Clinical Paper

The duration of cardiopulmonary resuscitation in emergency departments after out-of-hospital cardiac arrest is associated with the outcome: A nationwide observational study

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A B S T R A C T

Aim of the study: The appropriate duration of cardiopulmonary resuscitation (CPR) for patients who experience out-of-hospital cardiac arrest (OHCA) remains unknown. This study aimed to evaluate the duration of CPR in emergency departments (EDs) and to determine whether the institutions’ median duration of CPR was associated with survival-to-discharge rate.

Methods: A cohort of adult patients from a nationwide OHCA registry was retrospectively evaluated. The main variable was the median duration of CPR for each ED (institutional duration), and the main outcome was survival to discharge. Multivariable logistic regression analysis was performed to adjust for individual and aggregated confounders.

Results: Among the 107,736 patients who experienced OHCA between 2006 and 2010, 30,716 (28.5%) were selected for analysis. The median age was 65 years, and 67.1% were men. The median duration of CPR for all EDs was 28 min, ranging from 11 to 45 min. EDs were categorized into 3 groups according to their institutional duration of CPR: groups A (<20 min), B (20–29 min), C (>30 min). The observed survival rates of the 3 groups were 2.11%, 5.20%, and 5.62%, respectively. Compared with group B, the adjusted difference (95% confidence interval) for survival to discharge was 3.01% (1.90–4.11, P<0.001) for group A, and 0.33% (−0.64 to 1.30, P=0.51) for group C.

Conclusion: The duration of CPR varied widely among hospitals. The institutional duration of CPR less than 20 min was significantly associated with lower survival-to-discharge rate.

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1. Introduction

The prompt initiation and maintenance of high-quality cardiopulmonary resuscitation (CPR) is critical for patients who experience out-of-hospital cardiac arrest (OHCA). In addition, focused care must be provided from the field to the emergency department (ED), and the quality of care in the ED becomes more important when CPR is performed in the ambulance. Although studies have shown that resuscitation during transport is of poor quality, CPR is often performed during transport, for legal, cultural, or ethical reasons.

Once the patient arrives at the ED, one of the most difficult questions that faces the attending physicians is when to terminate resuscitation.8,9 However, there have been few studies regarding the optimal duration of resuscitation efforts10–13 and even fewer studies that focus directly on the duration of resuscitation in the ED.10 Therefore, there is wide variation in practice among EDs regarding the specific duration of resuscitation efforts.

The aims of this study were to evaluate the duration of CPR in EDs and to determine whether the median duration of CPR in the ED was associated with the survival of patients who experienced OHCA.

2. Methods

2.1. Design and setting

This nationwide, retrospective study was performed using data from the Cardiovascular Disease Surveillance Project of the Korea
Centers for Disease Control and Prevention. The purpose of this project was to create a cohort of patients with emergency medical services (EMS)-assessed OHCA. For this study, we enrolled patients in this cohort who experienced OHCA between 2006 and 2010.

2.2. Study population

The study population consisted of adult patients who experienced OHCA that was presumed to be of cardiac origin. Patients who were transferred to an ED with a low patient volume (<12 patients/year) were excluded, as data from these institutions were considered outliers. Patients who were transferred from the initial ED to another facility were also excluded because of the lack of necessary information. We also excluded patients who did not receive CPR in the ED.

2.3. Variables of interest

The selected factors were based on the Utstein style. We also included the EMS response interval and the transport interval. The duration of CPR for each patient (individual duration) was calculated as the interval from his or her arrival in the ED to the termination of CPR. The median duration of CPR for each ED (institutional duration) was calculated as the median duration in patients who did not experience return of spontaneous circulation (ROSC).

2.4. Statistical analysis

The patients’ baseline characteristics were analysed according to the individual duration of resuscitation, which was divided into 6 categories using 5 cut-off values: 10, 20, 30, 40, and 50 min. The P-value for trend was calculated for each factor using univariate linear regression analysis. We used the Kruskal–Wallis and χ² tests to examine the baseline differences and clinical characteristics across the groups based on the duration of resuscitation.

The primary factor studied was the institutional duration of CPR for each ED, which was divided into 3 groups (A, B, and C) using cut-off values of 20 and 30 min. Group B was selected as the reference group. The main outcome was survival to discharge, and the Utstein variables and EMS time intervals were considered potential confounders.

In order to analyse the correlation between institutional survival rate and institutional CPR duration, Spearman’s correlation was calculated. For determining the association between individual survival and institutional CPR duration, we used an unadjusted logistic regression analysis model and a multivariable logistic regression model with cluster effect for the final analysis. We calculated the adjusted difference of survival (with group A as reference) using the adrij command of STATA 13 (StataCorp., College Station, TX).

2.5. Sensitivity analysis

In order to determine the effect of population setting and grouping on the result, we performed the same regression analysis for different settings. First, regression analysis was performed only for EDs with at least 1 survivor, which could have minimized the effect of poor quality of care. Second, regression analysis with different cut-off points (20, 25, 30, and 35) was performed.

3. Results

The patient selection process is illustrated in Fig. 1. In total, 107,736 patients in the cohort experienced OHCA between 2006 and 2010, and 71,519 (66.4%) of these cases were presumed to be of cardiac origin with documented outcome. A total of 35,752 patients (33.2%) underwent CPR in an ED, and 30,691 of these patients (28.5%) were selected for the final analysis.

The median patient age was 65 years (interquartile range [IQR]: 53 to 76 years), and 20,577 (67.1%) were men. In total, 3513 cases of OHCA (11.5%) occurred in a public place, 16,779 (54.7%) were witnessed, and 1114 (3.63%) involved a bystander performing CPR. The median response time was 6 min (IQR, 5–8 min), the median transport time was 13 min (IQR, 9–17 min), and the median individual duration of CPR in ED was 27 min (IQR: 15–38 min). The point and cumulative distributions of patients over individual duration of CPR are shown in Figs. 2 and 3.

The basic characteristics of the patients and their individual durations of resuscitation are shown in Table 1. For the ROSC group, gender, place, bystander CPR, initial rhythm, and response time were associated with longer duration of CPR. For the no ROSC group, long resuscitation time was associated with factors that are generally known to be good prognostic signs.

In total, 337 EDs were included in the study, and the institutional duration of CPR ranged from 11 to 45 min, with a median duration of 28 min (IQR, 24–31 min). The average survival rate for each ED ranged from 0 to 0.17 (median 0.02). The institutional duration and survival rate showed a positive correlation of statistical significance (Spearman’s rho = 0.15, P = 0.004). The survival rates in the 3 groups (A, B, and C) were 2.11%, 5.20%, and 5.62%, respectively.

Risk factors were re-assessed with institutional duration of resuscitation (Table 2). There was no statistically significant difference among groups with respect to age, sex, witness, and initial rhythm. There was a small but significant difference with respect to the place of arrest, response interval, and transport interval.
We performed regression analysis to predict survival to discharge, and 2 models were used to measure the effect. The first was an unadjusted regression analysis and showed that, compared with the institutional duration group B, groups A and C had survival rates with odds ratios (ORs) of 0.39 (95% confidence interval [CI]: 0.23–0.66) and 1.08 (95% CI: 0.98–1.20), respectively. The second model was a multivariable logistic regression analysis with cluster effect and showed that the ORs of groups A and C were 0.40 (95% CI: 0.26–0.62) and 1.07 (95% CI: 0.88–1.31), respectively. The adjusted difference between groups A and B was 3.01% (95% CI: 1.90–4.11) and 0.33% (95% CI: −0.64 to 1.30) for groups B and C, respectively (Table 3).

Results of sensitivity analysis showed that the significant differences among groups were consistent even after excluding EDs with no survivors. When cut-offs were changed into 5 groups, the results were the same, revealing that only the group with a

Table 1
Baseline characteristics of study population with ROSC and without ROSC (N=30,691).

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>&lt;20 min</th>
<th>20–29 min</th>
<th>30–39 min</th>
<th>≥40 min</th>
<th>P-for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROSC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>65 (52–75)</td>
<td>64 (52–75)</td>
<td>67 (53–76)</td>
<td>65 (53–75)</td>
<td>64 (52–75)</td>
<td>0.58</td>
</tr>
<tr>
<td>Male sex</td>
<td>6294 (64.6)</td>
<td>2920 (62.8)</td>
<td>994 (64.2)</td>
<td>885 (68.0)</td>
<td>1495 (66.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Public place</td>
<td>1186 (12.2)</td>
<td>545 (11.7)</td>
<td>178 (11.5)</td>
<td>154 (11.8)</td>
<td>309 (13.8)</td>
<td>0.03</td>
</tr>
<tr>
<td>Witness</td>
<td>6432 (66.0)</td>
<td>3109 (66.9)</td>
<td>1008 (65.1)</td>
<td>850 (65.3)</td>
<td>1465 (65.3)</td>
<td>0.16</td>
</tr>
<tr>
<td>Bystander CPR</td>
<td>451 (4.6)</td>
<td>242 (5.2)</td>
<td>64 (4.1)</td>
<td>55 (4.2)</td>
<td>90 (4.0)</td>
<td>0.02</td>
</tr>
<tr>
<td>Shockable rhythm</td>
<td>1065 (10.9)</td>
<td>439 (9.44)</td>
<td>182 (11.8)</td>
<td>154 (11.8)</td>
<td>290 (12.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Response interval (min)</td>
<td>6 (5–8)</td>
<td>6 (5–8)</td>
<td>6 (5–8)</td>
<td>6 (5–8)</td>
<td>6 (5–8)</td>
<td>0.01</td>
</tr>
<tr>
<td>Transport interval (min)</td>
<td>12 (9–16)</td>
<td>12 (9–16)</td>
<td>12 (9–16)</td>
<td>12 (9–16)</td>
<td>12 (9–16)</td>
<td>0.66</td>
</tr>
</tbody>
</table>

| **No ROSC**        |         |         |           |           |         |             |
| Age (years)        | 66 (53–76) | 70 (58–80) | 67 (54–77) | 64 (51–75) | 61 (50–73) | <0.001 |
| Male sex           | 14,283 (68.2) | 3378 (63.4) | 1564 (67.4) | 3942 (70.4) | 3399 (71.8) | <0.001 |
| Public place       | 2327 (11.1) | 390 (7.32) | 538 (10.2) | 686 (12.3) | 713 (15.1) | <0.001 |
| Witness            | 10,347 (49.4) | 2206 (41.4) | 2432 (46.0) | 2913 (52.0) | 2796 (59.1) | <0.001 |
| Bystander CPR      | 663 (3.2) | 120 (2.3) | 168 (3.2) | 212 (3.8) | 163 (3.4) | <0.001 |
| Shockable rhythm   | 989 (4.7) | 94 (1.8) | 199 (3.8) | 318 (5.7) | 378 (8.0) | <0.001 |
| Response interval (min) | 6 (5–9) | 6 (5–9) | 6 (5–9) | 6 (5–9) | 6 (5–9) | <0.001 |
| Transport interval (min) | 13 (10–18) | 15 (10–20) | 14 (10–18) | 13 (9–18) | 12 (9–16) | <0.001 |

ROSC, Return of spontaneous circulation; Response interval, interval from call to EMS arrival at patient side. Transport interval: interval from the scene departure and arrival at hospital
Continuous variables were described as median and Interquartile range, categorical values were expressed as numbers and percentage.
Table 2
Description of patients’ characteristics based on hospital groups.

<table>
<thead>
<tr>
<th></th>
<th>Group A (&lt;20) n = 712</th>
<th>Group B (20–29) n = 15,699</th>
<th>Group C (≥30) n = 14,280</th>
<th>P-for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>67 (53–75)</td>
<td>66 (51–76)</td>
<td>65 (53–76)</td>
<td>0.51</td>
</tr>
<tr>
<td>Male sex</td>
<td>480 (67.4)</td>
<td>10,452 (66.6)</td>
<td>9,645 (67.5)</td>
<td>0.13</td>
</tr>
<tr>
<td>Public place</td>
<td>94 (13.2)</td>
<td>1,684 (10.7)</td>
<td>1,735 (12.2)</td>
<td>0.004</td>
</tr>
<tr>
<td>Witness</td>
<td>374 (52.1)</td>
<td>8,549 (54.5)</td>
<td>7,859 (55.0)</td>
<td>0.14</td>
</tr>
<tr>
<td>Bystander CPR</td>
<td>13 (1.8)</td>
<td>627 (4.0)</td>
<td>474 (3.3)</td>
<td>0.08</td>
</tr>
<tr>
<td>Shockable rhythm</td>
<td>37 (5.2)</td>
<td>1,075 (6.9)</td>
<td>942 (6.6)</td>
<td>0.90</td>
</tr>
<tr>
<td>Response interval (min)</td>
<td>6 (4–10)</td>
<td>6 (5–9)</td>
<td>6 (5–8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Transport interval (min)</td>
<td>13 (9–19)</td>
<td>13 (9–17)</td>
<td>13 (9–17)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

ROSC, Return of spontaneous circulation; Response interval, interval from call to EMS arrival at patient side. Transport interval: interval from the scene departure and arrival at hospital. Continuous variables were described as median and Interquartile range, categorical values were expressed as numbers and percentage.

Table 3
Multivariable analysis of CPR duration on survival to discharge. Unadjusted logistic regression analysis and adjusted regression analysis was performed. Difference of adjusted probability difference was analyzed and added to the table.

<table>
<thead>
<tr>
<th></th>
<th>CPR Duration (min)</th>
<th>ED n</th>
<th>Patient n</th>
<th>Survivor n (%)</th>
<th>Unadjusted OR</th>
<th>95% CI</th>
<th>Adjusted OR</th>
<th>95% CI</th>
<th>Adjusted Difference (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;20</td>
<td>19</td>
<td>712</td>
<td>15 (2.11)</td>
<td>0.39</td>
<td>(0.23–0.66)</td>
<td>0.40</td>
<td>(0.26–0.62)</td>
<td>3.01</td>
<td>(1.90–4.11)</td>
</tr>
<tr>
<td>B</td>
<td>20–29</td>
<td>172</td>
<td>15,699</td>
<td>817 (5.20)</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>0.33</td>
<td>(0.98–1.20)</td>
</tr>
<tr>
<td>C</td>
<td>≥30</td>
<td>146</td>
<td>14,280</td>
<td>802 (5.62)</td>
<td>1.08</td>
<td>(0.98–1.20)</td>
<td>1.07</td>
<td>(0.88–1.31)</td>
<td>(−0.64 to 1.30)</td>
<td></td>
</tr>
</tbody>
</table>

CPR, Cardiopulmonary resuscitation. ED, Emergency department. OR, Odds ratio. 95% CI, 95% Confidence interval.

![Fig. 3. Association between ED CPR duration and average survival to discharge rate. (Spearman’s rho = 0.15, P = 0.004). CPR, Cardiopulmonary Resuscitation. ED, Emergency Department.](image)

The institutional duration of CPR ranged from 11 to 45 min, and these differences may be a result of different levels of quality and quantity of care. For example, patients in the longer duration groups may have received more aggressive treatment such as extracorporeal life support, which is known to enhance patient survival.18–21 In addition, the longer duration of CPR may have been caused by the ED attempting to implement resuscitation guidelines, thereby resulting in improved survival.

The duration of CPR could be considered ‘downtime’, which suggests the negative effect of prolonged duration on survival. The negative effect may be due to prolonged ischemic time as well as the confounding effect of Utstein factors that would affect both the downtime and the survival of patients. CPR team leaders declare termination of CPR for patients who do not achieve ROSC, ‘announcing death’, based on clinical findings and institutional policy. In our study, clinical findings associated with the outcome included shockable rhythm, bystander CPR, responsible interval, and, interestingly, male gender.

Several previous studies have reported that prolonged CPR is associated with a poor survival outcome and is also an independent predictor of mortality.22–25 These findings may have caused the healthcare providers in the present study to withhold additional CPR after a given duration. However, because of several biases, the previous studies’ results regarding the appropriate duration of CPR should be applied with care. For example, small study populations, ambiguous definitions of CPR, and in-hospital settings limit the extrapolation of the previous studies’ results.

Therefore, unlike previous studies that considered duration of CPR in individuals, the present study focused on the institutional duration in the ED for patients who experienced OHCA, which helped reduce bias based on individual cases. In addition, we used a large, nationwide cohort that enrolled patients from multiple institutions, which strengthens the result. Additionally, we evaluated the duration of CPR only in patients who did not experience ROSC, thereby minimizing the bias introduced by including cases of ROSC.

We showed that the adjusted difference between groups A and B was 3.01% (95% CI: 1.90–4.11). This implies that bringing patients to group B or C centres instead of group A centres would result in saving 3.01–0.33% more lives, that is, 3 out of 100 patients who
experience OHCA. Using an intuitive number is important to make the outcome more comprehensible.

4.1. Limitations

This study has some major limitations. First, we enrolled patients from a single country who experienced an OHCA and had access to basic life support and some aspects of advanced life support. In Korea, EMS must transport patients to the ED while providing CPR; therefore, caution should be used when applying our results to populations with different EMS systems.26

Second, this was a retrospective observational study, and it is possible that undetected bias exists. For example, the providers may have considered some patients to have a high possibility of survival and therefore may have prolonged their duration of CPR, although this information could not be recorded in the registry. For the same reason, we could not prove a causal relationship between the association and duration of CPR, and an association among factors. Thus, a randomized controlled trial could confirm whether sustaining a certain duration of resuscitation would result in better outcomes.

Third, we could not directly monitor the quality of the CPR in each facility, and it is difficult to verify which quality measures affect patient survival. In addition to that, advanced resuscitation procedures such as extracorporeal life support or the application of therapeutic hypothermia were not indicated in our data.27

Last, the number of patients and hospitals in group A is very small. The small number may have caused the outcome to be very biased even with adequate adjustments of the regression model. However, this does not necessarily mean that the result is not statistically acceptable, but rather demonstrates the need for further investigation of the outliers with poor outcomes.

5. Conclusion

The duration of CPR varied widely among hospitals. The institutional duration of CPR of less than 20 min was significantly associated with a lower survival-to-discharge rate.

Conflict of interest statement

The authors have no conflicts of interest.

Previous presentation

This paper has not been presented previously.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2015.05.005

References


