Characteristics of the Resuscitated Out-of-hospital Cardiac Arrest Victim with Coronary Heart Disease

SIDNEY GOLDSTEIN, M.D., J. RICHARD LANDIS, Ph.D., RICHARD LEIGHTON, M.D.,
GEORGE RITTER, M.D., C. MARK VASU, M.D., ALLYN LANTIS, B.S.,
AND RUTH SEROKMAN, B.A.

SUMMARY The clinical entry characteristics and medical history of 142 resuscitated out-of-hospital cardiac arrest victims with coronary heart disease were studied in order to identify factors that affect their long-term survival. The cardiac arrest event was classified as being secondary to an acute myocardial infarction (AMI) in 44% (62 of 142), an ischemic event (IE) in 34% (49 of 142) and a primary arrhythmic event (PAE) in 22% (31 of 142). The majority of patients in all groups had a history of angina pectoris. Twenty-seven percent of the AMI, 55% of the IE, and 71% of the PAE patients had a history of infarction. Ten percent of the AMI, 31% of the IE, and 55% of the PAE had used digitalis before their cardiac arrest. Cardiac arrest was the first cardiac event in 35% of the AMI, 16% of the IE and 6% of the PAE patients. One year after arrest, 89% of the AMI, 80% of the IE and 71% of the PAE were alive (p < 0.01). Covariate analysis for more than 40 variables indicates that a high-risk group that included 22% (31 of 142) of the cardiac arrest victims had 1- and 2-year survival rates of 71% and 55%, respectively, and was characterized as having used digitalis before arrest, experiencing blood urea nitrogen elevation and pulmonary congestion during the hospitalization for the event, and classification of the cardiac arrest event as a PAE. A low-risk group comprised 78% (111 of 142) of the survivors and had 1- and 2-year survival rates of 85% and 69%, respectively. These data indicate that cardiac arrest due to coronary heart disease is secondary to several mechanisms related to subsequent survival.

MOST coronary heart disease deaths occur suddenly outside the hospital. Many victims are being resuscitated after sudden cardiac arrest outside the hospital, reflecting the success of well-trained emergency medical squads (EMS). Persons who have been resuscitated after cardiac arrest have a high mortality rate, and represent a population in which a variety of medical and surgical interventions may be tested. Study of survivors of sudden cardiac arrest can also increase our knowledge about mechanisms of death in coronary heart disease. For these reasons, considerations of their history, entry event and subsequent mortality is important.

Initial clinical studies of cardiac arrest victims resuscitated outside the hospital suggested heterogeneity in the extent of coronary heart disease and in the mechanisms of death. In this report of patients resuscitated outside the hospital after cardiac arrest due to coronary heart disease, we describe the clinical characteristics of the patients before their arrest, the event itself and the immediate postresuscitation course, and correlate these observations with the long-term survival of the resuscitated patient.

Methods

All emergency cardiac arrest runs of the EMS and all successfully resuscitated cardiac arrest victims in Lucas County, Ohio (population 484,370), Kent County, Michigan (population 411,044) and Southfield, Michigan (population 69,285), from July 1, 1975 through June 15, 1979 were registered. The EMS squads were the primary responding unit and were comparably equipped, trained and staffed with paramedic personnel. All emergency cardiac runs were counted regardless of the status of the patient at arrival. An emergency cardiac run is defined as the dispatch of the EMS for an event not related to trauma associated with a cardiac arrest either at arrival or during transit to the hospital. The mean arrival time was 4.73 minutes for all runs and 3.87 minutes for the successfully resuscitated patients. A total of 1913 cardiac arrest events occurred before the arrival of the emergency medical units and 258 occurred after arrival of the unit, for a total of 2171 arrest events. Of the 258 cardiac arrests that occurred after arrival of the EMS, 180 occurred before transit, 73 occurred during transit and before arrival at the emergency room and five occurred with an unknown time sequence. Arrival time (response time) was calculated from the initial emergency call to the arrival of the EMS. In some cases, the event had occurred so long before that any reasonable possibility of a successful resuscitation was unlikely. Nevertheless, these runs were included so as to understand the logistic problems of these EMS programs. Of these 2171 patients, 1754 (81%) were dead on arrival at the receiving hospital. Of the 417 patients who survived to reach the hospital, 112 (27%) died within the first day, an additional 136 (33%) died before discharge and 169 (40%) were discharged alive. Successful resuscitation was considered to have occurred when the patient was discharged from the hospital. For this group of
patients, 169 (7.8%) were considered to be successful resuscitations. These emergency runs occurred in 166 patients, three of whom had successfully treated repeat arrests.

While in the hospital, the patients were registered and laboratory and electrocardiographic data were collected. Hospital and EMS records were reviewed for clinical information relating to medical history.

The patients were classified as having coronary heart disease or other forms of cardiovascular disease. Patients were classified as having coronary heart disease if they had electrocardiographic evidence of an old or new myocardial infarction, if angina pectoris was present, or if coronary arteriography demonstrated significant disease. Of the 166 patients successfully resuscitated, 142 (86%) were classified as having significant coronary heart disease and are the population analyzed in this study.

Serum enzyme determinations for each resuscitated patient were reviewed at the hospital. Patients in the study were admitted to many different hospitals; thus, no standardized normal enzyme levels were available. Therefore, we used a relative change in serum enzyme concentration and considered a value twice the upper limit of normal at the receiving hospital as an abnormal value. Enzymes considered were creatinine phosphokinase (CPK), serum glutamic-oxalacetic transaminase (SGOT) and lactic dehydrogenase (LDH). All three enzyme determinations were available in all patients. In situations where CPK or LDH were not twice normal, LDH isoenzyme or CPK-MB fraction was also measured. LDH isoenzymes were separated by electrophoresis and an abnormal pattern was considered to be present when LDH₁ equalled or exceeded LDH₂. CPK-MB fraction was measured using electrophoretic separation with visualization of the fluorescent band measured qualitatively for its presence or absence. The presence of MB-CPK alone or an abnormal LDH isoenzyme pattern was also considered to be abnormal. If three of these five tests were abnormal, the patient was considered to have evidence of myocardial enzymatic ischemia. Electrocardiographic evidence of myocardial ischemia was considered to be present when, in the presence of normal intraventricular conduction, T waves became negative with or without associated ST-segment depression or when ST-segment depression or elevation greater than 1 mm was recorded. The 142 patients with coronary heart disease were classified into three groups using enzyme and electrocardiographic information (table 1).

Group 1 — Acute Myocardial Infarction (AMI)

Group 1 patients were characterized by the development of a new Q wave on serial ECG or when compared to previous ECGs when available. All patients in this group satisfied the criteria of myocardial enzymatic ischemia as described above.

Group 2 — Ischemic Event (IE)

Group 2 patients all had myocardial enzymatic ischemia associated with the acute event. Included in this group were patients who developed significant ST-segment and T-wave changes compatible with ischemia, patients with left bundle branch block and patients who failed to demonstrate serial changes in the ST and T waves.

Group 3 — Primary Arrhythmic Event (PAE)

Group 3 patients did not demonstrate sufficient elevation in serial enzyme determinations to fulfill the criteria of myocardial enzymatic ischemia. Serial changes in the ST and T waves were recorded in some of these patients.

All other victims without evidence of coronary heart disease were excluded from further data analysis. Of the 142 patients in whom a diagnosis of coronary heart disease was established, 62 (44%) were classified as AMI, 49 (34%) as IE, and 31 (22%) were considered to have had a primary arrhythmic event (PAE).

Patients were interviewed 2 months after discharge and every 4 months thereafter, at which time the clinical status of the patient was evaluated. Hospitalization, nonfatal and fatal events were identified, reviewed, and classified for each of the 142 patients. Witnessed death within 1 hour of symptoms was classified as sudden death. Prodromal symptoms were defined as either the development of new symptoms or increase in the frequency or duration of previous symptoms.

An extensive data base, involving several hundred variables on each patient, has been assembled and stored in disk files on the University of Michigan Am-dahl 470/V8 computer. These data were analyzed within the Michigan Interactive Data Analysis System (MIDAS) package and other special-purpose programs developed in the Department of Biostatistics. The Cox-Breslow^7 life-table procedure was used to adjust the survival curves for relevant covariables.

**Results**

The success of the out-of-hospital resuscitation is directly related to the arrival time of the EMS, based on the total of 169 cardiac resuscitations. If cardiac arrest was present upon arrival of the EMS, it was associated with a 6.5% (124 of 1913) success rate. If the arrest occurred after arrival, the success rate was 17.4% (45 of 258). The overall success rate was 7.8% for our entire population and was related to the duration of the arrival time of the EMS (fig. 1). When the EMS arrived in less than 3 minutes, 10.2% (80 of 781) of the victims were resuscitated. This success rate fell precipitously as arrival time was prolonged. In those who had a cardiac arrest after arrival of the unit, either before or during transit, arrival time had little significance.

The distribution of patients in each group is shown in table 1. The classification system was developed to establish whether the arrest event was either an AMI, an IE, or an episode lacking evidence of myocardial enzymatic ischemia, defined as a PAE. The fact that
TABLE 1. Classification of Coronary Heart Disease Cardiac Arrest Events

<table>
<thead>
<tr>
<th>Classification of arrest event</th>
<th>No. of pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute myocardial infarction</td>
<td>62 (44%)</td>
</tr>
<tr>
<td>Ischemic events</td>
<td>49 (34%)</td>
</tr>
<tr>
<td>Enzyme elevation with ST and T changes</td>
<td>38</td>
</tr>
<tr>
<td>Enzyme elevation with LBBB</td>
<td>7</td>
</tr>
<tr>
<td>Enzyme elevation without ECG changes</td>
<td>4</td>
</tr>
<tr>
<td>Primary arrhythmic event</td>
<td>31 (22%)</td>
</tr>
<tr>
<td>ST and T changes</td>
<td>12</td>
</tr>
<tr>
<td>No significant ST and T changes</td>
<td>19</td>
</tr>
<tr>
<td>Total patients with CHD</td>
<td>142</td>
</tr>
</tbody>
</table>

Numbers in parentheses indicate percent of all CHD patients in each classification.
Abbreviations: LBBB = left bundle branch block; CHD = coronary heart disease.

cardiac arrest and the subsequent resuscitation efforts, including defibrillation, could occur without inducing significant serum enzyme elevation, as observed in the PAE group, led us to attach importance to enzyme elevation when it did occur. There was no relationship between the use of the defibrillators or the number of defibrillations and the presence of myocardial enzymatic ischemia. Although the enzyme criteria for myocardial ischemia were arbitrarily established, abnormal serum concentrations of cardiac enzymes that did not fulfill the criteria for myocardial enzymatic ischemia, as well as changes in the ST and T waves, were observed in some of the PAE patients. The IE group differed distinctly from the other two groups by the absence, on one hand, of electrocardiographic evidence of a new transmural infarction as seen in the AMI group, and on the other, by the presence of myocardial enzymatic ischemia lacking in the PAE group. The IE group, however, must represent a spectrum of arrest victims, from those who sustained a nontransmural infarction to those who had enzyme elevation secondary to the arrest event itself.

The clinical characteristics of the resuscitated vict-
tims are listed in table 2. Patients with PAE were older than those with IE, who were older than those with AMI ($p < 0.01$). A history of angina was common in all three groups. Patients with AMI and IE were more often free of evidence of heart disease than those in the PAE group ($p < 0.05$). Cardiac arrest was the first cardiac event in 35% of the AMI patients. Most of the patients in the PAE group had a history of cardiovascular disease. Twenty-seven percent of the AMI group, 55% of the IE group and 71% of the PAE group had a history of infarction. Evidence of congestive heart failure, manifested by the use of digitalis before the arrest event, was more frequent in the PAE group ($p < 0.05$).

Prodromal symptoms, usually present for less than 1 hour before arrest, were commonly reported in all three groups. Pain and indigestion were more common in the AMI group. There was no difference among the three groups in the duration of the prodromal symptoms. The estimation of the frequency of prodromal symptoms is based on a small fraction of all cardiac arrests, the survivors. The presence of prodromal symptoms could be a factor in their survival. Analysis of the arrest arrhythmia at onset of EMS monitoring, when the arrest occurred before EMS arrivals (table 3), indicates that ventricular fibrillation was more common in the AMI and IE groups compared with the PAE group ($p < 0.01$) and asystole was more common in the PAE group ($p < 0.01$).

The survival experience for the patients classified according to the entry event subgroups is shown in figure 2, beginning from arrest event and for a maximum of 54 months of follow-up. The cumulative survival rates are significantly different ($p < 0.05$) among all three groups. The survival rate at 1 year for the AMI patients was 89%, for IE 80% and for the PAE 71%. This comparison is not adjusted for other relevant covariates, such as age, history of medications, or other signs and symptoms.

An extensive list of potential risk factors relating to history, entry event classification and the severity of the entry event itself (more than 40 in all) was examined initially using the Cox-Breslow life-table procedure\textsuperscript{4-7} in order to identify which covariate

![Figure 1. Success of resuscitation related to emergency medical squad (EMS) response time. Total number in each group is less than in text because of incomplete response time data.](http://circ.ahajournals.org/cover)
TABLE 2. Clinical Characteristics of Successfully Resuscitated Out-of-hospital Cardiac Arrest Victims

<table>
<thead>
<tr>
<th>Entry event</th>
<th>Acute myocardial infarction (n = 62)</th>
<th>Ischemic event (n = 49)</th>
<th>Primary arrhythmic event (n = 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)*</td>
<td>57.7</td>
<td>63.7</td>
<td>68.5</td>
</tr>
<tr>
<td>History</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angina</td>
<td>53% (33)</td>
<td>53% (26)</td>
<td>61% (19)</td>
</tr>
<tr>
<td>Hypertension†</td>
<td>29% (18)</td>
<td>53% (26)</td>
<td>55% (17)</td>
</tr>
<tr>
<td>Digitalis therapy‡</td>
<td>10% (6)</td>
<td>31% (15)</td>
<td>55% (17)</td>
</tr>
<tr>
<td>Myocardial infarction‡</td>
<td>27% (17)</td>
<td>55% (27)</td>
<td>71% (22)</td>
</tr>
<tr>
<td>Anteroseptal</td>
<td>24% (4)</td>
<td>30% (8)</td>
<td>36% (8)</td>
</tr>
<tr>
<td>Anterolateral</td>
<td>17% (3)</td>
<td>7% (2)</td>
<td>18% (4)</td>
</tr>
<tr>
<td>Inferior‡</td>
<td>47% (8)</td>
<td>26% (7)</td>
<td>9% (2)</td>
</tr>
<tr>
<td>Multiple‡</td>
<td>6% (1)</td>
<td>33% (9)</td>
<td>32% (7)</td>
</tr>
<tr>
<td>Subendocardial</td>
<td>6% (1)</td>
<td>0% (0)</td>
<td>5% (1)</td>
</tr>
<tr>
<td>Left bundle branch block</td>
<td>0% (0)</td>
<td>4% (1)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>No history of the above‡</td>
<td>35% (22)</td>
<td>16% (8)</td>
<td>6% (2)</td>
</tr>
<tr>
<td>Acute event</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any prodromal symptoms</td>
<td>78% (46/59)</td>
<td>57% (25/44)</td>
<td>73% (19/26)</td>
</tr>
<tr>
<td>Chest pain†</td>
<td>56% (32/57)</td>
<td>22% (10/45)</td>
<td>40% (10/25)</td>
</tr>
<tr>
<td>Indigestion‡</td>
<td>30% (17/57)</td>
<td>13% (6/46)</td>
<td>0% (0/24)</td>
</tr>
<tr>
<td>Syncope</td>
<td>12% (7/59)</td>
<td>7% (3/45)</td>
<td>25% (6/24)</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>34% (20/59)</td>
<td>27% (12/44)</td>
<td>37% (9/24)</td>
</tr>
<tr>
<td>Duration of symptoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 hour</td>
<td>52% (24/46)</td>
<td>72% (18/25)</td>
<td>68% (13/19)</td>
</tr>
<tr>
<td>1–12 hours</td>
<td>24% (11/46)</td>
<td>4% (1/25)</td>
<td>11% (2/19)</td>
</tr>
<tr>
<td>&gt; 12 hours</td>
<td>24% (11/46)</td>
<td>24% (6/25)</td>
<td>21% (4/19)</td>
</tr>
</tbody>
</table>

Numbers in parentheses indicate number of patients.
*Denotes all three pairwise differences significant at α < 0.05.
†Denotes AMI significantly different from combined IE and PAE groups at α < 0.05.
‡Denotes PAE significantly different from combined AMI and IE groups at α < 0.05.
Abbreviations: AMI = acute myocardial infarction; IE = ischemic event; PAE = primary arrhythmic event.

singly was most predictive of survival. Based on this screening, nine variables were found to be significant (p < 0.05) and are listed in table 4. They were used in a stepwise sequence to develop a prognostic model that best characterizes the survival experience of these patients, using the largest chi-square value at each step as the selection criterion, provided that the increment in the chi-square statistic was significant at the 5% level. At each step, the statistical significance for including a given variable in the model is assessed by subtracting the chi-square value associated with the model selected at the previous step, which includes all the other covariates, from the chi-square value obtained by adding the given variable. For example, the incremental chi-square statistic for inclusion of variable 9 at step 2, having selected variable 5 at step 1, is 10.46 (22.52−12.06). Because each of these nine variables is either analyzed as a continuous or as a dichotomous variable, each of these increments in the chi-square criterion has one degree of freedom; consequently, at each step the inclusion of a given variable is statistically significant at the 5% level if this difference exceeds 3.84. In this analysis, age and blood urea nitrogen (BUN) concentration were used as continuous variables.

The single best predictor of survival for these data at step 1 is a history of digitalis therapy; at step 2, the highest concentration of the BUN during the entry event; at step 3, pulmonary congestion during the

TABLE 3. Cardiac Arrest Arrhythmia Recorded Initially by Emergency Medical Squads*

<table>
<thead>
<tr>
<th>Entry event</th>
<th>AMI (n = 43)</th>
<th>IE (n = 41)</th>
<th>PAE (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular tachycardia</td>
<td>7% (3)</td>
<td>5% (2)</td>
<td>5% (1)</td>
</tr>
<tr>
<td>Ventricular fibrillation‡</td>
<td>89% (38)</td>
<td>90% (37)</td>
<td>60% (12)</td>
</tr>
<tr>
<td>Asystole‡</td>
<td>2% (1)</td>
<td>5% (2)</td>
<td>25% (5)</td>
</tr>
<tr>
<td>Complete atrio-ventricular block</td>
<td>2% (1)</td>
<td>0% (0)</td>
<td>10% (2)</td>
</tr>
</tbody>
</table>

*Reduced sample sizes due to missing data or cardiac arrest occurred after arrival of emergency medical squad.
†Denotes AMI and IE significantly different from PAE at <0.01.
Abbreviations: AMI = acute myocardial infarction; IE = ischemic event; PAE = primary arrhythmic event.
acute event; and at step 4, the entry event classification of PAE. After step 4, no additional significant predictive information remains among the other variables.

Consequently, the covariates in the model in order of their statistical importance characterizing the survival experience of these 142 patients and also describing high- and low-risk groups are the use of digitalis before the entry event; the highest BUN concentration during the acute event; pulmonary congestion on x-ray associated with the entry event; and the classification of the event as a PAE.

The survival curves for the low-risk (AMI and IE) and high-risk (PAE) groups adjusted for the other covariates, based on the final model for the 142 patients, are displayed in figure 3. The low-risk group includes 78% (111 of 142) of the total survivors and the high-risk group makes up 22% (31 of 142). The 1- and 2-year survival rates for the low-risk group were 85% and 69% and for the high-risk group, 71% and 55% (p < 0.01). Therefore, the two curves for figure 3 demonstrate a significant (p = 0.01) difference when adjusted for the covariates.

The mode of the subsequent death of the resuscitated victims is shown in table 5. Sudden death was the most common mode of death for the group as a whole. The occurrence of sudden death and death due to congestive heart failure differed in the two risk groups. Using the previously identified covariates, there was no significant difference in the covariate-adjusted survival curves (fig. 4) for the high- and low-risk group for recurrent sudden death (NS). Death due to congestive heart failure (fig. 5), however, was more frequent in the high-risk group (p < 0.05).

### Table 4. Likelihood Ratio Chi-square Criterion for Joint Effects of Covariates in Successive Cox-Breslow Survival Analysis Models

<table>
<thead>
<tr>
<th>No.</th>
<th>Covariate Label</th>
<th>Other covariates in model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Step 1 None</td>
</tr>
<tr>
<td>1</td>
<td>Age</td>
<td>4.83</td>
</tr>
<tr>
<td>2</td>
<td>HxMI</td>
<td>8.01</td>
</tr>
<tr>
<td>3</td>
<td>Pulm. congest.</td>
<td>8.14</td>
</tr>
<tr>
<td>4</td>
<td>HxDiuretic</td>
<td>8.66</td>
</tr>
<tr>
<td>5</td>
<td>HxDigitalis</td>
<td>12.06*</td>
</tr>
<tr>
<td>6</td>
<td>PVD</td>
<td>6.60</td>
</tr>
<tr>
<td>7</td>
<td>AMI</td>
<td>3.89</td>
</tr>
<tr>
<td>8</td>
<td>PAE</td>
<td>5.03</td>
</tr>
<tr>
<td>9</td>
<td>BUN</td>
<td>9.83</td>
</tr>
</tbody>
</table>

Critical value for chi-square criterion at 1 degree of freedom = 3.84 (p < 0.05).

Successive incremental chi-square value can be obtained by subtracting the value at each step from the preceding step; significance of p < 0.05 is a difference equal to 3.84 or greater.

*Denotes largest chi-square criterion at next step.

Abbreviations: HxMI = history of myocardial infarction; Pulm. congest. = evidence of pulmonary congestion by chest x-ray during hospitalization; HxDiuretic = history of diuretics before entry event; HxDigitalis = history of digitalis therapy before entry event; PVD = peripheral vascular disease; AMI = acute myocardial infarction group; PAE = primary arrhythmic event; BUN = the highest BUN concentration during entry event. Age and BUN were considered as continuous variables.
Discussion

There is little question but that the success rate of the out-of-hospital resuscitation by the EMS is in a large part related to the arrival time after the onset of the acute event, which is influenced by the topography and population density of the region served. Our units serve a large geographic area, encompassing rural, suburban and urban areas that are distinctly different from those described in other experiences limited primarily to highly urbanized areas. Thus, our mean arrival time of 4.73 minutes was relatively long compared with urban units. Bystander cardiopulmonary resuscitation before EMS arrival may also have an impact on survival rates, although not studied in this series of patients. In our analysis, we included all emergency cardiac runs and arrest rhythms regardless of the status of the patient upon arrival of the EMS. This approach is somewhat different from that of other groups reporting similar data. There were a surprising number of arrests in transit, which was, in terms of percent of resuscitation success, the most effective part of the program.

Other studies have noted that victims of cardiac arrest frequently have a history of cardiac disease, particularly of prior myocardial infarction. Death may be sudden, but it is usually not without some warning. Our study confirms these findings. The frequency and type of preexisting heart disease, however, is different in the three groups. History of myocardial infarction was infrequent in patients with AMI. Cardiac arrest was the first cardiac event in 35% of the group. However, the majority of cardiac arrest survivors have evidence of previous heart disease. In fact, 77% (110 of 142) of the total group had a history of cardiac disease and 46% (66 of 142) had a previous myocardial infarction. Prodromal symptoms were common in all patients, but acute chest pain was more frequent as a prodromal symptom in the AMI patients. Ventricular fibrillation was the most common cause of cardiac arrest, with its highest incidence in the AMI and IE groups. Asystole and complete atrioventricular block were successfully treated in 11 of 103 arrests. Brady-asystolic cardiac arrest is a significant problem in out-of-hospital arrest and occurred in 25% of spontaneous arrests attended by paramedics and was associated with a poor immediate prognosis.

Liberthson et al. in a combined clinical and pathologic study of out-of-hospital cardiac arrest, observed that 39% of their patients experienced an AMI as an entry event, 34% had ischemia without infarction, and 19% had no evidence of ischemia or infarction. Our observations are similar. In an autopsy study, Love-

<table>
<thead>
<tr>
<th>Table 5. Mode of Subsequent Death of Survivors Resuscitated Outside Hospital — High- and Low-risk Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudden death</td>
</tr>
<tr>
<td>High-risk</td>
</tr>
<tr>
<td>Low-risk</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

High-risk group is significantly different from low-risk group by life-table analysis (p < 0.01).
grove and Thompson found that 20.5% of cardiac arrests were associated with acute infarction and 74.6% were associated with a previous infarct. Post-mortem evidence of a recent myocardial infarction was observed in 26% and early infarction in 51% of witnessed deaths within 24 hours. Approximately 10% of these witnessed deaths occurred in patients who had large hearts, a history of hypertension, congestive heart failure and no evidence of recent infarction. Baum et al. noted that only 19% of their resuscitated patients after out-of-hospital arrest had electrocardiographic evidence of a transmural infarction. An additional 38% had ischemia or necrosis without infarction determined by elevation of the LDH isoenzyme, and 43% had neither electrocardiographic or enzyme evidence of new infarction or necrosis. We observed a greater frequency of transmural infarction and a similar frequency of ischemia using different enzyme criteria. Myerburg et al. found evidence of an acute subendocardial or transmural myocardial infarction in 36% of out-of-hospital resuscitated cardiac arrests based on electrocardiographic or enzymatic criteria, although the enzyme criteria were not stated. Our own experience indicates that evidence of myocardial infarction and myocardial ischemia is a major associate of out-of-hospital cardiac arrest and was found in over three-fourths of the resuscitated victims. Although classification methods are slightly different, all studies seem to show three separate subgroups of arrest victims in whom arrest is precipitated either by an acute transmural infarction, an ischemic event, or neither.

The use of serum enzyme elevation as an indication of ischemia in these patients is obviously fraught with problems. Elevation of LDH isoenzyme was selected as a criterion of ischemia by Baum et al. Using this criterion, they had an incidence of IEs similar to that in our study. Closed-chest massage and multiple defibrillation did occur in many subjects in this study without achieving our criterion of myocardial enzymatic ischemia. Previous studies have indicated that in man, direct-current electrical countershock caused elevation of CPK concentration with only modest increase in the MB fraction, slight elevation of the SGOT and little, if any, elevation in the LDH. Although these studies are not entirely comparable to the resuscitation experience, they do lend support to the view that arrest and cardiopulmonary resuscitation can occur without release of enzyme in the blood sufficient to exceed the threshold used in this study as an indicator of enzymatic myocardial ischemia. We believe that the observed enzyme elevation in the IE group indicates that significant myocardial ischemia occurred in association with the arrest. Nevertheless, we cannot state unequivocally that the enzyme abnormalities are not secondary to the arrest event.

Analysis of survival of the population resuscitated is important to our understanding of the natural history and mechanism of death in patients with coronary heart disease. Studies of victims of out-of-hospital cardiac arrest indicate that those who had transmural myocardial infarction or enzyme evidence of myocardial necrosis did better than those who lacked such evidence. In our study, the 1- and 2-year survival rates for all patients with coronary heart disease of 84% and 67% are almost identical to those reported by Cobb et al. We observed poorer 1-year and 2-year survival rates in our AMI group (89% and 71%) than Cobb et al. (96% and 89%). We cannot explain this, for our classification of AMI victims appears to be similar to theirs. AMI survival in our study is similar, however, to that of patients with AMI who sustain ventricular fibrillation while under coronary care. The occurrence of ventricular fibrillation does not significantly affect the long-term survival rate of patients who sustained an AMI.

The risk of subsequent mortality in populations with previously identified coronary heart disease has been shown to be due to multiple variables. To describe a prognostic model of the natural history of out-of-hospital cardiac arrest victims in which therapeutic interventions can be tested, we examined our population with over 40 variables considered to be descriptive of history of disease, the event itself, and myocardial damage associated with the entry event. The presence of digitalis therapy before entry and pulmonary congestion associated with the event identified patients at high risk of subsequent mortality. BUN elevation was also a significant descriptor and is probably related to both cardiac and renal dysfunction. A separation of these two factors was not possible within the scope of this investigation. In this model, BUN was used as a continuous variable that was highly predictive of recurrent arrest for values greater than 35 mg%. Left ventricular dysfunction and BUN elevation after AMI have been associated with increased mortality. A myocardial infarction associated with the arrest event has been noted to improve survival rates. Of particular interest was the relationship of the IE group to the low-risk group. Although the IE group represented an intermediate
position on the unadjusted survival curve (fig. 2), when
the data were adjusted for the covariates related to left
ventricular function and BUN elevation, it became part
of the low-risk subgroup. The adjusted survival
curve for the low-risk group was almost identical to
the unadjusted survival curve for the AMI alone, since
left ventricular dysfunction was infrequent in this
group. This low-risk group made up of the AMI and
the IE group comprises 78% of our total population.
This model, however, must be tested in subsequent
populations in order to be validated.

The patients in the PAE group constituted the high-
risk group. The unadjusted survival curve for the PAE
group changed very little when adjusted for evidence
of left ventricular dysfunction, because it was such a
dominant feature of this group. The mode of recurrent
death in the high-risk group also differed from that in
the low-risk group. Recurrent sudden death was the
dominant feature in both high- and low-risk groups,
but death due to congestive heart failure was of added
significance in the high-risk group. Sudden cardiac
dearth was the mode of death in 54% of our patients.

Resuscitated out-of-hospital cardiac arrest victims
and other patients with coronary heart disease show a
similar variability in the clinical manifestation of their
disease. Therapeutic attempts directed at decreasing
the mortality of coronary heart disease should take
this information into consideration when testing the
effectiveness of these interventions.

References
1. Baum RS, Alvarez H III, Cobb LA: Survival after resuscita-
tion from out-of-hospital ventricular fibrillation. Circulation
50: 1231, 1974
2. Cobb LA, Baum RS, Alvarez H III, Schaffer WA: Resuscita-
tion from out-of-hospital ventricular fibrillation: 4 years follow-
up. Circulation 52 (suppl III): III-233, 1975
3. Schaffer WA, Cobb LA: Recurrent ventricular fibrillation and
modes of death in survivors of out-of-hospital ventricular
4. Liberthson RR, Nagel EL, Hirschman JG, Nussenfeld SR:
Prehospital ventricular defibrillation: prognosis and follow-up
5. Liberthson RR, Nagel EL, Hirschman JC, Nussenfeld SR,
Blackbourne BD, Davis JH: Pathophysiologic observations in
prehospital ventricular fibrillation and sudden cardiac death.
Circulation 49: 790, 1974
6. Cox DR: Regression models and life tables with discussion. J
7. Breslow N: Analysis of survival data under the proportional
hazards model. Rev Int Stat Inst 45: 45, 1975
8. Cobb LA, Conn RD, Sampson WE: Pre-hospital coronary
care: the role of a rapid response mobile intensive coronary care
system. (abstr) Circulation 44 (suppl II): II-45, 1971
9. Guzy PM, Pearce ML, Greenfield S, Beck L, McElroy CR:
Citizen cardiopulmonary resuscitation during out-of-hospital
emergencies in metropolitan Los Angeles. Clin Res 27: 79A,
1979
10. Thompson RG, Hallstrom AP, Cobb LA: Bystander-initiated
cardiopulmonary resuscitation in the management of ventricu-
12. Iseri LT, Humphrey SB, Siner EJ: Prehospital brady-asystolic
13. Myerburg RJ, Conde CA, Sung RJ, Mayorga-Cortes A,
Mallon SM, Sheps DS, Appel RA, Castellanos A: Clinical,
electrophysiologic and hemodynamic profile of patients
resuscitated from prehospital cardiac arrest. Am J Med 68:
568, 1980
14. Lovegrove T, Thompson P: The role of acute myocardial in-
farction in sudden cardiac death — a statistician's nightmare.
Am Heart J 96: 711, 1978
15. Rissanen M, Romo M, Siltapanen P: Prehospital sudden death
from ischaemic heart disease. A postmortem study. Br Heart J
40: 1025, 1978
16. Ehsani A, Ewy GA, Sobel BE: Effects of electrical counter-
shock on serum creatine phosphokinase (CPK) isoenzyme ac-
tivity. Am J Cardiol 37: 12, 1976
17. Hunt D, Bailie MJ: Enzyme changes following direct current
18. Slodki SJ, Falicov RE, Katz MJ, West M, Zimmerman HJ:
Serum enzyme changes following external direct current shock
therapy for cardiac arrhythmias. Am J Cardiol 17: 792, 1966
19. Goldberg R, Szklo M, Tonascia JA, Kennedy HL: Acute myo-
cardial infarction: prognosis complicated by ventricular fibrilla-
tion or cardiac arrest. JAMA 241: 2024, 1979
20. Lawrie DM: Long-term survival after ventricular fibrillation
stratification after acute myocardial infarction. Am J Cardiol
42: 202, 1978
22. Davis HT, DeCamilla J, Bayer LW, Moss AJ: Survivorship
patterns in the posthospital phase of myocardial infarction.
Circulation 60: 1252, 1979

Appendix

Variables considered for the Cox model were: timing of arrest
either before or after EMS arrival; patient rhythm on EMS arrival
(ventricular fibrillation, asystole or complete atrioventricular
block); timing of arrest before or during transit to the emergency
room; cardiovascular status in the emergency room; occupational
and educational level, combination of occupational and educational
level; current smoking status; clinical status before emergency room
arrival; the presence of shock (systolic blood pressure less than 90
mm Hg), hypertension (systolic blood pressure greater than 150
mm Hg), tachycardia (heart rate more than 120 beats/min), brady-
cardia (heart rate less than 50 beats/min), ventricular fibrillation,
tachyplea, stable vital signs, or complete atrioventricular block;
age; history of myocardial infarction; presence of peripheral
vascular disease; diuretic treatment before arrest; classification of
entry event as AMI, IE or PAE; location of new myocardial infarc-
tion; transmural or subendocardial infarction; cardiac medications
before arrest; history of angina pectoris; duration of hypotension;
history of congestive heart failure; prodromal symptoms of syncope,
chest and arm pain, shortness of breath, indigestion; duration of
prodromal symptoms; and medications at the time of hospital
discharge (digitalis, quinidine, procainamide, other antiarrhythmic
agents, diuretics, propranolol).
Characteristics of the resuscitated out-of-hospital cardiac arrest victim with coronary heart disease.
S Goldstein, J R Landis, R Leighton, G Ritter, C M Vasu, A Lantis and R Serokman

Circulation. 1981;64:977-984
doi: 10.1161/01.CIR.64.5.977

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/64/5/977