Resuscitation Science

Impact of Onsite or Dispatched Automated External Defibrillator Use on Survival After Out-of-Hospital Cardiac Arrest

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Background—There have been few studies on the effectiveness of bystander automated external defibrillator (AED) use in out-of-hospital cardiac arrest. The objective of this study was to determine whether actual use of onsite or dispatched AED reduces the time to first shock compared with no AED use and thereby improves survival.

Methods and Results—We performed a population-based cohort study of 2833 consecutive patients with a nontraumatic out-of-hospital cardiac arrest before emergency medical system arrival between 2006 and 2009. The primary outcome, neurologically intact survival to discharge, was compared by use of multivariable logistic regression analysis. An onsite AED had been applied in 128 of the 2833 cases, a dispatched AED in 478, and no AED in 2227. Onsite AED use reduced the time to first shock from 11 to 4.1 minute. Neurologically intact survival was 49.6% for patients treated with an onsite AED compared with 14.3% without an AED (unadjusted odds ratio, 5.63; 95% confidence interval, 3.91–8.10). The odds ratio remained statistically significant after adjustment for confounding (odds ratio, 2.72; 95% confidence interval, 1.77–4.18). Dispatched AED use reduced the time from call to first shock to 8.5 minutes. Neurologically intact survival was 17.2% for patients treated with a dispatched AED (unadjusted odds ratio, 1.07; 95% confidence interval, 0.82–1.39). Every year, onsite AEDs saved 3.6 lives per 1 million inhabitants; dispatched AEDs saved 1.2 lives.

Conclusions—The use of an onsite AED leads to a doubling of neurologically intact survival. In our system, the survival benefit of dispatched AED use was much smaller than that of onsite AED use. (Circulation. 2011;124:2225-2232.)

Key Words: automatic external defibrillator ■ cardiac arrest ■ defibrillation ■ outcomes research ■ resuscitation

Despite much effort, out-of-hospital cardiac arrest (OHCA) is generally reported as having poor outcome.1,2 Early defibrillation is essential for survival. An automated external defibrillator (AED) allows lay rescuers to advance defibrillation by starting treatment before emergency medical services (EMS) arrive on the scene.3 There are 2 ways of making an AED available to cardiac arrest victims. First, AEDs are placed at a specific location where people gather, such as shopping malls, airports, hotels, sports facilities, or public and office buildings (onsite AED); the placement of onsite AEDs is generally accompanied by training for local lay rescuers. Second, EMS may dispatch first responders like firefighters or policemen with an AED to the scene of the cardiac arrest (dispatched AED programs). In both programs, the reduction in time to shock is a critical factor that determines the effectiveness of the AED program. For onsite AEDs, the time to shock depends on the distance and vigilance of the trained local lay rescuers. For a dispatched AED, the time to shock is governed by the response time of the first responder.
Table 1. Study Area and Number of Onsite and Dispatched Automated External Defibrillators

<table>
<thead>
<tr>
<th>AEDs</th>
<th>Present on Site</th>
<th>Available for Dispatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study area, km²</td>
<td>3818</td>
<td>1206</td>
</tr>
<tr>
<td>Inhabited study area, km²*</td>
<td>1353</td>
<td>653</td>
</tr>
<tr>
<td>Population served, n</td>
<td>2,426,097</td>
<td>1,325,410</td>
</tr>
<tr>
<td>Total AEDs, n</td>
<td>1,583</td>
<td>67</td>
</tr>
<tr>
<td>Per 1 km²</td>
<td>0.41</td>
<td>0.06</td>
</tr>
<tr>
<td>Per 1 km² inhabited area*</td>
<td>1.17</td>
<td>0.10</td>
</tr>
<tr>
<td>Per 100,000 population</td>
<td>65.25</td>
<td>5.06</td>
</tr>
<tr>
<td>Patients treated by AED per year, n</td>
<td>0.03</td>
<td>2.20</td>
</tr>
</tbody>
</table>

AED indicates automated external defibrillator.

*Defined as areas in which people can live, excluding forests, lakes, and agricultural areas.

Emergency personnel dial the national emergency number. Calls are immediately transferred to the regional EMS dispatch center. When suspecting a cardiac arrest, the EMS dispatcher sends out 2 ambulances from a single tier. The standard EMS consists of ambulances with a team qualified to perform advanced cardiopulmonary life support and equipped with a manual defibrillator (LIFEPAK 12, Physio Control Inc, Redmond WA). In part of the study area, the EMS personnel inspected the AED and collected its ECG and the impedance recording. All ECGs were stored and analyzed with dedicated software. Clock drift of all defibrillators was corrected to standardized times for each recording.

We distinguished patients in whom an onsite AED had been used, a dispatched AED had been used, and no AED had been used. Patients were excluded from the analysis if the use of an AED could not be verified. We verified the actual use of the AED by reviewing the impedance signal for chest compressions and by reviewing the continuous ECG recording for rhythm analysis and delivered shocks. If the AED did not contain an ECG recording, we presumed that the AED had not been used effectively; these cases were counted as patients in whom no AED had been used. AED cases were also excluded if they had been treated by a mobile general practitioner unit.

**Onsite AEDs in the Study Region**

Placement of AEDs in public areas, including schools, retirement homes, work places, sports and cultural facilities, and transportation facilities, has been facilitated by public and private initiatives, but is not centrally controlled or directed. In the province of North Holland, the total number of onsite (out-of-hospital) AEDs, as proportionally estimated from national AED sales, was 1583 during the study period (Table 1). Placement of onsite AEDs is generally accompanied by training for local lay rescuers such as shop owners, according to the guidelines of the European Resuscitation Council. Only these trained onsite lay rescuers have access to AEDs. At least 1 trained lay rescuer is present at sites where AEDs have been placed. The AEDs are not used by nonassigned lay rescuers.

**Design of the Amsterdam Resuscitation Study Registry**

The Amsterdam Resuscitation Study (ARREST) is an ongoing, prospective registry of all OHCAs in the Dutch province of North Holland. All data are collected according to the Utstein recommendations. The institutional review board approved the study. The requirement of written informed consent was waived.

**Study Design**

The present analysis included all consecutive patients with an OHCA of presumed cardiac origin in whom a resuscitation attempt had been undertaken by EMS personnel between January 1, 2006, and March 31, 2009. Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation. All arrests were deemed of cardiac origin unless an unequivocal noncardiac cause was documented. We reviewed all case files and verified the presence of a noncardiac cause. We excluded EMS-witnessed cardiac arrests and aborted resuscitation efforts in individuals with a “do not resuscitate” status, and in cases of signs of prolonged death such as rigor mortis.

**Exposure Status**

EMS personnel routinely reported whether an onsite AED or a dispatched first responder AED had been applied. First responders (firefighters or policemen) routinely contacted the study center immediately after they applied an AED. Study personnel inspected the AED and collected its ECG and the impedance recording. All ECGs were stored and analyzed with dedicated software. Clock drift of all defibrillators was corrected to standardized times for each recording.

We distinguished patients in whom an onsite AED had been used, a dispatched AED had been used, and no AED had been used. Patients were excluded from the analysis if the use of an AED could not be verified. We verified the actual use of the AED by reviewing the impedance signal for chest compressions and by reviewing the continuous ECG recording for rhythm analysis and delivered shocks. If the AED did not contain an ECG recording, we presumed that the AED had not been used effectively; these cases were counted as patients in whom no AED had been used. AED cases were also excluded if they had been treated by a mobile general practitioner unit.

**Definitions**

Time to shock was determined by calculating the time between the beginning of the emergency call and the first shock given by either the AED or the manual defibrillator. Survival to discharge was determined by review of the hospital charts, and survival was confirmed in the civic registry. Two researchers (J.B. and A.B.) classified neurological outcome on the Cerebral Performance Category scale by reviewing hospital charts of patients who survived until hospital discharge. Category 1 represents good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death. Neurologically intact survival was defined as a Cerebral Performance Category of 1 or 2.

**Data Analyses**

The primary end point of this analysis was neurologically intact survival to discharge; the secondary end point was survival to discharge. In a logistic regression analysis, neurologically intact survival to hospital discharge was regressed on binary indicators of whether an onsite AED or a dispatched AED was used before EMS arrival (adjusting for whether the study area dispatched AEDs) and the prognostic factors age, sex, location of the collapse at home, bystander cardiopulmonary resuscitation (CPR) performed, witnessed collapse, shockable initial rhythm, and time interval from emergency call to EMS arrival.

We further addressed potential confounding in the observed relationship between AED use and survival through a propensity analysis to account for a patient’s probability of receiving treatment with an onsite or a dispatched AED. We estimated propensity scores as predicted probabilities from a logistic regression model with AED use as the outcome and the covariates listed previously as predictors. We then stratified patients by propensity score in 6 strata with approximately the same number of survivors. A stratified Mantel-Haenszel analysis was performed to estimate the odds ratio (OR) for survival with onsite or dispatched AED use versus no AED use, stratified by propensity score.

Next, we calculated the number of lives saved attributable to use of an onsite or a dispatched AED by comparing the observed survival rate with the expected survival rate had the AED not been used. The expected survival was calculated from the multivariable logistic regression model described above by setting the indicator for AED use to 0. The expected survival percentage was calculated as the average of the individual expected survival percentage.

**Results**

**Inclusion**

During the 39-month study period, EMS personnel attempted to resuscitate 3,604 OHCA patients, 3,160 of whom had a
presumed cardiac cause. We excluded 327 patients (the Figure). The eventual analysis cohort consisted of 2833 arrests; 128 patients (5%) had been treated with an onsite AED, 478 (17%) were treated with a dispatched AED, and 2227 (79%) had not received AED treatment. Lay rescuers brought the onsite AED from a nearby location other than the location of the arrest in 32 of 128 cases (25%); most were from a nearby public building (9 of 32, 28%) or were publicly available AEDs (8 of 32, 25%).

Onsite AED Treatment Versus No AED Treatment

Table 2 shows patient and process characteristics. Most OHCAs occurred at home (1962 of 2833, 69%). An onsite AED had been applied in 0.6% of these cases (11 of 1962) that had not received AED treatment. Lay rescuers brought the onsite AED from a nearby location other than the location of the arrest in 32 of 128 cases (25%); most were from a nearby public building (9 of 32, 28%) or were publicly available AEDs (8 of 32, 25%).

Onsite AED received the first shock 6 minutes (median) earlier.

Patients treated with an onsite AED had a significantly higher rate of neurologically intact survival than those without AED treatment (50% versus 14%, respectively; unadjusted OR, 5.63; 95% confidence interval [CI], 3.91–8.10; Tables 3 and 4). The OR for neurologically intact survival remained statistically significant after adjustment for confounding by age, public location, witness status, bystander CPR, dispatched AED area, and initial rhythm in a multivariable regression analysis (adjusted OR, 2.72; 95% CI, 1.77–4.18). Adjustment with a stratified propensity score analysis yielded a similar OR (2.60; 95% CI, 1.67–4.01). The adjusted ORs were virtually the same when the population was restricted to those arrests that occurred at a public location or to those that received bystander CPR.

Among patients with a shockable initial rhythm, those who had been treated with an onsite AED had a significantly higher rate of neurologically intact survival (64% versus 28%, respectively; unadjusted OR, 4.26; 95% CI, 2.77–6.57; Tables 3 and 4). The OR remained statistically significant after adjustment for relevant prognostic confounders in a multivariable regression analysis, after adjustment with a
stratified propensity score analysis, and after restriction to those who were at a public location or those who received bystander CPR.

Among patients with a nonshockable initial rhythm, those who had been treated with an onsite AED had a rate of neurologically intact survival similar to those without AED treatment (3% versus 2%, respectively; unadjusted OR, 1.46; 95% CI, 0.19–11.00; Tables 3 and 4). The ORs were similar after adjustment for relevant prognostic confounders in a multivariable regression analysis, after adjustment with a stratified propensity score analysis, and after restriction to those who were at a public location or those who received bystander CPR.

**Dispatched AED Treatment Versus No AED Treatment**

Patient characteristics were similar for patients treated with a dispatched AED and those not receiving AED treatment (Table 2). Patients treated with a dispatched AED were more likely to have received bystander CPR and received the first shock 2.5 minutes (median) earlier.

### Table 2. Characteristics of 2833 Out-of-Hospital Cardiac Arrests by Automated External Defibrillator Treatment Received

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Treated With an Onsite AED</th>
<th>Treated With a Dispatched AED</th>
<th>Not Treated With an AED</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events, n</td>
<td>2833</td>
<td>128</td>
<td>478</td>
<td>2227</td>
<td></td>
</tr>
<tr>
<td>Patient age, mean±SD, y</td>
<td>65±15</td>
<td>61±14</td>
<td>65±15</td>
<td>66±15</td>
<td>0.01</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>2094 (74)</td>
<td>111 (87)</td>
<td>338 (71)</td>
<td>1645 (74)</td>
<td>0.01</td>
</tr>
<tr>
<td>Collapse location, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At home</td>
<td>1962 (69)</td>
<td>11 (9)</td>
<td>345 (72)</td>
<td>1606 (72)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Street/highway</td>
<td>408 (14)</td>
<td>22 (17)</td>
<td>60 (13)</td>
<td>326 (15)</td>
<td></td>
</tr>
<tr>
<td>Industrial place</td>
<td>41 (1)</td>
<td>5 (4)</td>
<td>5 (1)</td>
<td>31 (1)</td>
<td></td>
</tr>
<tr>
<td>Place of sports/recreation</td>
<td>150 (5)</td>
<td>32 (25)</td>
<td>22 (5)</td>
<td>96 (4)</td>
<td></td>
</tr>
<tr>
<td>Other public building</td>
<td>265 (9)</td>
<td>57 (45)</td>
<td>44 (9)</td>
<td>164 (7)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7 (0)</td>
<td>1 (1)</td>
<td>2 (0)</td>
<td>4 (0)</td>
<td></td>
</tr>
<tr>
<td>Witnessed collapse, n (%)</td>
<td>2162 (76)</td>
<td>115 (90)</td>
<td>354 (74)</td>
<td>1693 (76)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bystander CPR performed, n (%)</td>
<td>1837 (65)</td>
<td>127 (99)</td>
<td>426 (89)</td>
<td>1284 (58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Shockable initial rhythm, n (%)</td>
<td>1372 (48)</td>
<td>97 (76)</td>
<td>238 (50)</td>
<td>1037 (47)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EMS response time, median (Q1–Q3), min</td>
<td>9.0 (6.0–11.0)</td>
<td>9.0 (6.1–11.4)</td>
<td>9.2 (7.9–11.5)</td>
<td>8.9 (7.0–11.0)</td>
<td>0.33</td>
</tr>
<tr>
<td>Time from call to first shock, median (Q1–Q3), min</td>
<td>10.3 (8.0–13.1)</td>
<td>4.1 (2.0–7.5)</td>
<td>8.5 (6.3–10.5)</td>
<td>11.0 (8.7–13.7)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; and Q, quartile. Comparisons of continuous variables were made with ANOVA; comparisons of discrete variables were made with the Kruskal-Wallis; the χ² test was used when binary variables were compared. All statistical tests were 2 tailed.

### Table 3. Neurologically Intact Survival After Out-of-Hospital Cardiac Arrest According to Automated External Defibrillator Treatment Received

<table>
<thead>
<tr>
<th>Initial Rhythm</th>
<th>Total</th>
<th>Treated With an Onsite AED</th>
<th>Treated With a Dispatched AED</th>
<th>Not Treated With an AED</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>n/N</td>
<td>%</td>
<td>n/N</td>
<td>%</td>
</tr>
</tbody>
</table>

Any initial rhythm
- **All arrests**
  - 16.4 | 464/2833 | 49.2 | 63/128 | 17.2 | 82/478 | 14.3 | 319/2227 |
  - **Arrests in public locations**
    - 30.3 | 264/871 | 52.1 | 61/117 | 38.0 | 49/133 | 24.8 | 154/621 |
  - **Arrests with bystander CPR**
    - 20.6 | 379/1837 | 49.6 | 63/127 | 18.1 | 77/426 | 18.6 | 239/1284 |

Shockable initial rhythm
- **All arrests**
  - 31.5 | 432/1372 | 63.9 | 62/97 | 32.4 | 77/238 | 28.3 | 293/1037 |
  - **Arrests in public locations**
    - 42.9 | 249/581 | 67.0 | 59/88 | 50.0 | 46/92 | 35.9 | 144/401 |
  - **Arrests with bystander CPR**
    - 37.0 | 357/1022 | 64.2 | 61/95 | 33.5 | 72/215 | 31.5 | 224/712 |

Nonshockable initial rhythm
- **All arrests**
  - 2.2 | 32/1461 | 3.2 | 1/31 | 2.1 | 5/240 | 2.2 | 26/1190 |
  - **Arrests in public locations**
    - 5.2 | 15/290 | 6.9 | 2/29 | 7.3 | 3/41 | 4.5 | 10/220 |
  - **Arrests with bystander CPR**
    - 2.7 | 22/815 | 6.3 | 2/32 | 2.4 | 5/211 | 2.6 | 15/572 |

AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation.
Neurologically intact survival was not statistically significantly improved among patients treated with a dispatched AED compared with those without AED treatment (17% versus 14%, respectively; unadjusted OR, 1.07; 95% CI, 0.82–1.39; Tables 3 and 4). The ORs were unchanged after adjustment for confounding and after limiting the population to those who had received bystander CPR. When the population was limited to arrests that occurred in a public location,
there was a statistically significant benefit in survival (multivariable-adjusted OR, 1.88; 95% CI, 1.18–3.00; propensity score–adjusted OR, 1.52; 95% CI, 0.96–2.39). Among patients with a shockable initial rhythm, neurologically intact survival of patients treated with a dispatched AED was similar to that of patients without AED treatment (32% versus 28%, respectively; unadjusted OR, 1.06; 95% CI, 0.79–1.43; Tables 3 and 4). The ORs were similar to those for all initial rhythms. Among patients with a nonshockable initial rhythm, those who had been treated with a dispatched AED had a similar rate of neurologically intact survival (2% versus 2%; unadjusted OR, 0.87; 95% CI, 0.33–2.27; Tables 3 and 4). These ORs also were similar to those for all initial rhythms.

**Lives Saved by AED Treatment**

We estimated that the use of onsite AEDs saved 3.6 lives per 1 million population per year, whereas AEDs dispatched by the EMS response system saved 1.2 lives per 1 million population per year (Table 5).

**Discussion**

From a continuous registry of OHCA in a population of 2.4 million inhabitants, we report an increased survival when onsite AEDs were used. Multiple analytic approaches designed to account for confounding consistently demonstrated a statistically significant benefit in neurologically intact survival of onsite AED use, with an OR of ≈2.8 for all arrests and of 3.9 for arrests with a shockable initial rhythm. Our results are consistent with those of previous studies showing that onsite AEDs available in public locations effectively improve survival after OHCA among patients with ventricular fibrillation.⁷⁻⁹ The Public Access Defibrillation Trial demonstrated the benefit of onsite AED use in prospective, community-based, multicenter clinical trial in which community units were randomly assigned and lay responders centrally trained.⁹ In our contiguous OHCA registry, AED placement was uncontrolled and training of lay responders was done by local initiative, reflecting the unintended way that AEDs were implemented. Regardless, our study shows a survival benefit of onsite AED use similar to that of the Public Access Defibrillation Trial.

The median time to ambulance arrival was ≈9 minutes in all groups. Patients treated with an onsite AED received their first shock a median 4 minutes after the call to the dispatch center. If no onsite AED had been present, these patients would presumably have received their first shock at ≈2 minutes after EMS arrival, ie, at 11 minutes, similar to the delay observed in patients with no AED treatment. Thus, onsite AED treatment shortened the time to shock ≈7 minutes. We previously demonstrated that the survival rate of patients receiving their first shock at 5 minutes is twice as high as that of patients treated at 11 minutes.²¹ In our study, the expected survival of onsite AED patients was 27.5%, whereas the AED not been used. The application of the onsite AED almost doubled survival to 49.6%. We conclude that the survival benefit of treatment with an onsite AED is fully explained by a shortening of the time to first shock and the associated higher proportion of patients found in ventricular fibrillations.

We report a marginal survival benefit from the use of a dispatched AED. In a subgroup analysis, however, we found an indication that dispatched AEDs may be effective when the arrest occurs in a public location. In our study, dispatching an AED led to a shortening of the time from call to shock from 11 to 8.5 minutes. This limited reduction in time to shock, observed at the end of the survival window, explains the marginal benefit.²¹ Our findings, consistent with earlier observations in our EMS system,³ are supported by Myerburg et al.,¹⁰ who found a small increase in survival of 7.6% with dispatched AED use versus 6.0% without AED use, with an improvement in response time from 8.1 to 5.3 minutes. Capucci et al.¹¹ found a much greater (unadjusted) survival benefit of 10.5% with dispatched AED use versus 3.3% without AED use, with a reduction in response time from 6.2 to 4.8 minutes. This greater benefit may be explained by the fact that the reduction in response time occurred at the beginning of the survival window; the same reduction in time to shock may be of little to no benefit in EMS systems with a longer response time. Moreover, the study lacked appropriate control for confounding. Our data contradict the expected benefit of dispatched AEDs calculated in a study by Pell²² using a statistical modeling approach.

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**Table 5. Observed and Expected Neurologically Intact Survival by Automated External Defibrillator Treatment Received**

<table>
<thead>
<tr>
<th>Treatment Received</th>
<th>Treated With an Onsite AED (n=128)</th>
<th>Treated With a Dispatched AED (n=478)</th>
<th>Not Treated With an AED (n=2227)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed survival, % (n)</td>
<td>49.6 (63)</td>
<td>17.2 (82)</td>
<td>14.3 (319)</td>
</tr>
<tr>
<td>Expected survival without AED use, mean %</td>
<td>27.5</td>
<td>16.1</td>
<td>14.4</td>
</tr>
<tr>
<td>Lives saved by AED use per year†</td>
<td>8.7</td>
<td>1.6</td>
<td>NA</td>
</tr>
<tr>
<td>Lives saved by AED use per 1 million inhabitants per year</td>
<td>3.6</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

AED indicates automated external defibrillator.

*The expected survival was calculated from a multivariable logistic regression model with the variables AED use, age, location of the collapse, witnessed collapse, and shockable initial rhythm by setting the indicator for AED use to 0. The shown expected survival percentage was the average of the individual expected survival percentage.

†The total time of the study was 3.25 years.

‡The study population is 2.4 million.
Our study demonstrates that the improved survival after AED use applies specifically to the use of onsite AEDs and the associated shortened time to defibrillation. The Resuscitation Outcomes Consortium found an adjusted OR of 1.8 for survival associated with AED use before ambulance arrival.\textsuperscript{12} We think that the OR presented in their study is similar to a weighted average of the ORs that we observed: 3.2 for onsite AED use and 1.1 for dispatched AED use.

In our study, \(\approx 16\%\) of the arrests occurred in public places. Only 19\% of those arrests received treatment with an onsite AED. One may speculate that most of the remaining cases would have been amenable to treatment with an onsite AED. Potentially, 12 additional lives per 1 million inhabitants would have been saved each year if all these patients had been treated with an onsite AED. This observation provides a rationale to increase the availability of onsite AEDs at public locations, with an emphasis on areas with the highest probability of OHCA. A recent study from Copenhagen demonstrated that undirected placement of a limited amount of AEDs (104 AEDs or 17 per 100 000 inhabitants) would result in a severe mismatch between sites of OHCA and location of AEDs and would be used at most in 2.2\% of all public OHCA, assuming full use of each available AEDs for a OHCA in a grid cell.\textsuperscript{23} We estimate that the overall availability of AEDs in the onsite locations in our study was \(\approx 4\) times higher (65 of 100 000 inhabitants), and we suspect that the majority of the AEDs were in public locations. The observed 13.4\% of patients with an OHCA in a public area actually treated with an onsite AED in our study by far exceeded the expected proportion calculated in Copenhagen.

The majority of the OHCA, however, occur at home. Fewer than 1\% of all OHCA at home were treated with an onsite AED. Access to a home AED did not significantly improve overall survival in patients with previous anterior wall myocardial infarction who were not candidates for an implantable cardioverter-defibrillator.\textsuperscript{24} According to another recent study from Copenhagen, placement of onsite AEDs in densely populated, low-income, and low-education residential areas might be cost-effective, provided that ventricular fibrillation survival is \(\geq 25\%\).\textsuperscript{25}

Dispatched AEDs reach OHCA patients in residential areas equally as well as EMS but only marginally faster. The use of dispatched AEDs can be recommended only if it leads to a substantial reduction in time to first shock. Our current system of dispatching AEDs does not meet this requirement. Programs of dispatching AEDs should be critically reviewed with regard to the reduction in time to first shock. If the decrease is small, all efforts should be undertaken to improve the response time interval.

Limitations

A limitation of this analysis is the observational nature of the data. Yet, the purpose of our study was to describe the contribution of actual AED treatment to survival in a real-world situation. This research question can be addressed only in an observational context. Another limitation is a possible bias in the survival benefit of dispatched AED use because the onsite and dispatched AED regions overlap. The underestimation was marginal because we estimated by extrapolating our observations. The expected survival of the dispatched AED group showed a minimal increase from 17.2\% to 17.7\% after the inclusion of patients treated with an onsite AED in the dispatched AED region (data not shown). We performed case verification, outcome verification, and sensitivity analyses for bystander CPR and public location of the arrest and adjusted for confounding in multiple ways. Although we cannot completely rule out the possibility of residual confounding, we believe that the observed benefit of onsite AEDs is genuine.

Conclusions

The use of an onsite AED leads to a substantial reduction in time to first shock and therefore to a doubling of the neurologically intact survival after OHCA to 50\%. Onsite AEDs are used mainly in nonresidential areas; further increasing the density of AEDs can enhance the potential benefit. Patients suffering an OHCA in residential areas are rarely treated with AEDs from public areas. Systems of dispatched AEDs serve OHCA patients in residential areas but should be critically evaluated with regard to the shortening in the time to first shock.

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Disclosures

None.

References


Patients suffering an out-of-hospital cardiac arrest depend heavily on the time to defibrillation for survival. An automated external defibrillator (AED) allows lay rescuers to advance defibrillation by starting the treatment before emergency medical services arrive on the scene. These AEDs can be either placed at the scene (onsite AEDs) or dispatched to the scene with firefighters or police vehicles (dispatched AEDs). Little is known about the time delays involved in onsite and dispatched AED programs and how they influence effectiveness. The use of an onsite AED substantially reduced time to first shock from 11 to 4 minutes, thereby increasing neurologically intact survival after out-of-hospital cardiac arrest.

**Clinical Perspective**

Patients suffering an out-of-hospital cardiac arrest depend heavily on the time to defibrillation for survival. An automated external defibrillator (AED) allows lay rescuers to advance defibrillation by starting the treatment before emergency medical services arrive on the scene. These AEDs can be either placed at the scene (onsite AEDs) or dispatched to the scene with firefighters or police vehicles (dispatched AEDs). Little is known about the time delays involved in onsite and dispatched AED programs and how they influence effectiveness. The use of an onsite AED substantially reduced time to first shock from 11 to 4 minutes, thereby increasing neurologically intact survival after out-of-hospital cardiac arrest from 14% to 50%. The current density of onsite AEDs in the North Holland province saves an additional 3.6 lives per 1 million inhabitants per year. However, the majority of out-of-hospital cardiac arrests take place in residential areas and are not covered by publicly placed AEDs. Onsite AEDs are used mainly in nonresidential areas; further increasing the density of AEDs can enhance the potential benefit. Systems of dispatched AEDs serve out-of-hospital cardiac arrest patients in residential areas; dispatched AED use reduces the time from call to first shock to 8.5 minutes, increasing neurologically intact survival only to 17.2%. This limited reduction in time to shock, observed at the end of the survival window, explains the marginal benefit. Systems of dispatched AEDs should be evaluated critically in terms of shortening the time to first shock.
Impact of Onsite or Dispatched Automated External Defibrillator Use on Survival After Out-of-Hospital Cardiac Arrest

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