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ORIGINAL RESEARCH

# Survival to admission after out-of-hospital cardiac arrest in Seoul, South Korea



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**Purpose:** Out-of-hospital cardiac arrest (OHCA) data derived according to the Utstein Style guidelines was used to try to determine factors influencing survival to admission (STA) and epidemiological rates of OHCA.

**Patients and methods:** This was an observational study of all age groups based on data from prehospital care reports in Seoul, South Korea. The collected data were reported according to the Utstein Style template for OHCA and analyzed in order to compare STA with non-STA. Univariate analysis was conducted using a binomial logistic regression model to identify predictors associated with trauma patients.

**Results:** Eighty-three (4.8%) OHCA survivors were admitted to the emergency department with carotid pulse. The median time from arrest to emergency medical personnel defibrillation was statistically significantly shorter in STA cases (8.0 minutes) than in non-STA cases (12.0 minutes; $P<0.001$). Factors independently associated with better prognosis in terms of trauma patients were female sex (odds ratio [OR]: 0.67; 95% confidence interval [95% CI]: 0.50–0.91; $P=0.01$), arrest at home (OR: 0.36; 95% CI: 0.27–0.49; $P<0.001$), and witnessed arrest (OR: 2.64; 95% CI: 1.94–3.39; $P<0.001$).

**Conclusion:** Early basic life support, performed by either a layperson or emergency medical personnel, had a positive effect on STA. Male sex, arrest outside of the home, and witnessed arrest are significantly associated with trauma.

**Keywords:** Utstein Style, prehospital, defibrillation, basic life support

## Introduction

The outcomes of out-of-hospital cardiac arrests (OHCAs) are relatively poor in Korea. One reason for this is that most research to improve this problem has not precisely reflected the situation, due to differences between research based on different data sources and nonstandardized processes. To reduce such problems, the Utstein Style[1] for OHCAs based on prehospital data has been adopted by a few researchers in Korea.

Survival rates of older trauma patients were lower as in other studies.[1,2] However, survival to discharge rates of OHCA cases differ between different studies. Survival to admission (STA) rates in studies that were carried out based on in-hospital data were much higher than the rates in studies carried out based on out-of-hospital data.[3–7] Therefore, it is difficult to compare outcomes between studies within Korea;[3–7] however, witnessed arrest, witnessed cardiopulmonary resuscitation (CPR), witnessed automated external defibrillation (AED), and shockable rhythm were directly related to arrest place, witness and prehospital emergency treatments in Korean studies, and Korean studies[3–7] revealed that some factors had a positive effect on outcomes in other studies.[8–25]

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The purpose of this study was to determine the factors influencing STA and OHCA rates according to the Utstein Style based on prehospital data. We hypothesized that early emergency treatment positively affects STA.

## Materials and methods

This was an observational retrospective study based on data for all age groups in Seoul, South Korea from PCRs (prehospital care reports) and reports for cardiac arrest patients recorded by emergency medical technicians and reflecting the Utstein Style. For quality management, the 1,716 cases recorded on the PCRs and the reports for cardiac arrest patients according to the Utstein Style guidelines in Seoul from January 1 to May 31, 2013 were filed and input into a database. The data were collected according to the Utstein Style guidelines to improve quality of prehospital emergency care in Seoul Metropolitan Fire and Disaster Headquarters and the data were selected for this study by the Institute of Emergency Medical Services, Eulji University (Seongnam-si, South Korea).

In order to maintain confidentiality, the following were excluded from the report: 119 fire emergency centers; callers' names, phone numbers, and social security numbers; and guardians' names and addresses. The collected data were recorded and analyzed according to the Utstein Style template for reporting data on OHCA. Cardiac arrest was confirmed by emergency medical service (EMS) personnel in the case of carotid pulse absence, unresponsiveness, and apnea. Cardiogenic cardiac arrest was defined as the cessation of cardiac mechanical activity due to heart disease or presumed not to be of non-cardiac etiology, such as in cases of drug overdose, suicide, drowning, hypoxia, trauma, etc, by EMS personnel based on definitions in the Utstein Style. Bystander CPR was defined as chest compression provided by someone who is a layperson. STA was defined as a patient being transferred to the emergency department with carotid pulse and then admitted to hospital. Return of spontaneous circulation (ROSC) was prehospital return of any spontaneous palpable pulse.

The population of patients experiencing OHCA was characterized using the Utstein Style template. Continuous variables such as age and time intervals were compared via mean and standard deviation or median and interquartile range. Categorical variables including sex and site of arrest were expressed as percentages. In order to compare STA cases admitted to hospital with carotid pulse and non-STA, frequencies were compared using chi-square test, and continuous variables such as age and time intervals were compared by Student's *t*-test at a significance level of $P$=0.05. Univariate analysis was conducted using a binomial logistic regression model to identify predictors associated with trauma. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The model calibration was evaluated by Hosmer–Lemeshow goodness-of-fit test. Statistical analysis was performed using SPSS for Windows (v 18.0; IBM Inc., New York, USA).

## Results

The number of cardiac arrests and the rates according to the Utstein Style template are shown in Table 1. The Seoul EMS is likely to respond to about 4,118 OHCAs in a year, which was estimated from the collected 1,716 OHCAs between January 1 and May 31, 2013. The number of OHCAs for 12 months was calculated as 4,118 from 1,716 OHCAs over 5 months. Fifty-three cardiac arrests were do-not-resuscitate cases, such as decomposition, rigor mortis, dependent lividity. A total of 1,663 patients (96.9%) received resuscitation, including opening airway, giving oxygen, and chest compression by EMS personnel. Of the confirmed 1,663 cases, 341 cases (20.6%) were of cardiac etiology, while the other cases had non-cardiac etiology including 295 trauma cases (17.2%). 297 cases (17.3%) were initial shockable rhythms (235 with ventricular fibrillation and 62 with ventricular tachycardia [VT]), while 1,419 cases were initial non-shockable rhythms (190 cases with asystole and 1,229 cases with the other rhythms according to the Utstein Style template). Three hundred and twenty three cases (18.8%) were defibrillated (32 cases treated by laypersons and 291 cases treated by EMS personnel). There were 156 bystander CPR cases (9.1%) and 83 STAs (4.8%).

**Table 1** OHCA rates according to the Utstein Style template

| Template | N | Rate (%) |
|---|---|---|
| OHCA | 1,716 | |
| Resuscitation not attempted | 53 | |
| Cardiac etiology | 341 | 20.6 (cardiac etiology rate) |
| Trauma | 295 | 17.2 (trauma incidence rate) |
| Arrests witnessed (layperson) | 783 | 45.6 (witnessed arrests rate) |
| Arrests witnessed (EMS) | 140 | 8.2 (witnessed arrests rate) |
| Arrests not witnessed | 793 | |
| Initial VF | 235 | 17.3 (VF + VT rate) |
| Initial VT | 62 | |
| Initial asystole | 190 | |
| Other initial rhythms | 1,229 | |
| Bystander CPR | 156 | 9.1 (bystander CPR rate) |
| Defibrillation (layperson) | 32 | 1.9 (defibrillation rate) |
| Defibrillation (EMS) | 291 | 17.0 (defibrillation rate) |
| STA | 83 | 4.8 (STA rate) |

**Abbreviations:** CPR, cardiopulmonary resuscitation; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest; STA, survival to admission; VF, ventricular fibrillation; VT, ventricular tachycardia.

**Table 2** Characteristics of out-of-hospital cardiac arrests transported to hospital by EMS

| Characteristics | N (%) |
|---|---|
| Mean age (years ± SD) | 57.6±21.1 |
| Sex | |
| Male | 1,061 (61.8) |
| Female | 655 (38.2) |
| Site of arrest | |
| Home | 1,085 (63.2) |
| Residential area | 96 (5.6) |
| Road | 92 (5.4) |
| Local hospital | 40 (2.3) |
| River, sea, mountain | 27 (1.6) |
| Hotel | 22 (1.3) |
| Office | 22 (1.3) |
| Construction site | 15 (0.9) |
| School | 10 (0.6) |
| Other | 307 (17.9) |
| Minutes from arrest to bystander CPR (median ± IQR) | 3.0±2.0 |
| Minutes from arrest to EMS personnel CPR (median ± IQR) | 8.0±5.0 |
| Minutes from arrest to EMS personnel defibrillation (median ± IQR) | 11.0±7.0 |

**Note:** Data are presented as N (%) unless otherwise specified.
**Abbreviations:** CPR, cardiopulmonary resuscitation; EMS, emergency medical services; IQR, interquartile range; SD, standard deviation.

**Table 3** Univariate analysis of STA predicted by variables

| Predictive variable | STA | *P*-value |
|---|---|---|
| Mean age (years ± SD) | Yes: 54.6±21.0<br>No: 57.8±21.0 | 0.23 |
| Sex | | |
| Male | 53/1,008 (5.3) | 0.70 |
| Female | 30/625 (4.8) | |
| Arrest at home | | |
| Yes | 41/1,044 (3.9) | 0.01 |
| No | 42/589 (7.1) | |
| Witnessed arrest | | |
| Yes | 67/716 (8.6) | <0.001 |
| No | 13/762 (1.7) | |
| Layperson CPR | | |
| Yes | 65/713 (8.2) | <0.001 |
| No | 17/865 (1.9) | |
| Layperson AED | | |
| Yes | 8/24 (25.0) | <0.001 |
| No | 74/1,593 (4.4) | |
| EMS defibrillation | | |
| Yes | 59/388 (13.2) | <0.001 |
| No | 24/1,245 (1.9) | |
| Trauma | | |
| Yes | 5/290 (1.7) | 0.01 |
| No | 78/1,343 (5.8) | |
| Minutes from arrest to bystander CPR (median ± IQR) | Yes: 2.0±2.0<br>No: 4.0±2.0 | 0.06 |
| Minutes from arrest to EMS personnel CPR (median ± IQR) | Yes: 7.0±5.0<br>No: 9.0±5.0 | <0.001 |
| Minutes from arrest to EMS personnel defibrillation (median ± IQR) | Yes: 8.0±6.0<br>No: 12.0±8.0 | <0.001 |

**Note:** Data are presented as n/N (%) unless otherwise specified.
**Abbreviations:** AED, automated external defibrillation; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; IQR, interquartile range; SD, standard deviation; STA, survival to admission; n/N, number/total number.

The number of patients transported to hospital by EMS personnel is reported in Table 2. The mean age of the patients was 57.6 years. There were more arrests among males (61.8%) than females in the prehospital setting, and 1,085 (63.2%) arrests occurred at home. The median time intervals were 3.0 minutes from arrest to bystander CPR; 8.0 minutes from arrest to EMS personnel CPR; and 11.0 minutes from arrest to EMS personnel defibrillation.

Univariate analysis of STA is presented in Table 3. The proportion of STA among the group of arrest at home was lower (3.9%; $P$=0.01) compared with that of outside of home (7.1%). The proportion of STA among the group of witnessed arrest was higher (8.6%; $P$<0.001) compared with that of unwitnessed arrest. The proportion of STA among the group of layperson CPR was higher (8.2%; $P$<0.001) compared with that of non-layperson CPR. The proportion of STA among the group of layperson AED was higher (25.0%; $P$<0.001) compared with that of non-layperson AED. The proportion of STA among the group of EMS personnel defibrillation was higher (13.2%; $P$<0.001) compared with that of non-EMS personnel defibrillation. The proportion of STA among the group of trauma was lower (1.7%; $P$<0.01) compared with that of non-trauma (5.8%). The median time from arrest to EMS personnel CPR was statistically significant. It was shorter in STA cases (7.0 minutes) than in non-STA cases (9.0 minutes; $P$<0.001). The median time from arrest to EMS personnel defibrillation was statistically significant. It was shorter in STA cases (8.0 minutes) than in non-STA cases (12.0 minutes; $P$<0.001).

Logistic regression of trauma predicted by variables in 295 trauma cases is summarized in Table 4. There were significant independent predictors, such as female

**Table 4** Logistic regression of trauma predicted by variables

| Predictive variable | Odds ratio | 95% confidence interval | *P*-value |
|---|---|---|---|
| Age | 1.00 | 0.99–1.01 | 0.79 |
| Sex (female) | 0.67 | 0.50–0.91 | 0.01 |
| Site of arrest (home) | 0.36 | 0.27–0.49 | <0.001 |
| Witness | 2.64 | 1.94–3.39 | <0.001 |
| Bystander CPR | 1.12 | 0.82–1.51 | 0.48 |
| Defibrillation | 1.57 | 1.09–2.27 | 0.02 |
| Non-STA | 1.88 | 0.72–4.92 | 0.20 |

**Note:** Hosmer–Lemeshow goodness-of-fit test with chi-square =5.20, $P$=0.740.
**Abbreviations:** CPR, cardiopulmonary resuscitation; STA, survival to admission.

sex (OR: 0.67; 95% CI: 0.50–0.91; $P$=0.01), arrest at home (OR: 0.36; 95% CI: 0.27–0.49; $P$<0.001), witnessed arrest (OR: 2.64; 95% CI: 1.94–3.39; $P$<0.001), and defibrillation by EMS personnel (OR: 1.57; 95% CI: 1.09–2.27; $P$=0.02). Hosmer–Lemeshow goodness-of-fit test with chi-square =5.20, $P$=0.740 was used for the model calibration.

## Discussion

Survival rates to discharge (0.7% in case of trauma; 13.3% in case of infant; 6.5% in case of pediatric; 6.3% and 6.7% in case of adult; and 3.6% in case of geriatric) in Korea[1,2,5–7] were similar to the trends in other countries' studies (Table 5).[8,10,11,15–25] However, the 4.8% rate of STAs in this study was far lower than the STA rates of 23.3%–46.0% based on data drawn from the hospital care reports. We assumed the 4.8% STA rate via the prehospital data collected to be a more accurate result for OHCA, hospital records have data of only patients who came to the emergency centers, whereas our data were systematically collected from the Seoul Metropolitan Fire and Disaster Headquarters taking charge of prehospital EMS in Seoul.

The 4.8% STA rate is compared with the 7.6% rate found in a previous study in a similar urban area with a similar patient group, and patient definition.[4] Nevertheless, the previous study based on PCR and hospital medical record differs from this study based on only PCR, and the study based on PCRs was well reflected OHCA compared with the other studies on HMR (see Table 5). Therefore, when all the Korean studies were combined, the prehospital STA rate of all patient groups in urban areas could be considered to be approximately 5% in Korea.

Because cardiac etiology data were assessed by EMS personnel assessment based on non-postmortem cases, 20.6% of the data was probably underestimated. The 17.3% initial shockable rhythm was lower than the 19% in Australia; 26% in Italy; 32% in New York city, USA; and 38% in Amsterdam, the Netherlands, and this seemed to be caused by delayed emergency care.[8,19,22,24] The American Heart Association have stated the chain of survival concept including early defibrillation for improving STA from sudden cardiac arrest. Early defibrillation remains crucial in VT and pulseless VT. To increase the chances of defibrillation delivery in sports facilities, train stations, and airports, and on trains, airplanes, passenger ships, etc, strategies of public-access defibrillation have been implemented since 2011 in Korea in attempts to reduce the time between patient arrest and defibrillation. However, the number of layperson defibrillations in this study (32 [1.9%]) is still too low. Thus, more sophisticated strategies in terms of AED device placement and public education are required.

Arrest at home, witnessed arrest, layperson CPR and defibrillation, EMS personnel defibrillation, and short time to CPR and defibrillation all positively affected STA. Though layperson CPR and AED were verified to be contributing factors to STA, there was no statistically significant difference in the time to CPR between STA and non-STA; these results suggest that early CPR might not be a positive effect on STA, but high-quality CPR could have a positive effect on STA. It needs to be stressed to educate laypeople regarding effective chest compression techniques ("push hard and fast") given the current situation in Korea.

Median interval times, such as from arrest to EMS personnel CPR (7–9 minutes) and defibrillation (8–12 minutes), were also statistically significant. It was similar to survival discharge when definitive care within 8 minutes was delivered, whereas it was different to when CPR within 4 minutes was started in King County, WA, USA.[15] In Asian studies, the call-to-shock times ranged from 9 to 11.7 minutes; this exceeded the arrest-to-shock time of 8 minutes.[16–18] In the present study, collapse-to-shock times of 8 minutes in STA cases and 12 minutes in non-STA cases were recorded by EMS personnel. In a meta-analysis, survival rates were constant when defibrillation time was less than 6 minutes.[26] To improve the bystander CPR and AED rates should invigorate pre-arrival instructions by emergency medical dispatcher. This is supported by the findings of a previous study, in which the highest

**Table 5** Survival to admission and survival to discharge in out-of-hospital cardiac arrest studies in Korea

| Area | Group | N | Survival to admission (%) | Survival to discharge (%) | Data source |
|---|---|---|---|---|---|
| Urban + suburbs* | Whole | 1,341 | 7.6 | NA | PCR |
| Urban[4] | Whole | 5,526 | 7.6 | 4.5 | PCR + HMR |
| Urban[5] | Adult | 176 | 23.3 | 6.3 | HMR |
| Urban[6] | Adult | 449 | 41.2 | 6.7 | HMR |
| Urban[2] | Geriatric | 804 | 46.0 | 3.6 | HMR |
| Urban[3] | Pediatric | 62 | 32.3 | 6.5 | HMR |
| Urban[7] | Infant | 45 | 33.3 | 13.3 | HMR |
| Urban[1] | Trauma | 409 | 35.2 | 0.7 | HMR |

**Notes:** *Outcomes of out-of-hospital cardiac arrest in Gyeonggi, Korea. [1]All pulseless patients with trauma for whom cardiopulmonary resuscitation was initiated. [2]Geriatric who came to the emergency centers with non-traumatic out-of-hospital cardiac arrest. [3]Pediatric who came to two tertiary hospitals were evaluated. [4]Hospital based cardiocerebrovascular disease monitoring. [5]Clinical analysis of prehospital cardiac arrest patients. [6]Clinical analysis of out-of-hospital cardiac arrest patients. [7]Infant who arrived arrest at the emergency center of three hospitals.
**Abbreviations:** HMR, hospital medical record; PCR, prehospital care report; NA, not available.

probability of survival was achieved when CPR was started by a bystander.[22]

We demonstrated that female sex (OR: 0.67), arrest at home (OR: 0.36), witnessed arrest (OR: 2.64), and EMS personnel defibrillation (OR: 1.57) were significant predictors of trauma in this study. These findings suggest that more males suffered serious wounds in accidents in public places such as roads, construction sites, and the work place. As a result, there were more witnesses of patient arrests.

However, bystander CPR to trauma had no statistically significant predictor, whereas EMS defibrillation had a statistically significant predictor. We speculated that laypersons hesitated to perform CPR due to dangers in the accident scene and bleeding of the patient; however, witnesses could recognize OHCA and called for EMS more quickly, and this had EMS personnel deliver more defibrillation for shockable rhythm.

## Conclusion

Our study shows that the 4.8% STA rate derived from the prehospital data according to the Utstein Style guidelines is far lower than STA rates that were derived from hospital medical records selectively collected in OHCA cases. The overall rate of STA in this study is much lower than those in other developed nations. This is due to low rates of bystander CPR and defibrillation. Arrest site, witnessed arrest, layperson CPR, layperson defibrillation, EMS personnel defibrillation, and time to CPR, are significantly associated with STA. Male sex, arrest outside of the home, and witnessed arrest are significantly associated with trauma. Rates of survival to discharge and to 1 year were not assessed in this study, although these in-hospital outcomes will be necessary to inform EMS systems on effective strategies for improving survival rates following cardiac arrest.

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## Author contributions

Both authors of this study made substantial contributions to the conception and design of the study, including analysis and interpretation of data; drafting the article and revising it critically for important intellectual content; and final approval of the version to be submitted. All contributors who do not meet the criteria for authorship as defined above are not listed.

## Disclosure

The authors report no conflicts of interest in this work.

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