Cary, NC).

Results

Demographics, Characteristics, and Outcome of Overall Group

Between February 1, 2002, and January 31, 2007, we identified 1277 cases of SCA aged ≥18 years among residents of the Portland, Ore, metropolitan area, in whom resuscitation was attempted. Mean age was 64.9±15.6 years, and 67% were male.

Return of spontaneous circulation was observed in 36%, and 161 cases (13%) survived to hospital discharge. Sixty-one percent of cases in whom resuscitation was attempted were witnessed by laypersons, 6% were witnessed by first responders, and 33% were not witnessed. The mean response time was 6.8±3.2 minutes, and 73% of cases had a response time >4 minutes. The presenting arrhythmia was PEA in 24.9% of cases, VF/VT in 47.8%, asystole in 25.5%, bradyarrhythmia in 1.3%, and other rhythms (including paced rhythms and third-degree heart block) in 0.5%. Initial arrhythmia was missing for 68 patients. There was no significant difference in mean response time based on presenting arrhythmia (P=0.74; means in each group ranged from 6.4 to 7.0 minutes).

Detailed Comparisons of PEA Versus VF/VT and Asystole Cases

Demographic and Resuscitation Parameters

SCA cases with PEA as presenting arrhythmia were older than VF/VT cases by ~5 years (P=0.0002) and more likely...
to be female (37% versus 26%, respectively; \( P < 0.0001 \)) (Table 1). VF/VT cases were more likely to be white, black cases were more likely to present with PEA, and Asian cases were more likely to present with asystole (\( P = 0.01 \)). There were no significant differences in marital status or education level when analyzed by presenting arrhythmia. Subjects with VF/VT cardiac arrests were more likely to be witnessed, to arrest in public locations, to experience return of spontaneous circulation, and to survive to hospital discharge (\( P < 0.0001 \)). There was no significant difference in the mean response time (\( P = 0.41 \)), in the proportion of response times >4 minutes (\( P = 0.35 \)), or when response time was categorized in 4-minute intervals (\( P = 0.83 \)). In addition, there were no gender differences in the response time overall (\( P = 0.72 \)) or by presenting arrhythmia (\( P = 0.16 \)).

**Comparison of Preexisting Clinical Conditions**

Cases that presented with VF/VT had a higher prevalence of documented CAD (\( P < 0.0001 \)) and hyperlipidemia (\( P = 0.0007 \)), whereas syncope (\( P = 0.004 \)) was more common in PEA cases (Table 2). Pulmonary disease (\( P = 0.0003 \)) was more frequent in cases with PEA and asystole as presenting arrhythmias compared with VF/VT.

No significant differences by presenting arrhythmia were observed with regard to history of hypertension, congestive heart failure, cerebral vascular accident, sleep apnea, diabetes mellitus, liver disease, and chronic renal insufficiency.

**Table 1. Demographics and Outcome by Presenting Arrhythmia at Time of Cardiac Arrest, Oregon-SUDS 2002–2007 (n=1187)**

|                      | PEA (n=301) | VF/VT (n=578) | Asystole (n=308) | \( P^* \)  \\
|----------------------|-------------|--------------|-----------------|---------  \\
| Age, mean±SD, y      | 67.8±15.1   | 63.3±14.8    | 65.7±16.4       | 0.0002  \\
| Male, n (%)          | 189 (62.8)  | 426 (73.7)   | 178 (57.8)      | <0.0001  \\
| Female, n (%)        | 112 (37.2)  | 152 (26.3)   | 130 (42.2)      |         \\
| Race/ethnicity, n (%)|             |              |                 | 0.01    \\
| White                | 249 (84.1)  | 475 (88.6)   | 251 (84.0)      |         \\
| Black                | 33 (11.1)   | 29 (5.4)     | 22 (7.4)        |         \\
| Hispanic             | 5 (1.7)     | 12 (2.2)     | 7 (2.3)         |         \\
| Asian                | 4 (1.4)     | 13 (2.4)     | 16 (5.3)        |         \\
| Other†               | 5 (1.7)     | 7 (1.3)      | 3 (1.0)         |         \\
| Missing‡             | 5           | 42           | 9               |         \\
| Marital status, n (%)|             |              |                 | 0.07    \\
| Married              | 128 (47.4)  | 234 (46.0)   | 153 (55.0)      |         \\
| Never married/widowed/divorced | 142 (52.6) | 184 (54.0)   | 125 (45.0)      |         \\
| Missing‡             | 31          | 160          | 30              |         \\
| Education status, mean±SD, y (n) | 12.9±3.0 (268) | 12.7±2.5 (417) | 12.7±2.4 (279) | 0.52    \\
| Return of spontaneous circulation, n (%) | 94 (31.2) | 282 (48.8) | 54 (17.5) | <0.0001  \\
| Survival to hospital discharge, n (%) | 17 (5.7) | 133 (24.9) | 1 (0.3) | <0.0001  \\
| Missing‡             | 5           | 44           | 5               |         \\
| Witnessed status, n (%)|             |              |                 | <0.0001 \\
| Witnessed            | 179 (59.7)  | 414 (72.2)   | 128 (41.5)      |         \\
| Witnessed by EMS     | 30 (10.0)   | 33 (5.8)     | 7 (2.3)         |         \\
| Not witnessed        | 91 (30.3)   | 126 (22.0)   | 173 (56.2)      |         \\
| Missing‡             | 1           | 5            | 0               | <0.0001  \\
| Arrest location, n (%)|             |              |                 |         \\
| Home                 | 174 (67.2)  | 249 (56.5)   | 192 (74.7)      |         \\
| Public building/outside | 36 (13.9)  | 126 (28.6)   | 25 (9.7)        |         \\
| Care facility/ambulance/outpatient clinic | 41 (15.8) | 40 (9.1) | 37 (14.4) |         \\
| Vehicle/other        | 8 (3.1)     | 26 (5.9)     | 3 (1.2)         |         \\
| Missing‡             | 42          | 137          | 51              |         \\
| Response time, mean±SD, min (n) | 6.9±3.2 (287) | 6.6±3.2 (517) | 6.9±3.1 (281) | 0.41    \\
| Response time >4 min, n (%) | 212 (73.9) | 363 (70.2) | 209 (74.4) | 0.35    \\

\( *P \) value from Pearson \( \chi^2 \) test for categorical variables and ANOVA with Tukey-Kramer post hoc test for continuous variables.

†Other race category includes American Indian, Alaska Native, Native Hawaiian, and Pacific Islander.

‡For variables with missing values, proportions and \( P \) values are calculated with the nonmissing data used as the denominator.
There was no difference in the disease burden among arrhythmia groups (P=0.38). Adjustment for age produced similar results (Table 2). In addition, there was no significant difference in the prevalence of cardiac conduction system disease on the resting ECG between PEA, VF/VT, and asystole cases (P=0.48) (Table 3).

### Table 2. Comparison of Preexisting Clinical Conditions by Presenting Arrhythmia at Time of Cardiac Arrest, Oregon-SUDS 2002–2007 (n=829)

<table>
<thead>
<tr>
<th>Categories</th>
<th>PEA (n=218)</th>
<th>VF/VT (n=401)</th>
<th>Asystole (n=210)</th>
<th>P*</th>
<th>Age-Adjusted P†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documented CAD</td>
<td>72 (33.0)</td>
<td>216 (53.9)</td>
<td>75 (35.7)</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>59 (27.1)</td>
<td>170 (42.4)</td>
<td>75 (35.7)</td>
<td>0.0007</td>
<td>0.0001</td>
</tr>
<tr>
<td>Syncope</td>
<td>26 (11.9)</td>
<td>19 (4.7)</td>
<td>15 (7.1)</td>
<td>0.004</td>
<td>0.006</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>76 (34.9)</td>
<td>89 (22.2)</td>
<td>73 (34.8)</td>
<td>0.0003</td>
<td>0.0007</td>
</tr>
<tr>
<td>Seizure</td>
<td>17 (7.8)</td>
<td>16 (4.0)</td>
<td>14 (6.7)</td>
<td>0.11</td>
<td>0.03</td>
</tr>
<tr>
<td>Hypertension</td>
<td>125 (57.3)</td>
<td>227 (56.6)</td>
<td>115 (54.8)</td>
<td>0.86</td>
<td>0.85</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>54 (24.8)</td>
<td>109 (27.2)</td>
<td>62 (29.5)</td>
<td>0.54</td>
<td>0.20</td>
</tr>
<tr>
<td>Cerebral vascular accident</td>
<td>34 (15.6)</td>
<td>46 (11.5)</td>
<td>23 (11.0)</td>
<td>0.25</td>
<td>0.58</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>24 (11.0)</td>
<td>64 (16.0)</td>
<td>20 (9.5)</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Sleep apnea</td>
<td>15 (6.9)</td>
<td>30 (7.5)</td>
<td>13 (6.2)</td>
<td>0.84</td>
<td>0.81</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>72 (33.0)</td>
<td>142 (35.4)</td>
<td>77 (36.7)</td>
<td>0.72</td>
<td>0.49</td>
</tr>
<tr>
<td>Liver disease</td>
<td>3 (1.4)</td>
<td>2 (0.5)</td>
<td>5 (2.4)</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Chronic renal disease</td>
<td>36 (16.5)</td>
<td>62 (15.5)</td>
<td>32 (15.2)</td>
<td>0.92</td>
<td>0.99</td>
</tr>
<tr>
<td>Disease burden‡</td>
<td>2.0 (1.0–4.0)</td>
<td>3.0 (1.0–4.0)</td>
<td>3.0 (1.0–4.0)</td>
<td>0.38</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Values are number (%) unless indicated otherwise. *P value from Pearson χ² test or Fisher exact test. †Median (interquartile range) of number of comorbidities; P value from Wilcoxon rank sum test and age-adjusted logistic regression analysis.

### Table 3. Prevalence of Cardiac Conduction System Disease on 12-Lead ECG by Presenting Arrhythmia, Oregon-SUDS 2002–2007 (n=391)

<table>
<thead>
<tr>
<th>Type of Conduction Abnormality</th>
<th>PEA (n=114)</th>
<th>VF/VT (n=171)</th>
<th>Asystole (n=106)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No conduction system abnormality</td>
<td>78 (68.4)</td>
<td>116 (67.8)</td>
<td>69 (65.1)</td>
<td>0.48</td>
</tr>
<tr>
<td>Low-grade conduction abnormality</td>
<td>14 (12.3)</td>
<td>20 (11.7)</td>
<td>20 (18.9)</td>
<td>0.001</td>
</tr>
<tr>
<td>First-degree AV block</td>
<td>5 (4.4)</td>
<td>7 (4.1)</td>
<td>9 (8.5)</td>
<td>0.57</td>
</tr>
<tr>
<td>LAFB</td>
<td>8 (7.0)</td>
<td>7 (4.1)</td>
<td>6 (5.7)</td>
<td>0.29</td>
</tr>
<tr>
<td>LPFB</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>3 (2.8)</td>
<td>0.28</td>
</tr>
<tr>
<td>IRBBB/LBBB</td>
<td>1 (0.9)</td>
<td>6 (3.5)</td>
<td>2 (1.9)</td>
<td>0.29</td>
</tr>
<tr>
<td>High-grade conduction abnormality</td>
<td>22 (19.3)</td>
<td>35 (20.5)</td>
<td>17 (16.0)</td>
<td>0.001</td>
</tr>
<tr>
<td>LBBB</td>
<td>3 (2.6)</td>
<td>8 (4.7)</td>
<td>1 (0.9)</td>
<td>0.09</td>
</tr>
<tr>
<td>RBBB</td>
<td>7 (6.1)</td>
<td>3 (1.7)</td>
<td>1 (0.9)</td>
<td>0.09</td>
</tr>
<tr>
<td>IVCD</td>
<td>8 (7.0)</td>
<td>22 (12.9)</td>
<td>12 (11.3)</td>
<td>0.28</td>
</tr>
<tr>
<td>Bifascicular block</td>
<td>4 (3.5)</td>
<td>2 (1.2)</td>
<td>3 (2.8)</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Values are number (%). AV indicates atrioventricular; LAFB, left anterior fascicular block; LPFB, left posterior fascicular block; IRBBB/LBBB, incomplete right/left bundle-branch block; RBBB, left bundle-branch block; RBBB, right bundle-branch block; and IVCD, intraventricular conduction delay. *P value from Pearson χ² test.

### Comparison of Cardiac History in Syncope Patients
Among the subset of patients with history of syncope (n=60), those who presented with PEA (n=26; 73±14 years) were older than patients with VF/VT (n=19; 61±16 years) and asystole (n=15; 65±17 years; P=0.001). No significant differences were identified in gender distribution or clinical history of cardiomyopathy, atrial fibrillation, aortic stenosis, and congestive heart failure (P≥0.11). Two patients with PEA and 1 with asystole had a history of permanent pacemaker implantation, and 3 VF/VT patients had an implantable cardioverter-defibrillator. One patient with PEA had a history of atrioventricular block, 1 had a history of paroxysmal supraventricular tachycardia, and 1 had a history of torsades de pointes. On the other hand, 3 patients with VF/VT had a history of VT, and 1 patient had a diagnosis of long-QT syndrome. One patient with asystole had a history of paroxysmal supraventricular tachycardia, 1 of VT, and 1 of atrioventricular block. Ten patients (6 PEA and 4 VF/VT) had no history of cardiac disease before cardiac arrest. All patients who presented with asystole had a history of cardiac disease. Vasovagal syncope was reported in 1 patient who presented with PEA, and the cause of syncope was unknown for the remainder of cases.

### Multivariable Analyses of PEA Versus VF/VT
Table 4 shows multivariable odds ratio (OR) estimates of correlates of PEA versus VF/VT from a logistic regression model. The full initial model included all variables in the final model, plus history of seizure, peripheral vascular disease, and disease burden. The final model for factors associated with PEA versus VF/VT included age, gender, race, witnessed status, arrest location, response time, CAD, hyperlipidemia, syncope, and pulmonary disease (LRT, full versus...
final model, \( P=0.76 \). Cases with CAD and hyperlipidemia were significantly less likely to present with PEA. Age (OR, 1.02 [1.01 to 1.04]), black race (OR, 2.64 [1.29 to 5.38]), and syncope (OR, 2.64 [1.31 to 5.32]) were significant factors associated with PEA. Significant 2-way interaction effects associated with PEA were found between gender and pulmonary disease (LRT, model with interaction versus model without, \( P=0.04 \)). Female gender was strongly associated with PEA (Table 4). Men with pulmonary disease were 3 times more likely than men without pulmonary disease to have PEA versus VF/VT as the presenting arrhythmia (OR, 3.17 [1.86 to 5.42]). Similar results were found in a model restricted to witnessed cases (data not shown).

### Multivariable Analyses of PEA Versus Asystole

Table 5 shows multivariable OR estimates of factors associated with PEA versus asystole. The full initial model was identical to the PEA versus VF/VT model. The final model for PEA versus asystole included the following: age, race, witnessed status, arrest location, response time, hyperlipidemia, and syncope (LRT, full versus final model, \( P=0.88 \)).

### Discussion

In this population-based evaluation of SCA cases, 25% had PEA as presenting arrhythmia and 48% had VF/VT, proportions that are similar to those reported in the literature.\(^\text{12–14}\) The methods of ascertainment of the initial recorded rhythm during manifestation of cardiac arrest also were consistent with prior studies.\(^\text{2,12,15}\) As anticipated, the outcome of resuscitation was significantly better in VF/VT versus PEA. However, unlike earlier reports that have focused largely on resuscitation variables and outcome, the present study was designed to incorporate lifetime clinical history and has identified distinct clinical factors associated with PEA versus VF/VT and asystole. CAD and hyperlipidemia were more likely to be associated with VF/VT. In addition to age, race, female gender, and pulmonary disease, a history of syncope was a significant correlate of PEA. The higher prevalence of syncope during the lifetime of PEA cases was not explained by differences in the status of the cardiac conduction system as evaluated from the resting ECG.

The increase in the proportion of PEA cases\(^\text{2,6}\) and corresponding decline in proportion of VF\(^\text{1–3,6,15,16}\) is now a well-established phenomenon. Although the reasons for this altered trend are not clear, this is unlikely to be a function of response time for resuscitation. The Ontario Prehospital Advanced Life Support (OPALS) study\(^\text{17}\) reported an increase in PEA cases over a period that witnessed significant decreases in response time. Similarly, in Sweden, shortening of the response time correlated with decreased VF prevalence and increased PEA prevalence.\(^\text{2}\) The present study observed no significant differences in response time between VF/VT, PEA, and asystole, consistent with findings in earlier studies.\(^\text{4}\) Also consistent with the existing literature,\(^\text{4–6,18–20}\) the present analysis found that 25% of VF/VT cases versus only 6% of PEA cases survived to hospital discharge. The combination of rising prevalence and low survival rates of PEA cases increases the urgency of enhancing the understanding of PEA mechanisms.

Like prior studies,\(^\text{21}\) age was a significant correlate of PEA in this population (OR, 1.02 [1.01 to 1.04]). We also observed that women had a higher likelihood of manifesting with PEA even after controlling for age, another finding that is consistent with earlier reports.\(^\text{14}\) In a cohort study from Seattle and King County, women had lower rates of VF than men (OR, 0.51 [0.46 to 0.56]).\(^\text{22}\) Earlier evidence suggested that longer response times in women may explain their increased likelihood of presenting with PEA.\(^\text{23}\) But in the present study, there were no gender-related differences in response time, indicating that delayed response in women may not entirely explain higher prevalence of PEA in women. Findings from the present study indicate that factors associated with PEA clearly extend beyond age and are gender specific. Furthermore, as reported in earlier studies,\(^\text{24–26}\) black race is strongly associated with PEA as opposed to VF, and determinants of this phenomenon need additional investigation.

#### Table 4. Multivariable Odds Estimates of Factors Associated With PEA vs VF/VT, Oregon-SUDS 2002–2007 (n=538)

<table>
<thead>
<tr>
<th>OR (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per year increase)</td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Hispanic</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Other race</td>
</tr>
<tr>
<td>CAD</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
</tr>
<tr>
<td>History of syncope</td>
</tr>
<tr>
<td>Male without pulmonary disease</td>
</tr>
<tr>
<td>Female without pulmonary disease</td>
</tr>
<tr>
<td>Male with pulmonary disease</td>
</tr>
<tr>
<td>Female with pulmonary disease</td>
</tr>
</tbody>
</table>

\( *\)Adjusted for witnessed status, arrest location, and response time.

#### Table 5. Multivariable Odds Estimates of Factors Associated With PEA vs Asystole, Oregon-SUDS 2002–2007 (n=393)

<table>
<thead>
<tr>
<th>OR (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per year increase)</td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Hispanic</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Other race</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
</tr>
<tr>
<td>History of syncope</td>
</tr>
</tbody>
</table>

\( *\)Adjusted for witnessed status, arrest location, and response time.
A unique aspect of this study is a detailed analysis of preexisting clinical conditions identified from the lifetime clinical history, in addition to circumstances of SCA and first-responder data. Previous clinical reports have focused largely on the SCA event, attributing manifestation of PEA to a variety of factors including hypoxia, hypovolemia, electrolyte imbalance, tamponade, pneumothorax, and thromboembolism.27 Consistent with several earlier reports in the literature,18,28,29 we observed that pulmonary disease was associated with increased frequency of PEA.

The finding that history of syncope was a significant correlate of future PEA (OR, 2.64 [1.31 to 5.32] versus VF/VT and OR, 2.27 [1.08 to 4.78] versus asystole) is also likely to be novel. The Framingham Heart Study has reported that the strongest predictor of overall mortality in patients with syncope was heart disease.30 Our findings, however, would suggest that syncope has a significantly greater association with PEA versus VF/VT and versus asystole, suggesting that patients with PEA may have had a propensity for syncope. Given the nature of the study, the cause of syncope could not be established in the majority of PEA or VF/VT patients. However, there were no differences in the prevalence of conduction system disease on the resting 12-lead ECG. On the basis of earlier evidence that vagal blockade can have potential beneficial effects31,32 atropine is currently employed for treatment of PEA during resuscitation.33 However, the potential link between syncope and future PEA warrants further investigation.

CAD and male gender are considered risk factors for occurrence of VF.5,34 During the second half of the last century, mortality due to CAD has been halved.35 It has been hypothesized that this recently observed decline in coronary heart disease could lead to a decline in incidence of VF.1 In a retrospective, observational study of cardiac arrest victims in Milwaukee, Wis, the decrease in VF/VT incidence was found not to be related with any patient- or EMS-dependent factors.15 However, our findings of the positive association between VF/VT and OR, 2.27 [1.08 to 4.78] versus asystole) is also emerging, and what to do about it. Resuscitation. 2003;58:31–35.


22. Dr Chugh is the Pauline and Harold Price Professor of Electrophysiology at the Heart Institute, Cedars-Sinai Medical Center, Los Angeles, Calif.

23. Sources of Funding

Dr Chugh is the Pauline and Harold Price Professor of Electrophysiology at the Heart Institute, Cedars-Sinai Medical Center, Los Angeles, Calif.

24. Disclosures

None.

25. References


CLINICAL PERSPECTIVE

In this population-based study, details of preexisting clinical conditions were combined with emergency medical services data to identify correlates of pulseless electric activity versus ventricular fibrillation and asystole. As expected, cases of cardiac arrest that presented with pulseless electric activity were significantly less likely to survive, and age, black race, female gender, and pulmonary disease were significant correlates of pulseless electric activity. As anticipated, ventricular fibrillation was more likely to be associated with a diagnosis of hyperlipidemia or coronary artery disease. However, there were no differences in the overall disease burden or resuscitation response time that explained occurrence of pulseless electric activity. In addition to reporting specific clinical correlates of pulseless electric activity, this study has identified a novel and significant association between lifetime syncope and future pulseless electric activity that was not explained by a higher prevalence of cardiac conduction system disease on the resting 12-lead ECG. Given the well-established rising prevalence of pulseless electric activity and significantly worse survival outcome compared with ventricular fibrillation, enhancing the mechanistic understanding of pulseless electric activity is a high priority. These findings, particularly the potential link between syncope and pulseless electric activity, are likely to provide a basis for new investigative approaches to evaluate mechanisms of this condition.
Factors Associated With Pulseless Electric Activity Versus Ventricular Fibrillation: The Oregon Sudden Unexpected Death Study
Carmen Teodorescu, Kyndaron Reinier, Celia Dervan, Audrey Uy-Evanado, Mershed Samara, Ronald Mariani, Karen Gunson, Jonathan Jui and Sumeet S. Chugh

_Circulation_. published online November 8, 2010;
_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2010 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/early/2010/11/08/CIRCULATIONAHA.110.966333

Data Supplement (unedited) at:
http://circ.ahajournals.org/content/suppl/2013/10/17/CIRCULATIONAHA.110.966333.DC1

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in _Circulation_ can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to _Circulation_ is online at:
http://circ.ahajournals.org//subscriptions/
Morphologie du bloc de branche et autres facteurs pronostiques après traitement de resynchronisation cardiaque chez des patients affiliés à Medicare

Kenneth C. Bilchick, MD, MS ; Sandeep Kamath, MD ; John P. DiMarco, MD, PhD ; George J. Stuktenborg, PhD

Contexte—Les essais cliniques menés sur le traitement de resynchronisation cardiaque (TRC) ont porté sur une population de patients sélectionnée et n’ont inclus que peu de sujets appartenant à des sous-groupes particuliers tels que ces présentant un bloc de branche droit (BBD). L’analyse des résultats cliniques au sein de populations spécifiques peut toutefois permettre d’identifier les facteurs prédisant le devenir effectif des patients après instauration d’un TRC.

Méthodes et résultats—Les données émanant du registre des défibrillateurs automatiques implantables tenu par Medicare pour les années 2005 et 2006 ont été colligées conjointement aux informations fournies par cet organisme sur le devenir clinique des patients après la pose des appareils. Des modèles de risques proportionnels de Cox ont été conçus en vue d’évaluer la mortalité et l’incidence du critère de jugement regroupant le décès et l’hospitalisation pour insuffisance cardiaque selon que les patients avaient reçu un dispositif de TRC simple ou comportant une fonction de défibrillation (TRC-D). Chez les 14 946 patients du registre qui avaient été dotés d’un TRC-D (durée médiane de suivi : 40 mois), les taux de décès à 1 an, 3 ans et global ont été de, respectivement, 12, 32 et 37 %. L’insuffisance cardiaque de classe IV de la New York Heart Association (rapport de risques [RR] à 1 an : 2,23 ; RR à 3 ans : 1,98 ; p <0,001) et l’âge égal ou supérieur à 80 ans (RR à 1 an : 1,74 ; RR à 3 ans : 1,75 ; p <0,001) sont apparus comme deux facteurs ayant augmenté les risques de décès précoce et tardif après implantation d’un TRC-D. Les deux autres facteurs ayant fait preuve, après ajustement, des plus fortes valeurs prédictives en la matière ont été la présence d’un BBD (RR à 1 an : 1,44 ; RR à 3 ans : 1,37 ; p <0,001) et celle d’une cardiomyopathie ischémique (RR à 1 an : 1,39 ; RR à 3 ans : 1,44 ; p <0,001). Considérés conjointement, le BBD et la cardiomyopathie ischémique ont été associés à un risque ajusté de décès deux fois plus élevé (RR : 1,99 ; p <0,001) que celui imputable au bloc de branche gauche (BBG) et à l’existence d’une cardiomyopathie non ischémique. La présence de complexes QRS d’une durée d’au moins 150 ms s’est montrée corrélée avec un pronostic plus favorable chez les patients présentant un BBG, mais n’a eu aucun impact chez ceux porteurs d’un BBD. Une analyse secondaire a, par ailleurs, montré que, chez les premiers, la pose d’un TRC-D avait été suivie de moins d’événements défavorables comparativement à celle d’un défibrillateur automatique implantable, ce qui n’a pas été observé chez les seconds.

Conclusions—Chez les patients de Medicare, le BBD, la cardiomyopathie ischémique, l’insuffisance cardiaque de classe IV de la New York Heart Association et l’âge avancé sont apparus, après ajustement, comme de puissants facteurs prédicatifs d’un pronostic péjoratif après implantation d’un TRC-D. Les taux de décès effectifs dans les 3 à 4 ans qui suivent la procédure semblent supérieurs à ceux précédemment publiés. (Tractat de l’anglais : Bundle-Branch Block Morphology and Other Predictors of Outcome After Cardiac Resynchronization Therapy in Medicare Patients. Circulation. 2010;122 : 2022–2030.)

Mots clés : bloc de branche □ insuffisance cardiaque □ résultats cliniques □ registres

Facteurs favorisant l’activité électrique sans pouls plutôt que la fibrillation ventriculaire

L’Oregon Sudden Unexpected Death Study

Carmen Teodorescu, MD, PhD ; Kyndaron Reinier, PhD ; Celia Dervan, MD ; Audrey Uy-Evanoan, MD ; Mershed Samara, MD ; Ronald Mariani, EMT-P ; Karen Gunson, MD ; Jonathan Jui, MD, MPH ; Sumeet S. Chugh, MD

Contexte—Parallèlement à la diminution continue de la prévalence des arrêts cardiaques subits liés à une fibrillation ventriculaire (FV), on assiste à une augmentation notable du taux d’accidents de ce type en rapport avec une activité électrique sans pouls (AESPs). Sachant que les chances de survie sont nettement plus faibles dans ce contexte que lorsque l’arrêt cardiaque découle d’une FV, nous avons effectué une recherche exhaustive des facteurs favorisant l’AESP en collégeant les renseignements fournis par les personnes ayant prodigué les premiers secours aux patients ainsi que des antécédents médicaux complets de ces derniers.

Méthodes et résultats—Nous avons recensé selon une approche prospective (de 2002 à 2007) tous les cas de mort subite d’origine cardiaque survenus dans la zone métropolitaine de Portland (regroupant environ un million d’habitants), dans l’Oregon, et ayant donné lieu à une tentative de réanimation. Des tests du χ², une ANOVA et une analyse par régression logistique ont été effectués pour comparer les cas en rapport avec une AESP et ceux liés à une FV ou une asystolie. Au total, 1 277 sujets âgés de 18 ans ou plus (âge moyen : 65 ± 16 ans ; 67% d’hommes) ont fait l’objet de gestes de réanimation par des intervenants présents sur les lieux. Le trouble du rythme cardiaque à l’origine de l’accident était une FV dans 48 % des cas, une AESP chez 25 % des sujets et une asystolie ou une autre anomalie chez les individus restants. Comparativement aux sujets ayant développé une FV, ceux dont l’arrêt cardiaque était lié à une AESP étaient plus âgés (âge moyen : 68 ans versus 63 ; p = 0,0002), plus fréquemment des femmes (37 % versus 26 % ; p = 0,008) et ont présenté de moindres chances de survie après leur sortie d’hôpital (6 % contre 25 % ; p <0,0001). L’existence d’un antécédent de syncope s’est montrée fortement corrélée avec la survenue d’une AESP (odds ratio : 2,6 ; intervalle de confiance : 1,3 à 5,3) après ajustement pour l’âge, le sexe, le délai de réaction et les circonstances de l’arrêt cardiaque. Le fait d’être noir a également été un facteur indépendant favorisant la survenue d’une AESP (odds ratio : 2,6 ; intervalle de confiance : 1,3 à 5,4). De même, la présence d’une pneumopathie et le sexe féminin sont apparus comme des facteurs significativement corrélés avec le risque d’AESP (p pour l’interaction = 0,04). Dans une analyse par sous-groupes fondée sur les tracés électrocardiographiques de repos (n = 391), aucune différence n’a été mise en évidence en termes d’antécédents cardiaques cliniques ou de prévalence des troubles de la conduction cardiaque (31,6 % d’AESP versus 32,2 % de FV ; p = 0,48).

Conclusions—Les cas d’arrêt cardiaque secondaire à une AESP se sont caractérisés par une prévalence significativement plus élevée des antécédents d’épisodes syncopaux et par divers autres facteurs favorisants, dont le fait d’être noir, qui les distinguaient des cas en rapport avec une FV. D’autres études sont souhaitables pour explorer les liens mécanistiques pouvant relier la survenue d’une syncope à la survenue ultérieure d’une AESP. (Tractat de l’anglais : Factors Associated With Pulseless Electric Activity Versus Ventricular Fibrillation. The Oregon Sudden Unexpected Death Study. Circulation. 2010;122 : 2116–2122.)

Mots clés : mort subite □ population □ réanimation □ syncope