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Short paper

The association between public access defibrillation and outcome in witnessed out-of-hospital cardiac arrest with shockable rhythm

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Abstract

Background: It is recommended globally that shocks by automated external defibrillators (AEDs) should be delivered immediately when a shockable out-of-hospital cardiac arrest (OHCA) occurs. However, the actual time-interval from collapse to first shock by public-access AED and its impact on subsequent outcome has not been extensively investigated in real-world settings.

Methods: OHCA data from 2013 to 2015 were obtained from the All-Japan Utstein Registry. Bystander-witnessed OHCA patients with shockable rhythm who were shocked by public-access AED in public locations were included. The primary endpoint was 1-month survival with favourable neurological outcome, and the association between time-interval from collapse to first shock by public-access AED and subsequent outcome was assessed.

Results: During the study period, 28% (2282/8126) of bystander-witnessed OHCA cases with shockable rhythm were shocked by public-access AED in public locations. The proportion of OHCA patients who were shocked by public-access AED within 5 min from collapse was 58% (1323/2282). Among these patients, the proportion of 1-month survival with favourable neurological outcome was 62% (815/1317). The proportion significantly decreased with increased time from collapse to shock by public-access AED (48% for 6–10 min, 38% for 11–15 min, 30% for 16–20 min, and 7% for 21–25 min; p-for-trend <0.001), and no patient survived if shock delivery occurred more than 26 min after OHCA.

Conclusion: In Japan, earlier shock by public-access AED led to better outcome after bystander-witnessed OHCA with shockable rhythm in public locations. However, the proportion of OHCA patients who received early shock was still low in public locations.

Keywords: Out-of-hospital cardiac arrest, Public-access defibrillation, Automated external defibrillator, Survival outcome

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Introduction

Out-of-hospital cardiac arrest (OHCA) is one of the major public health issues worldwide. Previous reports demonstrated that early shock by automated external defibrillators (AEDs) plays an important role in improving survival from OHCA.[1–4] Accordingly, it is recommended internationally that shocks by public-access AEDs should be delivered as soon as possible after the occurrence of OHCA with shockable rhythm (i.e., ventricular fibrillation and pulseless ventricular tachycardia).[5–7]

In Japan, the use of AEDs by bystanders in OHCA patients was legalised in July 2004, and the cumulative sales of public-access AEDs has rapidly increased thereafter (over 600,000 in 2015).[8] Several studies suggest that this nationwide dissemination of public-access AEDs significantly increased the AED shocks by bystanders, leading to improved survival after OHCA.[4,9] However, although AEDs have become widely accessible in public locations, the actual time-interval from collapse to first shock by public-access AED and its impact on subsequent outcome has not been extensively assessed in real-world settings.

The Fire and Disaster Management Agency (FDMA) of Japan has collected information on the time of public-access AED shock and detailed location of OHCA occurrence since 2013. Using this information from the nationwide OHCA database, the present study aimed to investigate the association between time from collapse to first shock by public-access AED and survival among OHCA patients with shockable rhythm in public locations.

Methods

Study design

Details of the All-Japan Utstein Registry of FDMA have been previously reported.[4] Briefly, this is a prospective population-based OHCA registry based on the international Utstein style,[10,11] that covers the entire population in Japan. Cardiac arrest was determined as the cessation of cardiac mechanical activity and was confirmed by the absence of signs of circulation by emergency medical service (EMS) personnel. In addition, when public-access AED shocks for patients were delivered by bystanders before EMS arrival, they were also recorded in our registry. The origin of cardiac arrest was presumed to be cardiac unless obvious evidence suggested non-cardiac causes, based on the current Utstein-style template.[12] These diagnoses were determined clinically by physician in-charge at the hospital; EMS personnel then recorded this information in the registry. Most OHCA patients were treated by EMS personnel, transported to a hospital, and registered in the registry, because EMS providers are usually not permitted to terminate resuscitation in the field, except in cases involving victims of decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis. All OHCA survivors were followed up for up to one month after the event by the EMS provider in-charge, to assess their outcomes. In addition to the previous data items of the international Utstein-style,[10,11] the FDMA started recording the time of shock by public-access AED and detailed information on the location

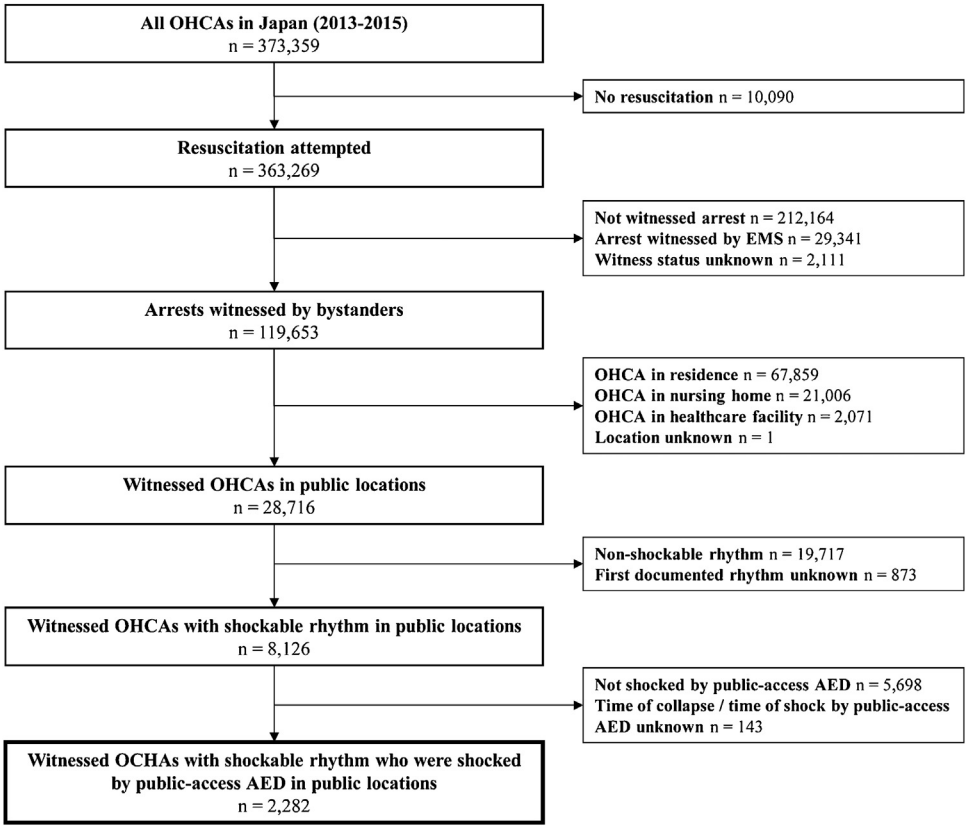

Fig. 1 – Study flowchart on the selection of patients with bystander-witnessed OHCA who underwent defibrillation via public-access AEDs in public locations in Japan between January 1, 2013 and December 31, 2015.
OHCA, out-of-hospital cardiac arrest; EMS, emergency medical service; AED, automated external defibrillator.

of OHCA occurrence in January 2013, according to the current international Utstein standardised template.[12]

Study subjects

The study subjects were bystander-witnessed OHCA patients with shockable rhythm who were shocked by public-access AED before EMS arrival in public locations (i.e., streets/highways, workplaces, recreation/sports institute, public institute, educational institute, and other public places) between January 1, 2013 and December 31, 2015. Cases of OHCA occurring in homes/residences, nursing homes, and healthcare facilities were excluded from the analyses. In addition, patients who had missing values regarding witness status, location of arrest, first documented rhythm, and time from collapse to shock by public-access AED were excluded.

Data collection

We obtained the following data from the All-Japan Utstein Registry: shock delivery by public-access AED, location of arrest, age, sex, origin of arrest, first documented rhythm, dispatcher instruction of cardiopulmonary resuscitation (CPR), initiation of bystander-CPR, time of collapse, time of call to EMS, time of first shock by public-access AED, time of EMS arrival, time of contact with the patient by EMS, time of hospital arrival, and outcomes after OHCA. First documented rhythm (i.e., shockable or non-shockable) was determined by EMS personnel from the electrocardiogram waveform of their AEDs. When the patients were shocked by public-access AEDs before EMS arrival, their first documented rhythm was determined to be a shockable rhythm. The time of collapse was obtained by EMS personnel interview of the bystander before the EMS personnel left the scene of OHCA occurrence. The time of first shock by public-access AED was collected by EMS personnel from the electrocardiogram waveform of public-access AED's internal records.

Endpoint

The primary endpoint was 1-month survival with favourable neurological outcome. The 1-month neurological status was scored by the physician in-charge, using the Glasgow–Pittsburgh cerebral performance category (CPC) scale: category 1, good performance; category 2, moderate disability; category 3, severe cerebral disability; category 4, coma/vegetative state; and category 5, death/brain death. EMS personnel were required to ask the hospital for this information. One-month survival with favourable neurological outcome was defined as CPC 1 or 2.[10,11] The secondary endpoint was 1-month survival after OHCA.

Statistical analyses

The association between time from collapse to first shock by public-access AED and outcome measures was assessed by the Mantel–Haenszel test for trend. In this analysis, the time variable was categorised into 0–5, 6–10, 11–15, 16–20, 21–25, 26–30, and $\geq$31 min. The statistical test was two-tailed, and a P-value of <0.05 was considered statistically significant. The analysis was conducted using the SPSS statistical package version 25.0J (IBM Corp, Armonk, NY).

Ethics

The study protocol was approved by the Ethics Committee of Osaka University. Personal identifiers were removed by the FDMA prior to the publication of the database. The requirement for informed consent by patients was waived.

Results

Fig. 1 shows a study flowchart of the selection of patients. During the 3-year study period, a total of 8126 patients of bystander-witnessed OHCA with shockable rhythm were documented in public locations, and 2282 of them (28.1%) were shocked by public-access AED before EMS arrival. Table 1 shows the patient characteristics. The median time from collapse to first shock by public-access AED was 5

Table 1 – Characteristics of bystander-witnessed OHCA patients with shockable rhythm who were shocked by public-access AED in public locations.

s	Total	
	N = 2282	
Location of arrest, n (%)		
Street/highway	247	(10.8%)
Workplaces	323	(14.2%)
Recreation/sports institute	530	(23.2%)
Public institute	745	(32.6%)
Educational institute	182	(8.0%)
Other public places	255	(11.2%)
Time of collapse, n (%)		
0:00–5:59	47	(2.1%)
6:00–11:59	917	(40.2%)
12:00–17:59	951	(41.7%)
18:00–23:59	367	(16.1%)
Weekday, n (%)	1593	(69.8%)
Age, years, median (IQR)	60	(49–69)
Age group, n (%)		
Children aged 0–17 years old	88	(3.9%)
Adults aged 18–74 years old	1874	(82.1%)
Elderly adults aged $\geq$75 years old	320	(14.0%)
Males, n (%)	2037	(89.3%)
Cardiac origin, n (%)	2160	(94.7%)
Dispatcher instruction, n (%)	1067	(46.8%)
Bystander CPR, n (%)		
Chest compression-only CPR	1557	(68.2%)
Conventional CPR with rescue breathing	667	(29.2%)
CPR type unknown	49	(2.1%)
No CPR	9	(0.4%)
Time from collapse to call to EMS, min, median (IQR)	2	(1–4)
Time from collapse to public-access defibrillation, min, median (IQR)	5	(3–8)
Time from collapse to EMS arrival at the scene, min, median (IQR)	10	(7–13)
Time from collapse to EMS personnel contact with the patient, min, median (IQR)	11	(8–14)
Time from collapse to hospital arrival, min, median (IQR)	33	(26–42)

OHCA indicates out-of-hospital cardiac arrest; AED, automated external defibrillator; IQR, interquartile range; CPR, cardiopulmonary resuscitation; EMS, emergency medical service.

(interquartile range, 3–8) min. Most patients had OHCA of cardiac origin (94.7%: 2160/2282) and received bystander-initiated CPR (99.6%: 2273/2282).

The overall proportion of patients who achieved 1-month survival was 61.4% (1401/2282) and the proportion of those with favourable neurological outcome was 54.5% (1243/2282). Fig. 2 shows the association between time from collapse to first shock by public-access AED and 1-month survival outcomes. The proportion of OHCA patients who were shocked by public-access AED within 5 min from collapse was 58.0% (1323/2282); i.e., 16.3% of all cases of bystander-witnessed OHCA with shockable rhythm in public locations. Of these patients, 61.7% (816/1,323) experienced 1-month survival with favourable neurological outcome. Thereafter, favourable survival significantly decreased with increased time from collapse to first shock by public-access AED (48.3% for 6–10 min, 38.2% for 11–15 min, 30.4% for 16–20 min, and 7.1% for 21–25 min; p-for-trend <0.001), and no patient survived if shock delivery occurred more than 26 min after OHCA.

Discussion

Using the nationwide OHCA registry in Japan, the present study investigated the actual situation of time interval from collapse to shock by public-access AED and its impact on subsequent survival. The nationwide dissemination of public-access AEDs and the population-based registry, including new information about the time of shock by public-access AED and location of arrest, enabled us to analyse a large number of OHCA patients who were shocked by public-access AED. Importantly, previous studies, which reported the effectiveness of early shock, included a small sample size and were limited in specific locations because they were conducted in the era when public-access AEDs were not widely available.[1,13] Our nationwide data provides real-world evidence that earlier AED shock before EMS arrival leads to better outcomes in bystander-witnessed OHCA with shockable rhythm at public locations; i.e., 61.7% of patients who were shocked by public-access AED within 5 min after collapse experienced 1-month survival with favourable neurological outcome. In addition, notably, 30% or more of the patients who received shock by public-access AED within 16–20 minutes after collapse experienced 1-month survival with favourable neurological outcome; however, previous reports have indicated that survival would decrease to approximately 2%–5% when defibrillation is delayed beyond 12 min.[7] Considering that most of our subjects received bystander-CPR, the combination of AED and bystander-CPR would have considerably greater benefits than previously expected, even in cases with delayed shock by AED. This fact should be emphasised in future basic life support trainings.

Another important finding of this study was that only 16.3% of all bystander-witnessed OHCA patients with shockable rhythm were actually shocked by public-access AED within 5 min from collapse. Considering that, globally, guidelines recommend that defibrillations by AEDs should be delivered within 5 min of shockable OHCA occurrence,[5–7] there is considerable room for improvement in this population. Although the number of public-access AEDs is increasing in Japan,[8] our findings highlight the importance of more effective usage of public-access AEDs as well as further dissemination of basic life support trainings to the public. For example, the introduction of new technologies, such as a positioning system for bystanders with mobile phones/smart phones[14,15] or the use of drones with a public-access AED would help to increase the rate of early shock and reduce AED delivery time.[16,17]

Limitations

There are several limitations to this study. First, since the time of collapse of unwitnessed OHCA patients was not evaluable, we could not assess the effects of early shock by public-access AED on these patients. In addition, since the time of collapse was obtained by EMS personnel interview of the bystander, it would be difficult to determine the exact

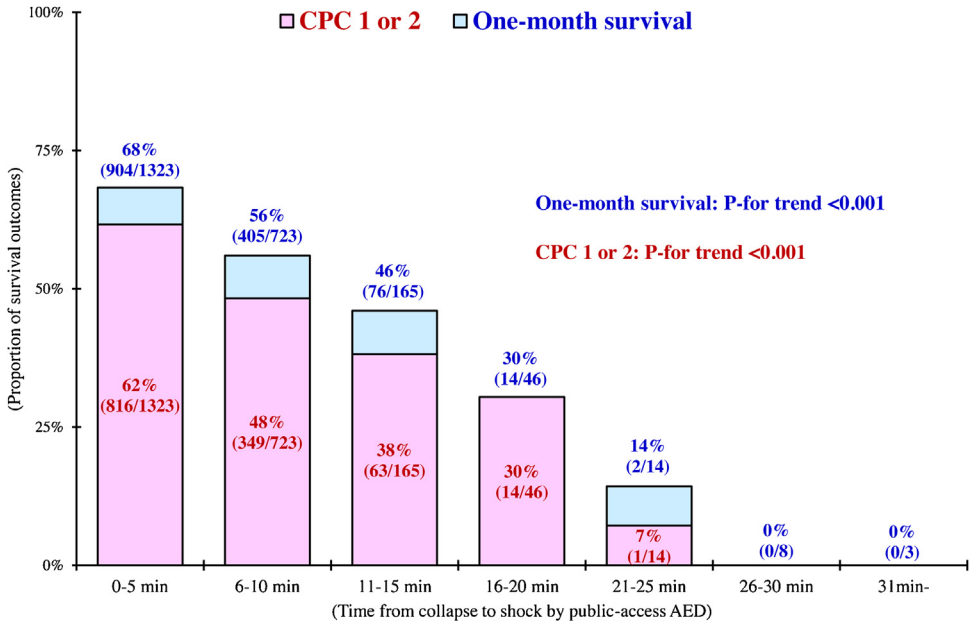

Fig. 2 – Association between time from collapse to shock by public-access AED and 1-month survival outcomes among bystander-witnessed OCHA patients with shockable rhythm in public locations in Japan.
CPC, cerebral performance category; AED, automated external defibrillator.

time[18] and the recorded time of collapse may sometimes be ambiguous. Second, we did not obtain information about whether a public-access AED pad was applied to OHCA patients. Instead, we used 'shock by public-access AED' as the main exposure variable. However, in terms of the assessment of bystander intervention, the information on AED pad application would be preferable and useful for policy making. Third, we were unable to consider information about several factors associated with the prognosis of cardiac arrests, such as activities at the time of arrest, past medical history, medication, quality of bystander-initiated CPR, and life habits of the patients before the arrest. Potential variability in post-arrest care was not addressed as well.

Conclusions

The real-world data in Japan demonstrated that earlier shock by public-access AED evidently led to better outcomes after bystander-witnessed OHCA with shockable rhythm in public locations. However, the proportion of OHCA patients who received early shock was still low in public locations.

Conflict of interest

All the authors declare that they have no potential conflict of interest.

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