Out-of-Hospital Cardiac Arrest in Octogenarians and Nonagenarians

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Background: Studies of elderly patients who have out-of-hospital cardiac arrest have contradictory results. The studies usually define elderly patients as those older than 70 years, and include relatively few octogenarians and nonagenarians.

Objectives: To compare the survival after out-of-hospital cardiac arrest of octogenarians, nonagenarians, and younger patients and to determine the influence of age on survival after adjusting for factors known to influence out-of-hospital cardiac arrest outcome.

Methods: We conducted a retrospective cohort study in suburban King County, Washington, on 5882 patients who had out-of-hospital cardiac arrest from presumed cardiovascular disease between January 1, 1987, and December 31, 1998, and who received cardiopulmonary resuscitation from bystanders, emergency medical technicians, or both. The main outcome measure was survival to hospital discharge.

Results: In patients who had out-of-hospital cardiac arrest due to a cardiac cause, younger patients had higher hospital discharge rates than octogenarians, who in turn had higher hospital discharge rates than nonagenarians (19.4% vs 9.4% vs 4.4%; P < .001). However, survival to hospital discharge improved significantly for younger patients, octogenarians, and nonagenarians who had ventricular fibrillation or pulseless ventricular tachycardia (36% vs 24% vs 17%; P < .001). After multiple logistic regression analysis controlling for other factors, increased age was weakly associated with decreased survival to hospital discharge (odds ratio, 0.92; 95% confidence interval, 0.85-0.99).

Conclusions: Octogenarians and nonagenarians have lower survival to hospital discharge than younger patients, but age is a much weaker predictor of survival than other factors such as initial cardiac rhythm. Decisions regarding resuscitation should not be based on age alone.

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While the risk of sudden cardiac death increases with age, the survival benefit in elderly patients from out-of-hospital resuscitation is controversial. Some studies demonstrate an inverse relation between age and survival, but others show no relation at all. Also, elderly patients may have worse neurological outcomes, although other studies found this was not significantly different between younger and older patients. Elderly patients have been defined as the population older than 70 years, but as life expectancy has increased, this definition may not be as relevant as before. Studies that have commented on out-of-hospital cardiac arrest in octogenarians and nonagenarians have been limited by small numbers of these patients.

Studies examining age and rhythm have found that age was a less important prognostic indicator of survival than if the patients had ventricular fibrillation (VF) or ventricular tachycardia (VT) as their initial rhythm in cardiac arrest. In studies of out-of-hospital cardiac arrest in general, survival has also been positively associated with witnessed arrest, decreased time from collapse to emergency medical service (EMS) care and cardiopulmonary resuscitation (CPR), bystander CPR, and public location of cardiac arrest. These factors have tended to be less favorable in elderly patients than in younger patients, and account at least in part for the association between age and increased mortality after out-of-hospital cardiac arrest.

In this retrospective cohort study, we compare the survival of elderly and younger patients for out-of-hospital cardiac arrest, and examine the distribution of other factors that could influence survival.

RESULTS

During the 12-year study, EMTs and paramedics attempted resuscitation on 5882 persons who were experiencing cardiac arrest due to presumed heart disease. Of these, 4572 (78%) were in individuals...
PATIENTS AND METHODS

Since 1976 in suburban King County, Washington (1990 population, 1,000,000), excluding the city of Seattle, a surveillance system has existed to identify every case of out-of-hospital cardiac arrest receiving emergency care. This system has been described in detail elsewhere. Emergency medical services are provided by a tiered response system. Firefighters trained as emergency medical technicians (EMTs) provide the first response, and paramedics provide the second response. The EMTs are equipped and trained in the use of defibrillators. Emergency medical technicians and paramedics have an average response time of 4.5 and 10 minutes, respectively. Data are abstracted from a medical incident report form completed by EMTs and paramedics, and include demographic information, whether the collapse was witnessed, whether bystander CPR was performed, the location of cardiac arrest, times from collapse to CPR and to the arrival of the responding units, and cardiac rhythm on arrival of the first EMS personnel. The interval of collapse to onset of CPR was estimated for incidents in which the collapse was directly witnessed or heard. A cardiac arrest case is defined as a person with a pulseless condition confirmed by an EMT or paramedic and for whom CPR is performed by a King County EMT or paramedic. For patients who experienced cardiac arrest in 1996 and 1997, we determined how many had “do not resuscitate” papers and if resuscitation was performed. The cause and outcome of each cardiac arrest was determined from medical incident report forms, hospital records, death certificates, and autopsy reports. Patients are presumed to have a cardiac cause for their arrest unless indicated otherwise by these sources. Survival was measured as discharge from the hospital, and information was collected on where patients were discharged to.

The study retrospectively examines patients experiencing cardiac arrest and receiving care between January 1, 1987, and December 31, 1998. Utstein recommendations for reporting survival were followed. We did not collect information on return of spontaneous circulation and thus this element of the Utstein template is not reported. Comparisons between categorical variables were evaluated with χ² analysis, and between continuous variables with t or F tests. The effect of age on survival to hospital discharge was calculated with unconditional logistic regression; the interaction of age with other covariates was calculated and entered into the model if significant, and relevant covariates were entered into the model and goodness of fit assessed. Age was analyzed as a continuous and a categorical variable.

From 1994 to 1996, a contemporaneous prospective study examined neurological and functional outcomes in patients who had out-of-hospital cardiac arrest. Interviews were conducted with survivors of out-of-hospital cardiac arrest at 4 weeks, 6 months, and 12 months after discharge from the hospital. During the interview, 6 scales were used: the Medical Outcomes Survey 36-Item Short Form Health Survey and the Duke Activity Index in the physical domain; the Medical Outcomes Survey 36-Item Short Form Health Survey, Cerebral Performance Examination, and the Depression Scale in the psychological domain; and the Employment Activity Index in the work performance domain. Scores were compared with national norms and with those of age- and sex-matched patients who were admitted for severe chest pain from the Myocardial Infarction Triage and Intervention Project database.

Younger than 80 years, 1084 (18%) were in octogenarians, and 226 (4%) occurred in nonagenarians; 15% of the younger patients, 2% of the octogenarians, and 1% of the nonagenarians (P < .001) underwent autopsy. Characteristics of octogenarians, nonagenarians, and younger patients are shown in Table 1 for the entire cohort of patients who had cardiac arrest. The percentage of patients who had VF or VT differed significantly between age groups, with the percentage of patients with VF or VT decreasing with age.

For patients who experienced cardiac arrest in 1996 or 1997, we had information on do not resuscitate orders: 172 patients, 107 (62%) of whom were aged 80 years or older, had do not resuscitate papers, and 114 (66%) had CPR prevented because of the papers. The remaining 58 patients (34%) had CPR started because the papers were not immediately available or not signed.

Overall survival to hospital discharge for patients who had out-of-hospital cardiac arrest with a cardiac cause was higher in younger patients than in octogenarians (19.4% vs 9.4%; P < .001) and higher in octogenarians vs nonagenarians (9.4% vs 4.4%; P = .02). Figure 1 and Figure 2 illustrate survival differences in different subgroups of patients who had cardiac arrest. Octogenarians who had VF or VT and witnessed cardiac arrest had a lower survival to hospital discharge than younger pa-

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home (4.7% vs 14.0%; P<.001). Age was weakly associated with survival to hospital discharge after adjustment for these covariates; for every decade increase in age, survival was decreased by 8%. Analyzing age as a continuous variable did not significantly change the odds ratio or the confidence interval. Age did not significantly interact with any of the covariates.

For assessment of neurological and functional outcomes after out-of-hospital cardiac arrest, 162 consecutive adults who survived to hospital discharge were eligible; 116 (72%) of the survivors and 48 control subjects were interviewed. Permission was denied to examine 16 patients (10%) by the patient’s personal physician, the patient’s family, or the patient because of health problems possibly related to the cardiac arrest. Thirteen patients (8%) died before they could be interviewed. When compared with age- and sex-matched controls and with national norms, the survivors had no significant reduction in the instrument scales. This was true for the subgroups of survivors by age group, sex, and location of arrest.

Table 1. Comparison of Factors Associated With Survival After Cardiac Arrest in Octogenarians, Nonagenarians, and Younger Persons

<table>
<thead>
<tr>
<th>Factor</th>
<th>Persons Younger Than 80 y (n = 4572)</th>
<th>Octogenarians (n = 1084)</th>
<th>P†</th>
<th>Octogenarians (n = 1084)</th>
<th>Nonagenarians (n = 226)</th>
<th>P†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age, y</td>
<td>64</td>
<td>83</td>
<td></td>
<td>83</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3411 (75)</td>
<td>607 (56)</td>
<td>&lt;.001</td>
<td>607 (56)</td>
<td>68 (30)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female</td>
<td>1161 (25)</td>
<td>477 (44)</td>
<td></td>
<td>477 (44)</td>
<td>158 (70)</td>
<td></td>
</tr>
<tr>
<td>Initial rhythm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventricular fibrillation or ventricular tachycardia</td>
<td>2401 (53)</td>
<td>337 (31)</td>
<td>&lt;.001</td>
<td>337 (31)</td>
<td>54 (24)</td>
<td></td>
</tr>
<tr>
<td>Pulseless electrical activity, asystole, or bradycardia</td>
<td>2094 (46)</td>
<td>722 (67)</td>
<td>&lt;.001</td>
<td>722 (67)</td>
<td>165 (73)</td>
<td>.04</td>
</tr>
<tr>
<td>Rhythm not known</td>
<td>77 (2)</td>
<td>25 (2)</td>
<td></td>
<td>25 (2)</td>
<td>7 (3)</td>
<td></td>
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<tr>
<td>Witnessed arrest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrest witnessed</td>
<td>2610 (57)</td>
<td>519 (48)</td>
<td></td>
<td>519 (48)</td>
<td>105 (46)</td>
<td></td>
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<tr>
<td>Arrest unwitnessed</td>
<td>1690 (37)</td>
<td>477 (44)</td>
<td>&lt;.001</td>
<td>477 (44)</td>
<td>109 (48)</td>
<td>.40</td>
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<tr>
<td>Bystander CPR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CPR administered</td>
<td>2372 (52)</td>
<td>496 (46)</td>
<td>&lt;.001</td>
<td>496 (46)</td>
<td>100 (44)</td>
<td>.68</td>
</tr>
<tr>
<td>No CPR administered</td>
<td>2200 (48)</td>
<td>588 (54)</td>
<td>&lt;.001</td>
<td>588 (54)</td>
<td>126 (56)</td>
<td></td>
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<td>Location of arrest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>3323 (73)</td>
<td>773 (71)</td>
<td>&lt;.001</td>
<td>773 (71)</td>
<td>145 (64)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Public location</td>
<td>1078 (24)</td>
<td>104 (10)</td>
<td></td>
<td>104 (10)</td>
<td>10 (4)</td>
<td></td>
</tr>
<tr>
<td>Nursing home</td>
<td>170 (4)</td>
<td>205 (19)</td>
<td></td>
<td>205 (19)</td>
<td>71 (31)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>3 (0.1)</td>
<td>2 (0.2)</td>
<td></td>
<td>2 (0.2)</td>
<td>0 (0)</td>
<td></td>
</tr>
</tbody>
</table>

*Data are given as the number (percentage) of persons unless otherwise indicated. Percentages may not total 100 because of rounding. CPR indicates cardiopulmonary resuscitation; ellipses, data not applicable.
†x² analysis.

COMMENT

Virtually all studies of cardiac arrest in elderly patients report outcomes for persons aged 70 years and older compared with those younger than 70 years. The contradictory findings, combined with the steady increase in the number of octogenarians and nonagenarians, led us to examine the out-of-hospital cardiac arrest outcomes for this age group. Overall, we found that younger patients have a higher likelihood of survival compared with octogenarians and nonagenarians. Increased age is associated with increased mortality primarily because fewer octogenarians have VF or VT, a rhythm with a favorable prognosis. If octogenarians have VF or VT, their survival reaches two thirds of the survival of younger patients with VF or VT, and nonagenarians with VF or VT have a survival exceeding two thirds of octogenarians with VF or VT.

Variability in outcomes between studies examining patients older than 70 years may have been due to variability in emergency medical systems between locations and differing baseline health of the examined patients who experienced sudden cardiac death. System factors include length of time to EMS response and availability of early defibrillation, both associated with likelihood of survival. Because of such system factors, cities such as Seattle and Milwaukee have relatively high survival rates, whereas cities such as New York and Chicago have lower ones. If the overall survival rates after sudden cardiac death are poor in elderly patients, studies need to place the findings in context of low survival rates of all age groups. In addition, younger patients have lower rates of structural heart disease than elderly patients, but age is not a perfect predictor of underlying disease. Therefore, failure to adjust for comorbidity can lead to the assumption that increased age itself will preclude healthy survival. Some studies have extrapolated the survival rates for elderly patients who experience in-hospital cardiac arrest to community-dwelling elderly patients who experience out-of-hospital cardiac arrest, which can be problematic since these populations also differ in the severity of chronic illness. Finally, the denominators used to calculate survival can vary between studies and can dramatically change the survival rate.
In our study, survival improved significantly if the patient's initial rhythm was VF or VT. Octogenarians and nonagenarians had lower rates of VF or VT than younger patients, although not as low as those reported in other studies.\textsuperscript{4} This may be due to the fact that although coronary atherosclerosis is the most commonly associated condition with sudden cardiac death in all adults, elderly patients tend to have more structural heart disease, and different underlying diseases may manifest in different rhythms.\textsuperscript{1,32} It is also possible that elderly patients have higher rates of other diseases, such as cerebrovascular events, that predispose them to rhythms besides VF or VT, and that these diseases are underdiagnosed. In our cohort, few patients who eventually were determined to have a cardiac cause as the cause of their cardiac arrest underwent autopsy. Although their hospital records were reviewed for other causes of cardiac arrest, it is possible that a cardiac cause was overdiagnosed in octogenarians.

A limitation of our study was that we did not measure the morbidity of the entire cohort after out-of-hospital cardiac arrest, although for a subgroup, elderly patients did not have significantly worse outcomes than younger patients.\textsuperscript{23} Previous studies\textsuperscript{3,5,6,8,10,12,33} have found little difference between patients younger than 70 years and patients aged 70 years or older when residual neurologic impairment was examined, but it is possible that patients who chose not to participate were ill as a result of the cardiac arrest, and a difference in outcomes was masked. Also, we did not account for patients who did

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**Figure 1.** Out-of-hospital cardiac arrest in patients younger than 80 years. EMS indicates emergency medical service; VF, ventricular fibrillation; and VT, ventricular tachycardia.

**Figure 2.** Out-of-hospital cardiac arrest in octogenarians. EMS indicates emergency medical service; VF, ventricular fibrillation; and VT, ventricular tachycardia.
not undergo resuscitation efforts because of do not resuscitate orders, and the proportion of these may be higher in octogenarians and nonagenarians. Finally, we did not have information on morbidity at the time of resuscitation, although controlling for comorbidity may have reduced the association between age and survival even more.

Are our findings generalizable to other communities? Survival from cardiac arrest among elderly patients may differ between communities because the local EMS factors may vary. For example, response times may be longer or bystander CPR rates may be lower. However, regardless of absolute survival rate differences, the relative importance of predictors’ survival should not change. Therefore, our finding that a rhythm is a stronger predictor of survival than age should be generalizable to any community. Low survival rates in various communities may reflect failures of the system, not the predes-
tined outcome of the patient.

The decision to resuscitate can be highly complex. Ideally, it should be an informed decision made by the patient in collaboration with the physician and family members. Reducing this process to an algorithm based on age precludes resuscitation for some patients. Also, imposing an algorithm in the field would place an extra burden on prehospital emergency personnel. As the number of elderly persons increases, so will the dilemmas of whom and when to resuscitate. Our conclusion is that octogenarians and nonagenarians who have out-of-hospital cardiac arrest, associated with VF or VT, have a survival rate comparable to younger patients. Age alone should not be a reason to withhold resuscitation.

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We thank the King County Emergency Medical Services Division for administrative support, and the paramedics and emergency medical technicians who have collected data, making these types of studies possible.

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### Table 2. Survival to Hospital Discharge, Multivariate Logistic Regression Analysis

<table>
<thead>
<tr>
<th>Covariate</th>
<th>OR (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female sex</td>
<td>0.97 (0.76-1.30)</td>
</tr>
<tr>
<td>Age‡</td>
<td>0.92 (0.85-0.99)</td>
</tr>
<tr>
<td>Ventricular fibrillation or pulseless ventricular tachycardia</td>
<td>5.30 (4.00-7.00)</td>
</tr>
<tr>
<td>Witnessed arrest</td>
<td>1.70 (0.19-15.00)</td>
</tr>
<tr>
<td>Bystander cardiopulmonary resuscitation</td>
<td>1.00 (0.80-1.30)</td>
</tr>
<tr>
<td>Public location of arrest§</td>
<td>2.00 (1.60-2.50)</td>
</tr>
<tr>
<td>Arrest in nursing home§</td>
<td>0.61 (0.31-1.20)</td>
</tr>
<tr>
<td>Interval to bystander cardiopulmonary resuscitation (minutes)</td>
<td>0.92 (0.88-0.97)</td>
</tr>
<tr>
<td>Interval to emergency medical service provider care (minutes)</td>
<td>0.95 (0.93-0.97)</td>
</tr>
</tbody>
</table>

*OR indicates odds ratio; CI, confidence interval.

‡Results were significant (P < .05).

§The OR is given in reference to arrest in the home.

### References