Original Article

Mortality Factors in Out-of-Hospital Cardiac Arrest Patients: A Nationwide Population-based Study in Taiwan

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Background: Survival after an out-of-hospital cardiac arrest (OHCA) depends on the integrity of the community chain of survival, including optimal and high-quality CPR, early defibrillation, and post-resuscitation care. Older OHCA patients may have worse outcomes than the younger ones. This study aimed to find out the influence of age and other factors on the outcomes of OHCAs.

Methods: We analyzed the original claims data of the National Health Insurance from 2005 to 2007, and identified all patients who were sent to the emergency department with OHCA. Traumatic OHCA patients and patients without codes for intubation and CPR were excluded. Survival rates between the different groups were identified. Factors such as age, sex, pre-existing comorbidities, and different hospital levels were adjusted in a logistic regression model for survival.

Results: A total of 1673 OHCA cases were identified. Overall, the 1-month survival rates were similar in each year. However, the survival rates for those who were treated in medical centers improved from 3.4% (2005) to 6.8% (2007) (p < 0.01). Of all OHCA patients admitted to the emergency room, patients older than 75 years of age had significantly worse survival rates. Patients with the same profile, but who were admitted to hospitals, had nonsignificant worse survival rates.

Conclusions: Our study shows that age is no longer an important factor for survival in admitted patients. In addition, medical centers are better for the OHCA patients, after adjusting for other factors. This finding suggests that we still need to try our best to treat older OHCA patients without discrimination.

Keywords: age, out-of-hospital cardiac arrest, risk factors, survival

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is one of the leading causes of death and an important public health issue in many countries. In Western countries, approximately three quarters of the OHCA cases stem from coronary artery diseases and ventricular dysrhythmia. The “chain of survival” concept, which includes early activation by emergency medical services (EMSs), early cardiopulmonary resuscitation (CPR), early automated external defibrillation (AED), and early advanced life support (ALS) is pivotal in decreasing death and disability as a result of OHCA. There have been many studies regarding the benefit of early CPR and early defibrillation in the survival of OHCA patients. However, the overall survival rates of OHCA patients do not exceed 5% in most communities, and are even less than 3% in most urban areas.

The new American Heart Association 2005 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care emphasize effective CPR and rapid defibrillation to improve the chances of survival for victims of sudden cardiac arrest. Post-resuscitation deaths are highest in the first 24 hours after return of spontaneous circulation (ROSC); therefore, bundled post-resuscitation care is also critical to improve patients’ survival.

Although the results of the Resuscitation Outcomes Consortium showed no association between hospital characteristics and outcomes, data from Osaka, Japan, have demonstrated a threefold increase in neurologically favorable survival when patients without field ROSC were transported to critical care medical centers.

Compared with research from Western countries, the ratio of initial ventricular tachycardia to ventricular fibrillation (VT/VF) for...
OHCA in Taiwan and other Asian countries is far less. Therefore, the possible methods for strengthening the chain of survival for OHCA in Asian countries could be different from those of Western countries.

In this study, the impact of the receiving hospitals’ levels on OHCA outcomes over a period of 3 years, after the implementation of Guidelines 2005, was assessed using the population-based claims data of the National Health Insurance (NHI) in Taiwan. The main study hypothesis was that the OHCA survival rate in older patients would be lower than that of younger patients, adjusting for hospital levels, sex, and comorbidities. The main purpose of our study is to evaluate the generalized risk factors for OHCA survivals in Taiwan.

2. Materials and methods

2.1. EMS and hospital characteristics

In Taiwan, prehospital emergency care is delivered by the emergency medical technicians (EMTs) in different fire departments. Most EMTs are EMT-II, but some cities have paramedics. Because of the limited number of EMT paramedics, complete prehospital ALS only exists in some urban areas. According to an evaluation carried out in urban Taipei, the ALS demand was estimated at approximately 9–16% of total EMS calls, and the average response time was 4.1–4.9 minutes, with the mean call-to-first-shock time for cardiac arrest of 9.3 minutes. In rural areas, the average response time was found to be longer, even exceeding 6.6 minutes.

In 2004, there were 461 acute care hospitals in Taiwan. All of the hospitals were categorized and certified by the Department of Health into three levels, based on their expertise and capability. In 2004, there were 22 medical centers, 72 regional hospitals, and 367 district hospitals.

2.2. NHI data set in Taiwan

Taiwan introduced the NHI in 1995, covering nearly all residents (approximately 98% of the total population). Taiwan’s NHI allows patients to go to any hospital or physician of their choice and provisions for low fixed co-payments, which are virtually affordable for the entire population, are made. Providers are geographically well dispersed, with moderate to intense competition for patients prevailing in almost all health-care markets.

The National Health Insurance Research Database (NHIRD) is possibly one of the largest and most comprehensive population-based health-care data sources currently available in the world. It includes one primary diagnosis and up to four secondary diagnoses, which are coded by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) system. The Longitudinal Health Insurance Database (LHID) 2005 contains the original claims data of one million beneficiaries randomly sampled from the 2005 registry for all beneficiaries of the NHIRD. There were approximately 25 million individuals in this registry in 2005. There was no significant difference in the sex distribution between the patients in the LHID 2005 and those in the original NHIRD ($\chi^2 = 0.008, df = 1, p = 0.05$).

2.3. Study sample

All of the patients who were older than 15 and sent to emergency departments (EDs) with an OHCA diagnosis were identified by scanning the 2005–2007 database for ICD codes (798, 798.1, 798.2, 798.9). All OHCA patients with the trauma codes ICD 800-959 were excluded. The OHCA patients without corresponding procedure codes for intubation (47031C) and CPR (47029C) in EDs were also excluded from our study. Patients were followed up for 1 month until the end of 2007.

2.4. Key variables of interest

The outcome variables were “alive at hospital discharge” and “alive at 1 month after hospital discharge.” Patient characteristics were age, sex, and comorbidities. Patient age was categorized into three groups, namely, 15–54, 55–74, and >75 years. The pre-existing comorbidities were measured by Charlson Comorbidity Index (CCI), which was developed in 1987, and has been widely applied in research for risk adjustment. Acute myocardial infarction was also identified from the discharge diagnoses and used in the multivariate analysis.

Transfer status was identified by scanning the disparities between the initial receiving and subsequent admitting hospitals. System characteristics included the number of hospitals, medical centers, fire stations, ambulances, and EMTs per million population. Bystander CPR, initial cardiac rhythm, and transport time were not available in our data set, but bystander CPR rates are quite low in Taiwan, and the rates for initial VT/VF are also as low as 10%. The transport time from the OHCA scene to the hospital was usually within 10 minutes in urban areas.

2.5. Statistical analysis

All of the statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS 10.0 for Windows, 1997, Chicago, IL, USA). Descriptive analyses were performed on all identified variables, including frequency, percentage, and mean and standard deviation. A logistic regression analysis was used later to compare mortality between the different levels of hospitals and different age groups, adjusting for sex and pre-existing comorbidities.

2.6. Ethics statement

This work was supported by grants from Department of Health (DOH95-NH-1011). Since all personal identification was stripped from the secondary files before analysis, the Institutional Review Board of Shin Kong Wu Ho-Su Memorial Hospital waived the requirement for written informed consent from the involved patients.

3. Results

3.1. Overall survival

A total of 1736 OHCA patients were identified from the 2005–2007 data of the one million NHI beneficiaries, including 1673 nontransferred patients and 63 transferred patients. There were 558 OHCA patients in 2005, 594 in 2006, and 584 in 2007. There were 456 patients (26.3%) transported to medical centers, 804 patients (46.3%) transported to regional hospitals, and 476 patients (27.4%) transported to district hospitals.

A total of 226 (13.0%) OHCA patients survived to hospital admission, 119 (6.9%) patients survived to hospital discharge, and 43 (2.5%) patients survived up to 1 month after hospital discharge. Among those 226 patients, 107 patients subsequently died in the hospitals. A total of 52 (48.6%) patients survived less than 1 day, 11 (10.3%) patients survived less than 2 days, 23 (21.5%) patients survived 2–7 days, and 21 (19.6%) patients survived more than 8 days. Among all of the discharged alive patients, 76 (4.4%) patients died.
within 1 month after discharge, and 43 (2.5%) patients survived more than 1 month. Because very few patients were transferred after ED arrival (63/1736), and it was difficult to ascertain the relative benefits for survival between initial and subsequent hospitals, only the nontransferred patients were included for further survival analysis. When the data from 2005 to 2007 were grouped together, there was no significant difference between the ages and sexes. However, patients who were treated at the medical centers were more likely to be alive for 1 month than the patients at the regional and district hospitals (4.8% vs. 2.0% vs. 0.4%; p < 0.01) (Tables 1 and 2).

3.2. Time trends for survival to hospital discharge

Overall, the outcomes of OHCAs were similar from 2005 to 2007. However, when the benefits of survival rates between the different levels of hospital were further assessed by time, those patients who were treated at medical centers were more likely to have improved after 1 month (2005–2007: 3.5% vs. 4.4% vs. 6.8%; p < 0.05). However, no such time trends on outcomes were observed among patients treated at regional and district hospitals (Table 2).

3.3. Multivariate regression analysis

As shown in Table 3, age and hospital levels were significantly associated with outcomes for all OHCA patients who were admitted to the emergency room. Compared with the younger patients (15–54 years old), the odds ratio of survival for the patients older than 75 years was 0.5 [95% confidence interval (CI) = 0.3–0.7, p = 0.03]. When compared with the patients treated in district hospitals, the odds ratio of survival for the patients treated in medical centers was 4.0 (95% CI = 1.8–10.1, p < 0.01).

Nonetheless, for those OHCA patients who survived until hospital discharge, the only variable associated with a better outcome was the hospital level. Table 4 shows that, compared with the district hospitals, the odds ratio of survival for 1 month at medical centers is 3.8 (95% CI = 1.0–14.3, p < 0.05), after adjusting for age, sex, CCI, and acute myocardial infarction. Within the group of admitted OHCA patients, the odds ratio of survival for the patients older than 75 years was 0.6 (95% CI = 0.3–1.5, p = 0.28), which was not significant when compared with younger patients.

4. Discussion

4.1. Medical centers are beneficial for OHCA patients

In this first-ever investigation using population-based NHI claims data to study OHCA, the outcomes were significantly higher among patients treated at medical centers by adjusting for age, sex, and comorbidity. The benefits of survival after being treated in a medical center were more pronounced in 2007 than in 2005. The results were different from Callaway et al, but similar to Kajino et al. Kajino’s research showed better outcomes for those patients who did not achieve ROSC at the OHCA scene but who were treated in medical centers. Attributes in higher levels of care, such as better CPR or postresuscitation care, may therefore improve the chance of survival.

In Taiwan, most OHCA patients were sent to the nearest hospital by ambulance, and once the patient had ROSC, they usually stayed in the same hospital. Our findings show that medical centers had better 1-month survival rates, and therefore, we suggest that OHCA patients might benefit from treatment at the nearest medical centers. However, it is more important to find out the true reasons (such as the hypothermic therapy) for better outcomes in treating OHCA patients, and transfer the experience to other levels of hospitals. After that, we could have many OHCA centers all over the place.

4.2. Influence of age and sex

As with our results, most research on OHCA has found that sex does not play an important role in survival. Herlitz et al showed that age was an independent predictor of mortality among patients discharged alive after OHCA (OR = 1.06, 95% CI = 1.05–1.08; p < 0.01). Using the OHCA registry data, Engdahl et al did a multivariate analysis among all patients with asystole. He also found that younger age (p = 0.01) and witnessed arrest (p = 0.03) were independent predictors of better survival. Another paper, based on 299 nontrauma OHCA patients at one medical center in Taiwan, reported that (if patients had ROSC) the adult group (18–64 years old) had a higher rate of survival to hospital discharge than the elderly (>64 years old; i.e., 31.3% vs. 14.1%; p = 0.035). Our data differed from previous reports. Although older age was associated with worse outcomes in all OHCA cases, it was not a predictor of worse outcomes once these patients were admitted to the hospitals.

Some EMTs and emergency physicians might pay less attention to older OHCA patients because they think that older OHCA patients have less chance of survival. However, our results did not show a significant difference in survival rates between the admitted older and younger OHCA patients, even after adjusting for sex and comorbidities. Hence, our data propose that EMTs and emergency physicians should not discriminate between old and young patients while treating OHCA patients. Registry data for OHCA patients are more accurate but very difficult to implement, especially when dealing with the nationwide data bank. Therefore, several study limitations need to be recognized in our research.

5. Limitations

5.1. Relatively small number of OHCA survival cases

The LHID 2005 contains the original claims data of one million beneficiaries randomly sampled from the 2005 registry for all OHCA – out-of-hospital cardiac arrest.
beneficiaries of the NHIRD. There were approximately 25 million individuals in this registry in 2005. There was no significant difference in the sex distribution between the patients in the LHID 2005 and those in the original NHIRD ($\chi^2 = 0.008, df = 1, p = 0.95$). Based on the unbiased sampling, although the case number was relatively small, the percentage should be unbiased. Therefore, the results from the whole nation could provide more evidence for treating the OHCA patients.

5.2. Lack of prehospital indicators

Some of the key prehospital variables, such as the ratio of bystander CPR, initial cardiac rhythm, prehospital transport time, use of defibrillation, and call-to-shock time were not recorded in the NHIRD database. Consequently, we cannot completely follow the Utstein template for OHCA patients' analyses. Prehospital factors known to influence outcomes are CPR, transport time, and ratio of VF. Nonetheless, we have a reason to believe that their impact would not offset the benefits we observed in our study.

The rate of bystander CPR is quite low in Taiwan (less than 10%); in addition, the rate of initial VT/VF is also below 10%\textsuperscript{16,18}. Although we assume their actual importance, the impact in OHCA survival would not be influenced in our setting. Spaite et al. designed research in 2008 that showed survival was not significantly impacted by transport interval\textsuperscript{19}. In Taiwan, almost all OHCA patients in urban city areas can be transferred to the nearest hospital within 10 minutes. In addition, all of the EMS systems have protocols for using AED on OHCA patients on arrival. Although we did not have the specific supporting information, it is generally accepted that EMTs try their best within the given protocols to defibrillate patients and minimize the call-to-shock time. Accordingly, we would like to conduct further research to find out which other important factors could be improved upon, aside from bystander CPR and an ALS ambulance.

5.3. Risk adjustment

Patient outcomes could be affected by pre-existing medical conditions. We tried to adjust for this with CCI and the existence of AMI. However, the adjustment might be inadequate due to the external validity of CCI in this population.

Moreover, although we could find out the diagnosis of myocardial infarction from our database, the severity of the infarction and left ventricular ejection fraction, which are important predictors for mortality in AMI, are not available from the NHIRD database. However, considering that the rate for initial VT/VF is as low as 10%, we presume myocardial infarction does not play an important role in OHCA patients in Taiwan.

Table 4
Factors associated with 1-month survival for the admitted OHCA patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Alive (%)</th>
<th>OR (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>226</td>
<td>39 (17.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>136</td>
<td>24 (17.6)</td>
<td>1.1 (0.5–2.2)</td>
<td>0.87</td>
</tr>
<tr>
<td>Female</td>
<td>90</td>
<td>15 (16.7)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;75</td>
<td>97</td>
<td>15 (15.5)</td>
<td>0.6 (0.3–1.5)</td>
<td>0.28</td>
</tr>
<tr>
<td>60–74</td>
<td>77</td>
<td>9 (11.7)</td>
<td>0.7 (0.3–1.9)</td>
<td>0.52</td>
</tr>
<tr>
<td>15–59</td>
<td>52</td>
<td>15 (28.8)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Hospital level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical center</td>
<td>85</td>
<td>21 (24.7)</td>
<td>3.8 (1.0–14.3)</td>
<td>&lt;0.05 *</td>
</tr>
<tr>
<td>Regional hospital</td>
<td>102</td>
<td>16 (15.7)</td>
<td>1.8 (0.5–6.7)</td>
<td>0.41</td>
</tr>
<tr>
<td>District hospital</td>
<td>39</td>
<td>2 (5.1)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>CCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>23</td>
<td>2 (8.7)</td>
<td>0.9 (0.3–3.0)</td>
<td>0.87</td>
</tr>
<tr>
<td>Moderate</td>
<td>48</td>
<td>7 (14.6)</td>
<td>0.7 (0.3–1.9)</td>
<td>0.54</td>
</tr>
<tr>
<td>Mild</td>
<td>64</td>
<td>11 (17.2)</td>
<td>0.6 (0.2–1.6)</td>
<td>0.31</td>
</tr>
<tr>
<td>0</td>
<td>91</td>
<td>19 (20.8)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>AMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>18</td>
<td>4 (22.2)</td>
<td>2.3 (0.7–7.3)</td>
<td>0.16</td>
</tr>
<tr>
<td>No</td>
<td>208</td>
<td>35 (16.8)</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

* Admitted OHCA patients refer to OHCA patients who did not die in the EDs.
AMI = acute myocardial infarction; CCI = Charlson Comorbidity Index; CI = confidence interval; ED = emergency department; OHCA = out-of-hospital cardiac arrest; OR = odds ratio.
5.4. Accuracy of NHI data set

The diagnoses for OHCA are sourced from physicians and hospital-reported claims data. Thus, the accuracy of the diagnosis may be questionable. However, through chart reviews using professional teams, the NHI regularly samples a certain percentage of cases from every hospital to verify the quality of care and the accuracy of diagnosis. Therefore, we deemed the validity of diagnosis to be acceptable.

6. Conclusion

From the population-based NHI data, our study shows no changes in overall 1-month survival between older and younger group from 2005 to 2007. However, in the subset of patients, changes in overall 1-month survival between older and younger cases from every hospital to verify the quality of care and the professional teams, the NHI regularly samples a certain percentage of hospital-reported claims data. Thus, the accuracy of the diagnosis may be questionable. However, through chart reviews using professional teams, the NHI regularly samples a certain percentage of cases from every hospital to verify the quality of care and the accuracy of diagnosis. Therefore, we deemed the validity of diagnosis to be acceptable.

Acknowledgments

Our study was based on data from the NHIRD, which was provided by the Bureau of NHI, Department of Health, and was organized by the National Health Research Institutes. The interpretations and conclusions here do not represent the Bureau of National Health Insurance, the Department of Health, or the National Health Research Institutes.

References