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Critical Care

Incidence and Outcome of Out-of-Hospital Cardiac Arrest With Public-Access Defibrillation

– A Descriptive Epidemiological Study in a Large Urban Community –

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Background: Detailed characteristics of those who experience an out-of-hospital cardiac arrest (OHCA) with public-access defibrillation (PAD) are unknown.

Methods and Results: A prospective, population-based observational study involving consecutive OHCA patients with emergency responder resuscitation attempts was conducted from July 1, 2004 through December 31, 2008 in Osaka City. We extracted data for OHCA patients shocked by a public-access automated external defibrillator (AED) and evaluated the patients' and rescuers' characteristics. The main outcome measure was neurologically favorable 1-month survival. During the study period, 10,375 OHCA patients were registered and of 908 patients suffering ventricular fibrillation arrest, 53 (6%) received public-access AED shocks by lay-rescuers, with the proportion increasing from 0% in 2004 to 11% in 2008 (P for trend<0.001). Railway stations (34%) were the places where PAD shocks were most frequently delivered, followed by nursing homes (11%), medical facilities (9%), and fitness facilities (7%). In 57% of cases, the subject received public-access AED shocks delivered by non-medical persons, including employees of railway companies (13%), school teachers (6%), employees of fitness facilities (6%), and security guards (6%). The proportion of neurologically favorable 1-month survival tended to increase from 0% in 2005 to 58% in 2008 (P for trend=0.081).

Conclusions: Railway stations are the most common places where shocks by public-access AEDs were delivered in large urban communities of Japan, and among lay-rescuers railway station workers use AEDs more frequently. (*Circ J* 2011; **75:** 2821–2826)

Key Words: Automated external defibrillator; Cardiopulmonary resuscitation; Out-of-hospital cardiac arrest; Public-access defibrillation; Survival

Out-of-hospital cardiac arrest (OHCA) is a leading cause of death in the industrialized world,[1] and approximately 50,000 arrests are documented every year in Japan.[2] To improve survival after an OHCA, early defibrillation by laypersons using an automated external defibrillator (AED) plays a key role in the "chain of survival".[1–3]

The public-access defibrillation (PAD) program, which encourages laypersons to use AEDs and perform cardiopulmonary resuscitation (CPR) for OHCA patients, has been introduced for use in various situations, and its effectiveness in many settings has now been established.[4–8] Recent observational studies showed that nationwide dissemination of public-access AEDs allowed shocks to be delivered more quickly, and increased the rate of survival after OHCA.[2,9] However,

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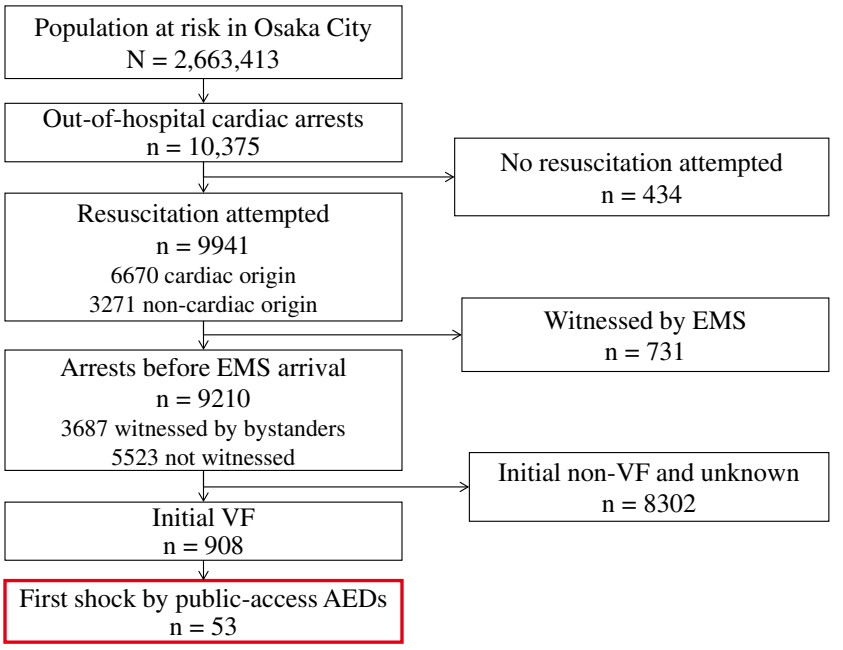

Figure 1. Patient flow. EMS, emergency medical service; VF, ventricular fibrillation; AED, automated external defibrillator.

there have been few reports on the characteristics of public-access AED users and the places where shocks are delivered.

In Japan, public-access AEDs have rapidly become more available since the PAD program started on July 1, 2004.[10,11] In 1998, the Osaka Municipal Fire Department launched a population-based registry of OHCA in Osaka City, a large urban community with approximately 2.7 million inhabitants. For the present study, we extracted detailed data on public-access AED users and the places where OHCA occurred, and merged them with data on resuscitation simultaneously collected according to the Utstein-style guidelines. The aim of this study was to identify the characteristics of OHCA patients shocked by public-access AEDs and those of their rescuers in a large urban community.

Methods

Study Design, Population, and Setting

This study was a population-based epidemiological description of OHCA in Osaka City. Citizen use of an AED has been legally permitted in Japan since July 1, 2004. The period of the present study was from July 1, 2004 through December 31, 2008. All patients who suffered OHCA and were provided shocks with public-access AEDs by lay-rescuers, treated by emergency medical service (EMS) personnel, and then transported to medical institutions, were enrolled in this study, which was approved by the Ethics Committee of Kyoto University Graduate School of Medicine.

Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.[12,13] The arrest was presumed to be of cardiac origin unless it was caused by trauma, drowning, drug overuse, asphyxia, exsanguination, or any other non-cardiac causes determined by the physicians caring for the patients in collaboration with the EMS personnel.

EMS System in Osaka City

Osaka City, which is the largest urban community in western Japan, has an area of 222 km^2, and its population was approximately 2.7 million as of 2000 (population density, approximately 12,000 persons/km^2).[14] The municipal EMS system is basically the same as in other areas of Osaka Prefecture, as previously described.[15] The EMS system is operated by the Osaka Municipal Fire Department and is activated by dialing 119 on the telephone. In 2007, there were 25 fire stations and 1 dispatch center in Osaka City.[16] Life support is available there 24 h every day. Usually, each ambulance has a crew of 3 emergency providers, including at least 1 Emergency Life-Saving Technician (ELST), a highly-trained prehospital emergency care provider. CPR training programs including chest compressions, rescue breathing, and AED operation based on the Japan CPR guidelines[17] were offered to approximately 40,000 citizens by the Fire Department in 2007.[16] Although no complete AED location data were available for this area, the voluntary AED registry in Osaka Prefecture (Osaka AED Map)[18] showed that 29% of public-access AEDs were deployed in schools, 21% in workplaces, and 10% in public transportation facilities such as railway stations.

Data Collection

Data were prospectively collected using a form that included all core data recommended in the Utstein-style reporting guidelines for OHCA,[12,13] including gender, age, initial cardiac rhythm, witness status, location, time course of resuscitation, as well as return of spontaneous circulation (ROSC) before hospital arrival, 1-month survival, and neurological status 1 month after the event. For OHCA patients who received shocks by public-access AEDs, we obtained information on the rescuers' occupation and previous AED training, and a detailed description of the places where shocks were delivered.

All of those who survived OHCA were followed for up to 1 month after the event by the EMS personnel in charge. The neurological status after 1 month was determined by the physicians caring for the patients using the cerebral performance category (CPC) scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe

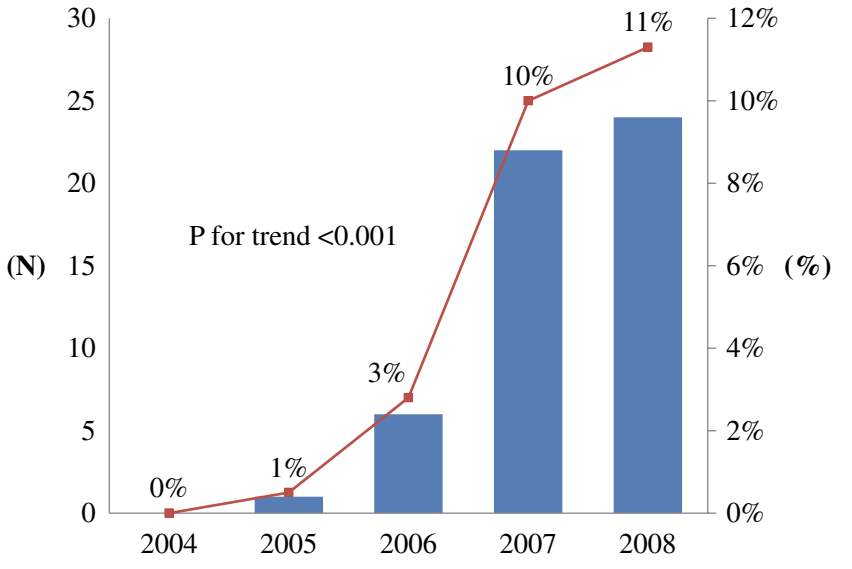

Figure 2. Temporal trends in the number of patients with public-access AED shocks and the proportion within all VF arrests in Osaka City from July 2004 to December 2008. Bars show the number of public-access AED-shocked patients, and lines indicate the proportion of public-access AED-shocked patients among VF arrests. VF, ventricular fibrillation; AED, automated external defibrillator.

cerebral disability; category 4, coma or vegetative state; and category 5, death.[12,13] Neurologically favorable survival was defined as a CPC score of 1 or 2.

The data form was filled out by the EMS personnel in cooperation with the physicians caring for the patients, transferred to the Information Center for Emergency Medical Services of Osaka, and then checked by the investigators. If the data sheet was incomplete, the relevant EMS personnel were contacted and questioned, and the data sheet was completed with their assistance.

Statistical Analysis

Summary statistics are expressed by mean±standard deviation (SD) for numerical variables, and percentages for categorical variables. Trends were tested with univariable regression models. All statistical analyses were performed using SPSS statistical package (Ver16.0J SPSS, Inc, Chicago, IL, USA). All tests were 2-tailed, and a P value of <0.05 was considered statistically significant.

Results

Patient Flow in This Study

During the study period, a total of 10,375 OHCAs were documented in Osaka City (Figure 1). Resuscitation was attempted for 9,941 of them, 6,670 (67%) of which were presumed to be of cardiac origin. Of 9,210 arrests occurring before EMS arrival, including 3,687 (40%) witnessed arrests and 5,523 (60%) non-witnessed arrests, 908 exhibited ventricular fibrillation (VF) as the initial rhythm and 53 of them (6%) received the first shock by public-access AEDs.

Temporal Trends in the Number and Proportion of Patients With Public-Access AED Shocks

The annual incidence of OHCAs and VF during the study period was 78.8 and 7.8 per 100,000 person-years, respectively. The number of OHCA patients receiving a first shock by public-access AEDs increased from 0 in 2004 to 24 in 2008, and from 0% in 2004 to 11% in 2008 among all VF arrests (P for trend<0.001) (Figure 2).

Table 1. Characteristics of OHCA Patients Shocked by Public-Access AEDs

	(n=53)
Patients' characteristics	
Age, mean (SD)	59.8 (17.7)
Men, n (%)	37 (70%)
Cardiac origin, n (%)	52 (98%)
Bystander-witnessed, n (%)	39 (74%)
Location, n (%)	
Railway station	18 (34%)
Nursing home for the aged	6 (11%)
Medical facility	5 (9%)
Fitness facility	4 (7%)
Street	4 (7%)
Workplace	4 (7%)
School	2 (4%)
Others	10 (19%)
Rescuers' characteristics	
Previous AED training, n (%)	25 (47%)
Non-medical professional, n (%)	30 (57%)
Resuscitation time course, min	
Collapse to shock by public-access AED*, mean (SD)	5.3 (3.7)
Call to CPR by EMS, mean (SD)	9.2 (3.6)
Call to hospital arrival, mean (SD)	26.3 (6.7)

*Calculated for bystander-witnessed arrests (n=26).
OHCA, out-of-hospital cardiac arrest; AED, automated external defibrillator; EMS, emergency medical service.

Characteristics of Public-Access AED-Shocked Patients

Table 1 shows the characteristics of 53 OHCA patients who received shocks by public-access AEDs. Their mean age was 59.8 years, 70% were male, and bystander witness was frequent (74%). The most common locations where the first shock by public-access AEDs was delivered were railway stations (34%), followed by Nursing homes for the aged (11%), medical facilities (9%), fitness facilities (7%), streets (7%), and workplaces (7%). Among the rescuers, 47% had received previous AED

Table 2. Proportion of OHCA Patients Shocked by Public-Access AEDs Among VF Arrests According to Location

	% (n/N)
Railway station	38 (18/48)
Nursing home for the age	19 (6/32)
Medical facility	19 (5/26)
Fitness facility	50 (4/8)
Street	3 (4/160)
Workplace	6 (4/68)
School	20 (2/10)
Home	0 (0/401)
Others	6 (10/155)

VF, ventricular fibrillation. Other abbreviations see in Table 1.

training, and 57% were non-medical professionals. In the bystander-witnessed cases (n=26), the mean time interval from collapse to first shock by public-access AEDs was 5.3 min.

The proportion of those who received shocks by public-access AEDs among cases of out-of-hospital VF was 38% (18/48) and 50% (4/8) in railway stations and in fitness facilities, respectively, while only 3% (4/160) and 6% (4/68) were on streets and in workplaces, respectively. Pessimistically, there was no patient (0/401) who received shocks by public-access AED at home (Table 2). The proportion of out-of-hospital VF patients who were delivered shocks by non-medical professionals with public-access AEDs was 61% (11/18) in railway stations, 50% (3/6) at Nursing homes for the aged, 100% (4/4) in fitness facilities, 50% (2/4) in workplaces, and 100% (2/2) at schools, while 0% (0/4) was on streets.

Bystanders Who Used Public-Access AEDs

Occupations of the lay-rescuers who used public-access AEDs are noted in Figure 3. As much as 43% of public-access AED users were off-duty medical professionals, including medical doctors (15%), nurses (15%), and EMS providers (7%). Aside from medical professionals, employees of railway companies (13%) were the most frequent, followed by school teachers (6%), security guards (6%), and employees of fitness facilities (6%).

Temporal Trends in Outcomes of Public-Access AED-Shocked Patients

Table 3 shows the temporal trends in the outcomes of pa-

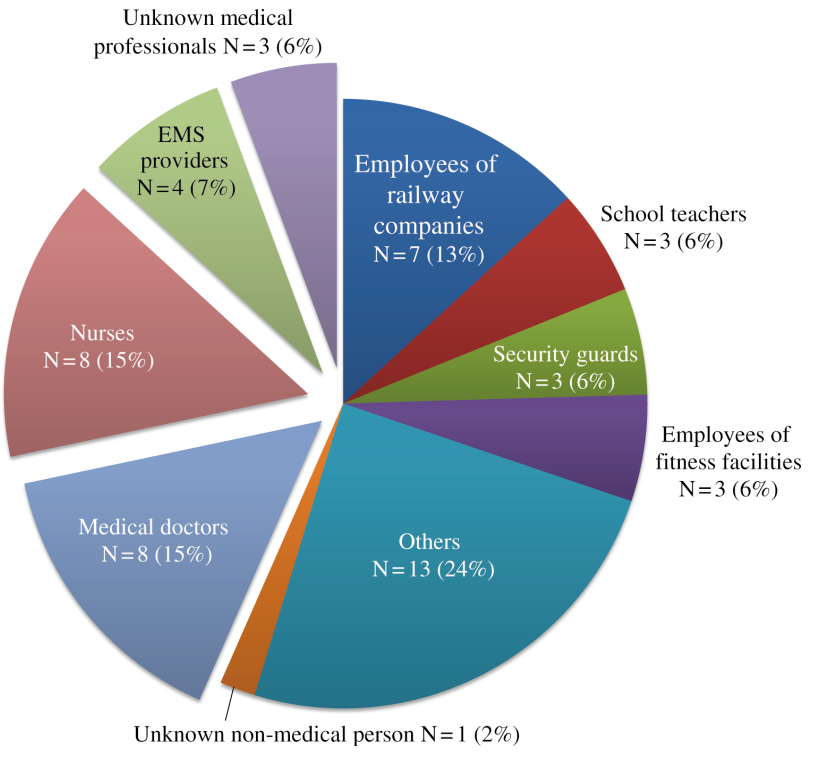

Figure 3. Occupations of the lay-rescuers who used public-access automated external defibrillator. EMS, emergency medical service.

Table 3. Outcomes of OHCA Patients Shocked by Public-Access AEDs

	Total (n=53)	2004 (n=0)	2005 (n=1)	2006 (n=6)	2007 (n=22)	2008 (n=24)	P for trend
Outcome, n (%)							
ROSC before hospital arrival	30 (57%)	–	0 (0%)	1 (17%)	9 (41%)	20 (83%)	<0.001
Hospital admission	34 (64%)	–	1 (100%)	2 (33%)	15 (68%)	16 (67%)	0.505
1-month survival	33 (62%)	–	1 (100%)	2 (33%)	14 (63%)	16 (67%)	0.439
1-month survival with favorable neurological outcome	27 (51%)	–	0 (0%)	1 (17%)	12 (55%)	14 (58%)	0.081

ROSC, return of spontaneous circulation. Other abbreviations see in Table 1.

tients who received shocks by public-access AEDs: 30 (57%) had ROSC before hospital arrival, 34 (64%) were admitted to a hospital, 33 (62%) had 1-month survival, and 27 (51%) had 1-month survival with a favorable neurological outcome. The proportion of ROSC before hospital arrival significantly increased from 0% in 2005 to 83% in 2008 (P for trend <0.001). As for 1-month survival with a favorable neurological outcome, the proportion also increased, from 0% in 2005 to 58% in 2008, although not statistically significant (P for trend=0.081).

Discussion

From a large population-based registry of OHCAs, we describe in detail the OHCA patients who received shocks by public-access AEDs, and their rescuers in a large urban community.

In this study, railway stations were found to be the most common places where shocks by public-access AEDs were delivered. Although we previously underscored that the energetic dissemination of public-access AEDs was useful for shortening the time to the shock and increasing survival after OHCA,[2] assessment of public-access AED locations has been insufficient, and issues surrounding the appropriate deployment of AEDs are still under debate.[1–3,9,19,20] Previous studies in Japan reported that approximately 10% of OHCAs occurred in public places, especially railway stations,[21,22] which contrasts somewhat with Western countries, where OHCAs have been more frequent in public buildings, schools, fitness facilities, and recreation facilities.[9,20,23,24] High frequencies in OHCA occurrence and the subsequent public-access AED use in railway stations may reflect the greater reliance on heavy railway transportation and may be a distinct feature of OHCA in Japan. These findings suggest that a nation- or region-specific strategy in public-access AED deployment may well be needed to improve survival after OHCA.

The present data demonstrated that approximately 60% of PAD cases in Japan were treated by non-medical persons, suggesting the effectiveness and feasibility of lay-rescuer PAD programs for the treatment of OHCA patients. Interestingly, the use of public-access AEDs in Japan has not been restricted to trained lay-rescuers but rather is open to anyone attempting to use an AED.[2,10,11] With first-responder PAD programs, however, only trained lay-rescuers such as firefighters or policemen as a part of dispatched system can use AEDs. This is a method popular in other countries.[1,25,26] The results of this study support the concept of lay-rescuer PAD programs and the new CPR guidelines recommending the unrestricted use of AEDs.[27,28]

This study demonstrated that the proportion of out-of-hospital VF patients shocked by public-access AEDs differed by location and it reached approximately 40–50% in railway stations and fitness facilities, which suggests that the PAD program has disseminated across the main public spaces in this large urban community of Japan. In these places, non-medical professionals frequently delivered shocks with public-access AEDs. This finding strengthens the importance of wider dissemination of CPR and AED training for non-medical professionals who are more likely to use a public-access AED, such as station workers, school teachers, and fitness instructors.

In this study, a favorable neurological outcome among patients shocked with public-access AEDs tended to improve year-by-year, although statistically insignificant. This possibly improving outcome could be explained not only by the dissemination of public-access AEDs and CPR training for the general public[27,28] but also the revision of CPR guidelines to the 2005 edition, and improvements in treatment before hospital arrival by EMS personnel and in-hospital advanced treatments such as hypothermia therapy.[29–31] Further accumulation of patients who received shocks by public-access AEDs is needed for better ascertaining the impact of the PAD program.

The present study also showed that some workers have a better chance of using a public-access AED than others. It is still controversial whether focused CPR training is better or not.[27,28] Although systemic CPR training programs have been offered to approximately 40,000 citizens every year,[16] bystander CPR was performed by only 40% of bystander-witnessed OHCA patients in this study area.[15] Considering this low proportion of bystander-initiated CPR despite many efforts to train lay-rescuers in CPR, a strategic approach, including focused training for those who are more likely to use a public-access AED, such as railway station workers, school teachers, and security officers, might effectively increase the proportion of bystander CPR and AED.[32–34] In addition, PAD programs with a simplified training program of chest compression-only CPR, which is much simpler and easier to learn and perform than conventional CPR,[35–37] would encourage lay-rescuers to perform CPR and use an AED in prehospital emergency settings.[38,39]

Study Limitations

An important limitation of this study is that we did not obtain information on the distribution of public-access AEDs in the study area. Without that data, we can neither evaluate the rate of AED use nor the cost-effectiveness of the widely disseminated public-access AEDs.

We only included OHCA patients to whom shocks were delivered by public-access AEDs. Lack of data on patients in which an attempt was made to use an AED but shocks were not delivered, is another limitation. In future studies, we will investigate OHCA occurrence, AED geographic distribution, and all AED uses involving both persons actually shocked or not shocked, to establish more effective methods for appropriate deployment of public-access AEDs.

Conclusions

This observational study showed that the lay-rescuer PAD program for the treatment of OHCA patients works relatively well in a Japanese metropolis, and characterizes the OHCA patients with PAD and their rescuers. Railway stations were the most common places where shocks by public-access AEDs were delivered, and station workers used AEDs most frequently among the lay-rescuers. These fundamental data should provide valuable clues for implementing a more effective PAD program.

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Disclosure

There are no conflicts of interest to declare.

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