THE EFFECT OF RESPONSE TIME ON SURVIVAL AMONG TRAUMATIC OUT-OF-HOSPITAL CARDIAC ARREST PATIENTS

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Abstract

Introduction: The association between emergency medical service (EMS) response time and out-of-hospital cardiac arrest (OHCA) patient survival has been reported, most studies have only focused on cases of non-traumatic etiology.

Objective: To examine the effect of EMS response time on the survival of traumatic OHCA patients in Thailand.

Methods: All traumatic OHCA patients receiving care by an advanced life support (ALS) team, Thailand between 2011 and 2013 were included. The primary outcome measure was survival to admission. Investigation of the effect of EMS response time and other risk factors on traumatic OHCA patients’ survival was conducted using binary logistic mixed effect regression. All statistical analysis was conducted using the R program.

Results: Of the 8,668 traumatic OHCA patients, 7,041 (81.26 %) survived. After adjusting for confounders, EMS response time was associated with patients’ survival (ORₙ = 0.97, 95% CI: 0.97, 0.98; p < 0.01). Intravenous fluid administration, urban location and initial GCS were also found to be associated with survival of traumatic OHCA patients.

Conclusions: Early delivery advanced care of traumatic OHCA patients are essential in reducing traumatic OHCA patients’ mortality in Thailand. Policy that facilitates early response is likely to substantially improve the prognosis of traumatic OHCA patients.

Keyword : Out-of-hospital cardiac arrest (OHCA), Emergency Medical Services, Advanced Life Support, Response time, Survival, Traumatic patient
Introduction:

Out-of-hospital cardiac arrest (OHCA) following trauma occurs infrequently compared with cardiac or non-traumatic etiology\(^1\text{,}^2\). Despite development of the emergency medical services (EMS) system, studies have found that the overall survival rate was very low with the reported survival rates between 7-10\%\(^3\text{–}^5\).

Unlike OHCA patients with a non-traumatic etiology, traumatic OHCA patients do not have comorbidity diseases; their cardiac arrest is mostly due to trauma related factors such as hypovolemic, airway obstruction, large pneumothorax, tracheobronchial injury, thoraco-abdominal injury and hypoxia. As a result, the emergency medical team must firstly identify the cause of the traumatic cardiac arrest, reverse these effects and critical care\(^5\text{,}^6\).

Several studies have shown that lower EMS response time is associated with desirable OHCA patient outcomes\(^7\text{–}^9\), and every minute without cardiopulmonary resuscitation (CPR) among OHCA patients reduces the chance of survival by 7-10\%\(^10\). However, most studies have focused on non-traumatic and cardiac origin. There is an essential need to investigate the effect of EMS response time on survival to hospital for traumatic OHCA patients. The aim of this study was to determine the effect of EMS response time on survival for traumatic OHCA patients in Thailand.

Methods:

Study design and setting

This study was a retrospective, national EMS data base cohort study from the National Institute for Emergency Medicine (NIEM), Thailand. The data were collected between 2011 and 2013 and maintained and available, along with the study protocol and case report form (CRF), from the DAMUS (Data Archival for Maximum Utilization System) website, developed by Medical Research Network of the Consortium of Thai Medical Schools, (MedResNet), Thailand\(^11\).

Cardiac arrest was defined as the sudden stop of cardiac activity, rechecked by the absence of pulse\(^12\). Inclusion criteria were OHCA patients, with a traumatic etiology, at least 15 years old, receiving CPR from an Advanced Life Support (ALS) team. Patients and relatives refusing treatment, those dying before arrival of the ALS team on the scene and missing information were excluded. This study was approved by the Ethics Committee, Khon Kaen University, Thailand (No.HE57149, 18 June 2014).

The following variables were retrieved from the EMS case report form: age, sex, initial Glasgow coma score (GCS), initial oxygen saturation, initial blood sugar, EMS response time defined as the time from dispatch call receipt to ALS unit arrival on scene), location (urban/rural), Ambu bag ventilation, pocket mask ventilation, suctioning the airway, endotracheal intubation, automated external defibrillator (AED), intravenous fluid administration and survival.

The primary outcome for this study was survival to admission (yes/no) defined as the traumatic OHCA patients who received resuscitation by an ALS team and did not die before admission in hospital, was considered as “survived”, whereas those who were dead on scene...
or during transportation before admitted to a hospital after unsuccessful resuscitation as “not surviving”.

Statistical analysis
Characteristics were summarized using and presented by frequencies for categorical variables, whereas means and standard deviations were for continuous variables. Crude and adjusted estimates of associations (represented by odds ratios) were generated using binary mixed effects logistic regression. A mixed effect modeling approach was used to adjust for a potential clustering effect of ALS teams. The best model was identified using the purposeful selection of covariates approach\(^{(13)}\). To investigate the potential bias introduced by missing values, multiple imputed data sets were generated and results from the analysis of the imputed data were compared to the complete case analysis. All statistical analysis was conducted using the R statistical language (version 3.0.3\(^{(14)}\)). Mixed effect modeling was performed using the R library \texttt{lme4}\(^{(15)}\) and multiple imputation was conducted using the R library \texttt{mi}\(^{(16)}\).

Results:
General characteristics
During the study period, 19,472 OHCA patients were attended by ALS teams in Thailand, of which 8,668 of these were traumatic OHCA patients included in the study. Among them, 432 OHCA patients were excluded because of refusal of treatment and / or age under 15 years.

Table 1 shows the characteristics of the enrolled 8,668 traumatic OHCA patients. 7,041 patients (81.26%) survived to hospital. Of the total member of traumatic OHCA patients, 2,034 patients (25.09%) were female, and their mean age ± standard deviation was 45.30 (SD = 19.50) years. In 3,116 (36.15%) of cases, the OHCA patients lived in an urban location, and 1,582 patients (18.26%) were OHCA with endotracheal intubation. The mean response time was 10.38 (SD = 7.68) minutes.

Table 1 Traumatic OHCA patients characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>n (%) or mean ± sd</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient factors</strong></td>
<td></td>
</tr>
<tr>
<td>Female sex</td>
<td>2,034 (81.26 %)</td>
</tr>
<tr>
<td>Age (year)</td>
<td>45.30 ± 19.50</td>
</tr>
<tr>
<td>Initial Glasgow coma score</td>
<td>3.55 ± 2.20</td>
</tr>
<tr>
<td>Initial oxygen saturation (%)</td>
<td>68.11 ± 29.76</td>
</tr>
<tr>
<td>Initial blood sugar (mg %)</td>
<td>149.62 ± 91.73</td>
</tr>
<tr>
<td><strong>Systematic &amp; Geographic factors</strong></td>
<td></td>
</tr>
<tr>
<td>EMS response time (min)</td>
<td>10.38 ± 7.68</td>
</tr>
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</table>
Main results
The results of the bivariate analysis demonstrates that survival of OHCA patients was significantly higher in patients with lower EMS response times, with every extra minute reduction in the response time leading to a 3% increase in the odds of the survival (OR = 0.97, 95% CI: 0.95, 0.99). Intravenous fluids administration, urban location and higher initial GCS were also associated with patient’s survival.

Multi-variable modeling of the complete-case data found that EMS response times was associated with better survival outcome (OR_{rt} = 0.97, 95% CI: 0.97, 0.98; p < 0.01). In addition, the response time effect remained largely unchanged in the imputed data analysis suggesting that, at least for the response time effect, missing values did not lead to substantial biases in the estimation of the response time effect.

OHCA Patients who were administered intravenous fluids had 3.59 times the odds of survival relative to patient without intravenous fluid (OR_{iv} = 3.59, 95% CI :3.04, 4.24, p < 0.001 ). Urban location and initial GCS were also associated with survival to hospital in patients (OR_{urban} = 1.49, 95% CI: 1.24, 1.80; p <0.001 andOR_{gcs} = 1.30 , 95% CI: 1.24, 1.37; p < 0.001, respectively). There was little change in the effect of GCS from the bivariate and multi-variable model suggesting few other effects confound the GCS effect.

The imputation analysis results demonstrate that most effects were comparable to the complete case analysis. In no case did the direction of association change, but there was some effects where there was a change in the magnitude of the effect, to the point of changing the statistical significance. Sex went from significant (females were more likely to survive) in the complete case analysis, to not statistically significant in the imputed data analysis (Table 2). The main purpose of conducting the imputed analysis was to gauge whether observations were systematically missing, or whether they were missing at random. The minimal difference between the complete case and imputed analysis suggest only small amounts of bias were introduced though missing values.
Table 2 Crude and adjusted odds ratio from both complete case and imputed data analyses for survival to admission in hospital of traumatic OHCA patients

<table>
<thead>
<tr>
<th>Effects</th>
<th>Complete case (n=2,889)</th>
<th></th>
<th>Multiple imputation (n=8,668)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR&lt;sub&gt;crude&lt;/sub&gt; 0.98***</td>
<td>OR&lt;sub&gt;adjust&lt;/sub&gt; 0.97 ***</td>
<td>95%CI 0.97, 0.98</td>
<td>OR&lt;sub&gt;adjust&lt;/sub&gt; 0.97***</td>
</tr>
<tr>
<td>Response time (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen cannula</td>
<td>1.68***</td>
<td>1.24</td>
<td>0.99, 1.54</td>
<td>1.22</td>
</tr>
<tr>
<td>Ambubag ventilation</td>
<td>1.21*</td>
<td>1.24**</td>
<td>1.07, 1.43</td>
<td>1.29**</td>
</tr>
<tr>
<td>Suctioning airway</td>
<td>1.41***</td>
<td>1.25**</td>
<td>1.06, 1.47</td>
<td>1.24*</td>
</tr>
<tr>
<td>IV fluid</td>
<td>3.37***</td>
<td>3.59***</td>
<td>3.15, 4.08</td>
<td>3.59***</td>
</tr>
<tr>
<td>AED</td>
<td>0.72*</td>
<td>0.76*</td>
<td>0.61, 0.96</td>
<td>0.68*</td>
</tr>
<tr>
<td>Female sex</td>
<td>1.14</td>
<td>1.15*</td>
<td>1.03, 1.29</td>
<td>1.15</td>
</tr>
<tr>
<td>Urban location</td>
<td>1.72***</td>
<td>1.49***</td>
<td>1.24, 1.80</td>
<td>1.74***</td>
</tr>
<tr>
<td>Initial GCS</td>
<td>1.37***</td>
<td>1.30***</td>
<td>1.24, 1.37</td>
<td>1.27***</td>
</tr>
</tbody>
</table>

*p < 0.05, ** p < 0.01, *** p < 0.001
IV fluid: Intravenous fluid administration, AED: Automated external defibrillator, Initial GCS: Initial Glasgow Coma Score

Discussion:

Impact of EMS response time on OHCA patient’s survival

Traumatic etiology of OHCA patient is a critical health problem because the probability of survival remains low despite the process being potentially reversible. This study is the first, large, multicenter study to demonstrate the association between response times and survival for traumatic OHCA patients in Thailand, and our results clearly shows that EMS response time is a significant independent predictor of survival to admission in hospital.

Currently, ambulances in Thailand are required to respond for critical emergency patient within 8 minutes but this study found that the mean response time (±SD) was 10.38 (±7.68) minutes. Our study suggest that decreasing response time to the 8 minutes target is likely to substantially increase the proportion of potential survivors.

Consistent with previous studies, a significantly lower response time was observed in out-of-hospital cardiac arrest patients who were successfully resuscitated than in patients who were not successfully resuscitated<sup>17–19</sup>. However, most previous studies consider non-traumatic and cardiac etiology patient<sup>17,18,20–22</sup>. Although the survival rates of traumatic OHCA patients are poor when compared with any causes, resuscitation is not universally futile<sup>23</sup>. Patients who arrested from hypoxic insults and those out-of-hospital patients who experienced thoracotomy after penetrating trauma had a higher patients’ survival.
Other risk factors for OHCA patient’s survival

Other factors for increasing chance of survival are intravenous fluid administration, urban location, and initial Glasgow coma score. The odds of survival increase about 3.59 times relative to those not receiving intravenous fluid. Our results are consistent with a prospective, observational study of OHCA in Japan from 2005 to 2009 that found pre-hospital use of LR solution was associated with patients outcomes before hospital arrival. A prospective, randomized controlled trial by Olasveengen et al. found patients with intravenous fluid administration had higher chance of short-term OHCA patients’ survival, but these interventions were not affected with long-term OHCA patients’ survival.

Our study demonstrated that survival in traumatic OHCA patients is significantly higher in urban areas, with urban patients having 1.49 times the odds of survival relative to those living in rural areas, even after adjusting for response time. This finding is consistent with those of a retrospective study from the Victorian Ambulance Cardiac Arrest Registry (Australia) that found the overall OHCA patients survival rate was higher in urban than in rural areas. There may be subtle but important differences in EMS management in urban when compared with rural areas. For example, there are typically fewer EMS personnel in the ALS teams in rural areas, compared with those in urban areas, which limits the critical interventions that may be achieved concurrently. One strategy to address this issue may be extra resourcing in rural areas, which at present, may be inadequate.

Another important factor we identified as associated with survival was initial Glasgow coma score. A retrospective study in the Netherlands found that GCS ≥ 13 is associated with higher survival OHCA patient. Our results support the use of GCS as a prognostic measure in traumatic-etioloogy OHCA patients.

Limitations

An important limitation of this study may be the potential of bias in our observational nationwide, retrospective cohort study. First, some bias may have been introduced by the substantial amount of missing data. To address this possibility, multiple iterative regression imputation was used to gauge the effect of missing values. The second potential limitation was that the patient outcome considered in the present study was a short term survival to hospital. We did not consider the association of short with long-term survival. However, many studies have evaluated the response time associated with long-term outcomes. We measured survival to admission rather than survival to discharge from hospital because we aim to identify the impact of the pre-hospital policy on the outcome of EMS performances. In contrast, the long-term survival was also depends on hospital intervention, including critical care, and other advanced treatments of underlying diseases.

Finally, most of previous studies on OHCA patients used the Utstein-Style reporting templates, but our data collection involved the use of the case record form (CRF) of the EMS, Thailand, a general purpose CRF. Consequently, some important predictors of traumatic-etioloogy OHCA patients survival were not considered (e.g., witnessed, bystander CPR).
Conclusion:
We show that reduced EMS response times increase the likelihood of survival to hospital of traumatic-etiology OHCA patients in Thailand. Early advanced care on OHCA patient was demonstrated as critical, and implementing policy to decrease response times is recommended. The findings of our study emphasize the need to minimize the time of traumatic-etiology OHCA patients arrival at hospital. Policy that facilitates early response is likely to substantially improve the prognosis of traumatic OHCA patients. Initiative may include additional and optimally distributed ALS teams, and additional trainings for ILS, BLS, and FR teams in CPR administration. Education of the public for bystanders CPR may also improve outcomes for traumatic OHCA patients’ survival.

Acknowledgements:
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Reference:


