Efficacy of bystander CPR: Intervention by lay people and by health care professionals

Johan Herlitz a,∗, Leif Svensson b, Stig Holmberg a, Karl-Axel Angquist c, Marie Young d

a Division of Cardiology, Sahlgrenska University Hospital, SE-413 45 Göteborg, Sweden
b Division of Cardiology, South Hospital, Stockholm, Sweden
c Surgical Department, Norrland’s University Hospital, Umeå, Sweden
d Division of Anaesthesiology, Malmö University Hospital, Malmö, Sweden

Received 30 November 2004; received in revised form 1 April 2005; accepted 18 April 2005

Abstract

Background: Early cardiopulmonary resuscitation (CPR) by bystanders prior to the arrival of the rescue team has been shown to be associated with increased survival after out-of-hospital cardiac arrest. The aim of this survey was to evaluate the impact on survival of no bystander CPR, lay bystander CPR and professional bystander CPR.

Methods: Patients suffering an out-of-hospital cardiac arrest in Sweden between 1990 and 2002 who were given CPR and were not witnessed by the ambulance crew were included.

Results: In all, 29,711 patients were included, 36% of whom received bystander CPR prior to the arrival of the rescue team. Among the latter, 72% received CPR from lay people and 28% from professionals. Survival to 1 month was 2.2% among those who received no bystander CPR, 4.9% among those who received bystander CPR from lay people (p < 0.0001) and 9.2% among those who received bystander CPR from professionals (p < 0.0001 compared with bystander CPR by lay people). In a multivariate analysis, lay bystander CPR was associated with improved survival compared to no bystander CPR (OR: 2.04; 95% CI: 1.72–2.42), and professional bystander CPR was associated with improved survival compared to lay bystander CPR (OR: 1.37; 95% CI: 1.12–1.67).

Conclusion: Among patients suffering an out-of-hospital cardiac arrest, bystander CPR by lay persons (excluding health care professionals) is associated with an increased chance of survival. Furthermore, there is a distinction between lay persons and health care providers; survival is highest when the latter perform bystander CPR. However, these results may not be explained by differences in the quality of CPR.

© 2005 Elsevier Ireland Ltd. All rights reserved.

Keywords: Bystander cardiopulmonary resuscitation; Cardiac arrest

1. Introduction

The prognosis among patients who suffer an out-of-hospital cardiac arrest is poor [1]. In recent decades, the concept of the chain of survival has evolved [2]. The second link in this chain is early CPR. This means that the earlier CPR is started after cardiac arrest the better. So, if a bystander who happens to be close to a cardiac arrest victim starts to perform CPR before the arrival of the emergency medical service system, the chances of survival ought to be increased.

Bystander CPR has been shown to be associated with an increased chance of survival in several observational studies [3–7]. For various reasons, a randomised study evaluating the true impact of bystander CPR on survival has never been performed. It might be argued that the beneficial effect on survival associated with bystander CPR is explained by health care professionals who often perform bystander CPR. However, more than 20 years ago, based on a very small number of patients (n = 57), it was suggested that bystander CPR

∗ Corresponding author. Tel.: +46 31 342 1000; fax: +46 31 829650.
E-mail address: johan.herlitz@hjl.gu.se (J. Herlitz).

0300-9572/$ – see front matter © 2005 Elsevier Ireland Ltd. All rights reserved.
performed by lay people improved survival [8]. As the quality of CPR appears to influence outcome [9,10], it could be argued that bystander CPR performed by lay persons is of low-quality and therefore will not improve survival. However, this theory has never been tested.

The aim of this survey was to evaluate the impact on survival of no bystander CPR, lay bystander CPR and professional bystander CPR. Previously, we have reported from the registry, the association between bystander CPR and survival after out-of-hospital cardiac arrest [6,7]. We present now a detailed description of the outcome considering whether the bystander was a lay person or a professional.

2. Patients and Methods

2.1. Patients

Patients suffering from cardiac arrest for whom the ambulance was called were included in the registry, with the exception of patients who had obviously been dead for a long time and therefore were not taken to the hospital by the ambulance crew. For those included, a standardised form was completed by the ambulance crew. In this survey, arrest cases witnessed by the ambulance crew and patients in whom CPR was inappropriate, were excluded.

2.2. Registry

This study is based on material collected by the Swedish Cardiac Arrest Registry, which is a joint venture between the Federation of Leaders in Swedish Ambulance and emergency services (FLISA) and the working group on CPR within the Swedish Society of Cardiology. Since 1993, the registry has been funded by the Swedish National Board of Health and Welfare. The registry, which is voluntary, started in 1990 with a few ambulance services. It has been joined successively by more services and, in 1995, the registry was based on reports from 57 ambulance services (most of which were single tiered). These services cover 85% of the total of 8.7 million inhabitants in Sweden. This survey covers the period between 1990 and 2002.

2.3. Study design

For each case of out-of-hospital cardiac arrest, the ambulance crew (mostly two persons, of whom one was usually a nurse) completed a form with information, such as age, place of arrest, probable background to the arrest, bystander occupation and a description of the resuscitation procedure, including times and interventions, such as bystander CPR (a bystander was defined as someone starting CPR before arrival of the ambulance, regardless of profession), defibrillation, intubation, drug treatment and status at the first contact.

In ambulances with manual defibrillators, the rhythm was defined as ventricular fibrillation, pulseless electrical activity or asystole. For automated external defibrillators, the rhythm was defined as shockable or non-shockable. In this study, ventricular fibrillation includes patients with pulseless ventricular tachycardia.

Bystander professionals included all health care professionals (including ambulance personnel but not the crew of the duty ambulance). The remaining bystanders were defined as lay persons, who also included policemen.

To establish the time of cardiac arrest in witnessed cases, the ambulance crew was instructed to ask the bystanders about the delay from arrest to the call. The ambulance crew also classified the aetiology of the arrest into nine different diagnostic categories (heart disease, lung disease, trauma, drug overdose, suicide, drowning, suffocation, sudden infant death syndrome and others) based on clinical assessment and bystander information. Their diagnosis was accepted for this study and no further enquiries were made among initial survivors during hospitalisation.

The form was completed during and immediately after the acute event. Each form was sent to the medical director and a copy was sent to the central registry in Göteborg. Another copy containing additional information as to whether the patient was dead or alive after 1 month, was subsequently completed. If there was uncertainty about survival, this was checked with the National Registry of Deaths. All data were computerised in a database in Göteborg.

No validation of absolute adherence to the protocol was performed. Instead, a questionnaire was sent to all the medical directors of the ambulance organisations participating in the registry. They were asked to estimate the accuracy of the representation of the study population. They estimated the percentage of the study population that was incorrectly omitted from the figures in their own district. Percentage values from this survey varied from 0 to 30% (mean 5%).

2.4. Statistical methods

2.4.1. Descriptive statistics

The distribution of variables is given as percentages, mean ± standard deviation and median.

2.4.2. Statistical analyses

For comparisons between groups in terms of continuous variables, Fisher’s non-parametric permutation test [11] was used. For comparisons of dichotomous variables between two groups, Fisher’s exact test was used. A p-value of <0.01 was regarded as significant. Two-tailed tests were applied.

2.4.3. Multivariate statistical analyses

A stepwise logistic regression was used to select independent predictors of dichotomous-dependent variables. In the multivariate analysis, the following factors associated with survival in univariate analysis (p < 0.2) were entered into the model: age (continuous variable), cardiac arrest witnessed by a bystander (yes versus no), gender (male versus female), aetiology (cardiac versus non-cardiac), place (at home versus...
Table 1
Characteristics and outcome in relation to type of bystander among all patients

<table>
<thead>
<tr>
<th>No B-CPR</th>
<th>Lay person CPR</th>
<th>Professional CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 18,166</td>
<td>n = 7076</td>
<td>n = 2695</td>
</tr>
<tr>
<td>Age (years; mean ± S.D.)</td>
<td>70 ± 15</td>
<td>62 ± 18</td>
</tr>
<tr>
<td>Gender: women (%)</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>Place: at home (%)</td>
<td>72</td>
<td>60</td>
</tr>
<tr>
<td>Etiology: cardiac (%)</td>
<td>72</td>
<td>73</td>
</tr>
<tr>
<td>Initial rhythm: ventricular fibrillation/tachycardia (%)</td>
<td>27</td>
<td>38</td>
</tr>
<tr>
<td>Interval between: call for and arrival of EMS (median; min)</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Hospitalised alive at 1 month (%)</td>
<td>12.8</td>
<td>16.1</td>
</tr>
<tr>
<td>Alive at 1 month (%)</td>
<td>2.2</td>
<td>4.9</td>
</tr>
</tbody>
</table>

a p-value denoted if <0.2.
b Number of patients with missing information.

did not at home), interval between call for and arrival of the ambulance (continuous variable, natural logarithm). Among patients with a bystander-witnessed cardiac arrest, the interval between estimated time of cardiac arrest and the start of CPR was included in the model (continuous variable, natural logarithm). Because of missing information for some variables, the multivariable analysis only included 80% of the total series. The results were expressed as odds ratio and 95% confidence limits.

3. Results

In all, 42,117 patients were included in the registry and CPR was initiated in 33,453 (79%). Among these, 3742 (11%) were excluded, as they were crew witnessed. Among the remaining 29,711 patients, information about witnessed status was missing in 2830 patients (10%). Among the remaining 26,881 patients, 17,050 (63%) were bystander witnessed.

3.1. All patients (n = 29,711)

In all, 36% received bystander CPR. Among them, information about the type of bystander was missing in 4%. Among the patients who received bystander CPR, 72% was initiated by lay persons and 28% by professionals.

3.1.1. Characteristics (Table 1)

Patients on whom lay-person bystander CPR was performed differed from those on whom CPR was not performed. They were younger, and included fewer women, they less frequently suffered from cardiac arrest at home, and more frequently were found in ventricular fibrillation and had a longer emergency medical service response time.

Patients on whom bystander CPR was performed by professionals differed from those on whom bystander CPR was performed by lay people by being older, and included more women, who less frequently suffered from cardiac arrest at home, and more frequently were found in ventricular fibrillation and had a shorter emergency medical service response time.

3.1.2. Outcome (Table 1)

Patients who received CPR from lay persons were hospitalised alive more frequently than patients who did not receive bystander CPR. Furthermore, the patients who received CPR from professionals were hospitalised alive more frequently than the patients who received CPR from lay persons.

Survival at 1 month was 2.2% among patients on whom bystander CPR was not performed compared with 4.9% among patients receiving lay bystander CPR and 9.2% among patients who received bystander CPR from professionals.

3.1.3. Multivariate analysis

When adjusting for dissimilarities in age, sex, place of arrest, witnessed status and emergency medical service response time, the odds ratio for survival at 1 month among patients who received bystander CPR from lay persons versus no bystander CPR was 2.16 (95% CI: 1.79–2.61; p < 0.0001).

3.2. Bystander-witnessed cardiac arrest (n = 17,050)

3.2.1. Outcome

The survival rate at 1 month after cardiac arrest was 3.1% for the “no bystander CPR group”, 6.2% for the “lay bystander CPR group” and 10.8% for the “professional bystander CPR group” (Fig. 1).

3.2.2. Multivariate analysis

When adjusting for differences in age, sex, place of cardiac arrest and emergency medical service response time, the odds ratio for survival at 1 month among patients who received bystander CPR from lay persons versus no bystander CPR was 2.16 (95% CI: 1.79–2.61; p < 0.0001).
The adjusted odds ratio for 1-month survival among patients who received bystander CPR from professionals versus lay persons was 1.31 (95% CI: 1.06–1.62; \( p = 0.013 \)).

However, when adjusting to the interval between the estimated time of collapse and the start of CPR (which was shorter for professionals), no significant association between the type of rescuer (professional versus lay person) and 1-month survival was found.

### 3.3. Non-witnessed cardiac arrest (n = 9831)

#### 3.3.1. Outcome (Fig. 1)

Survival to 1 month was 1.1% among patients who did not receive bystander CPR compared with 1.7% among patients who received lay bystander CPR and 4.5% among patients who received professional bystander CPR.

#### 3.3.2. Multivariate analysis

When adjusting for various differences at the resuscitation event, there was no significant difference in survival when comparing patients who received bystander CPR from lay persons compared with persons who did not receive bystander CPR.

The adjusted odds ratio for survival at 1 month among patients who received professional bystander CPR as compared with lay bystander CPR was 1.97 (95% CI: 1.10–3.51; \( p = 0.022 \)).

### 4. Discussion

We found that bystander CPR performed by lay persons was associated with a two-fold increase in the chance of survival when adjusting for dissimilarities in age, sex, place of arrest, witnessed status and emergency medical service response time, compared with no bystander CPR. This information is new (since previous reports have focused on bystander CPR, regardless of whether it was performed by lay persons or professionals) and suggests a clear strategy designed to train as many people as possible in the country in CPR.

Another important observation was that CPR performed by professionals was associated with higher survival compared with CPR performed by lay persons. This difference was partly but not completely explained by differences at the resuscitation event. It may be assumed that the quality of CPR was different when performed by professionals. However, the estimated interval from collapse until the start of CPR was also shorter when bystander CPR was started by professionals. This finding appears to have contributed to the improvement in survival if bystander CPR was performed by professionals, as, when the variable was included in the multivariate model, the significance did not remain. As a result, our study is not final proof that the quality of CPR is of ultimate importance for the outcome among patients suffering from cardiac arrest.

It appears that the impact of lay bystander CPR on survival was particularly marked among patients suffering from a bystander-witnessed cardiac arrest. Among patients with a non-witnessed cardiac arrest, lay bystander CPR was not associated with a significant improvement in survival when adjusting for differences in various factors at resuscitation. This subgroup needs to be re-examined when our registry population increases even further. It is still too early to say that lay bystander CPR is not effective in this subset.

Patients who received bystander CPR from lay persons were more frequently found in ventricular fibrillation as compared to patients on whom bystander CPR was not performed. This finding is in agreement with many previous reports [12–15]. The mechanism behind this observation is not known, but it can be speculated that the maintenance of ventricular fibrillation explains at least part of the improvement in survival. Another hypothesis is that improved quality of CPR explains why ventricular fibrillation was more common among patients who received CPR from professionals as compared with lay people. Another possibility is that the selection of cases suitable for CPR was improved among patients who received CPR from professionals. Finally, a possible contributory factor was that CPR was started earlier by the professionals. A possible but hopefully trivial bias is that patients with end-stage heart disease might be more likely to have asystole than ventricular fibrillation. Bystanders are more likely to resuscitate victims of unexpected cardiac arrest, who intrinsically are more likely to have ventricular fibrillation.

There were marked differences with regard to various factors at resuscitation, including age, sex, place of arrest and emergency medical service response time between the three groups that were evaluated. However, these differences were adjusted for in the final analysis of survival.

### 5. Limitations

There are a number of limitations in the present survey.
As in all previous studies evaluating the impact of bystander CPR on out-of-hospital cardiac arrest, survival data were extracted from an observational study. This means that the risk of confounding factors not being included in the multivariate analysis cannot be excluded.

Not all patients in Sweden suffering an out-of-hospital cardiac arrest on whom CPR was attempted were included. The ambulance registry does not include all ambulance organisations. Furthermore, we do not know whether all the patients in the participating ambulance organisations were included in the registry. This raises the possibility of biased data reporting.

With regard to most variables, there were a number of patients for whom information was missing. Although the aim should always be to reduce missing information to a minimum, it should be admitted that, in the setting of cardiac arrest, one of the most chaotic events in medicine, the risk of missing information is particularly high. If missing information was in any way systematic, this might adversely influence the registry data.

No data were available on the percentage of lay bystanders who had previously received CPR training. Is it possible that lay persons without CPR training were doing just as well as those who had some prior training? In that case, it would be inappropriate to recommend that widespread community training in CPR should be provided.

Among these major limitations, the first one has the greatest potential to influence the accuracy of our conclusions. At present, there is no better way of analysing registry data than adjusting for confounding factors in the most optimal manner possible.

6. Conclusions

The results of this national survey of out-of-hospital cardiac arrest suggest that bystander CPR performed by lay persons is linked to an increased chance of survival. Furthermore, our data suggest that survival is dependent on who performs bystander CPR. Our results lend support to the establishment of nationwide organisations for the mass education of people in CPR.

Among patients suffering from an out-of-hospital cardiac arrest, bystander CPR by lay persons only is associated with an increased chance of survival. Furthermore, there is a distinction between lay persons and health care providers; survival is higher when the latter perform bystander CPR. However, the results may not be explained by differences in the quality of CPR.

Acknowledgements

This study was supported by grants from the Swedish Heart and Lung Foundation.

References


