Effectiveness of Public Access Defibrillation with AEDs for Out-of-Hospital Cardiac Arrests in Japan

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Abstract

In Japan, about 60,000 out-of-hospital cardiac arrests of cardiac etiology occur annually. Early initiation of cardiopulmonary resuscitation (CPR) and early defibrillation with public access automated external defibrillators (AEDs) by bystanders is the key to increasing survival after an out-of-hospital cardiac arrest (OHCA). Japanese data shows that nationwide dissemination of public access AEDs actually increases the rate of survival with a good neurological outcome after OHCA. Recently, the number of public access AEDs has been increasing rapidly, but implementation of AED use and CPR by public bystanders has not been sufficiently frequent, despite having become more common than before.

To improve the rate of OHCA survival with a good neurological outcome by making effective use of AEDs, there need to be further spread of AEDs with specific installation criteria as well as infrastructure development for promoting AED use. In addition, educational activities and practical programs should be introduced in the community setting. Recently, many reports, including by the Utstein Osaka Project, have showed that chest compression-only CPR is as effective as conventional CPR with rescue breathing. To save more lives, we should encourage the widespread practice of CPR by widely diffusing AEDs and simplified chest compression-only CPR training.

Key words Cardiac arrest, Cardiopulmonary resuscitation, AED, Ventricular fibrillation

Introduction

In Japan, about 60,000 cases of cardiogenic out-of-hospital cardiac arrest occur annually. It has been reported that 1/2 to 2/3 of deaths from acute myocardial infarction take place outside of hospitals.[1] Most deaths from cardiac disease are sudden, occurring outside of a hospital setting. It is thus necessary to improve the out-of-hospital emergency care system to decrease mortality from cardiac disease.

In the first decade of the 21st century, the out-of-hospital emergency care system improved markedly. According to the data obtained in Osaka during the period from 1998 to 2006,[2] the median time from collapse (cardiac arrest) to defibrillation by emergency personnel decreased remarkably from 19 min to 9 min (**Fig. 1**). Along with this improvement in the chain of survival, the neurologically intact survival rose to about 20% among adults suffering witnessed cardiogenic cardiac arrest and who had ventricular fibrillation (VF) when emergency personnel arrived at the scene. However, further reduction of the time from collapse to defibrillation is difficult if defibrillation is left to emergency personnel alone. To further increase the neurologically intact survival of patients with out-of-hospital cardiac arrest, it is essential to introduce public access defibrillation (PAD) with the use of an automated exter-

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nal defibrillator (AED).[3]

The effectiveness of PAD has occasionally been reported. Among these reports, a particularly famous description is a community intervention trial concerning PAD (the PAD trial) in the US.[4] In this trial, about 19,000 people were randomly allocated by community blocks. As a result, the number of survivors was approximately doubled in the group receiving an AED + cardiopulmonary resuscitation (CPR) program as compared to the group given CPR alone. However, previous studies including the PAD trial were carried out under restricted situations. Therefore, it has remained unclear whether nationwide spread of AEDs would improve the survival of patients after out-of-hospital cardiac arrest. This report provides an overview of the effect of the rapidly increasing installation of AEDs in Japan and issues to be resolved for further improvement of the neurologically intact survival for out-of-hospital cardiac arrest patients.

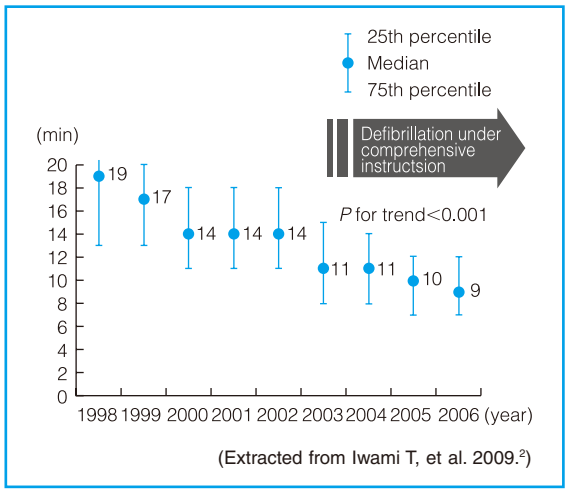

Fig. 1 Annual improvement of the emergency care system in Osaka: Time after collapse until defibrillation by emergency personnel

Effects of the Spread of AEDs in Japan

In Japan, the use of AEDs by the general public was approved in July 2004, and installation of AEDs has since been facilitated.[5] According to the report on a study conducted by Marukawa's group supported by a Ministry of Health, Labour and Welfare Grant-in-Aid for Scientific Research, the number of AEDs installed in public places increased from 9,906 to 88,265 over the three years from 2005 to 2007. Along with this increase in AEDs, the percentage of patients who underwent PAD among those with witnessed out-of-hospital cardiogenic VF increased from 1.2% to 6.2%. Neurologically intact 1 month survival was 14.4% among all patients with VF witnessed in a public setting, whereas the corresponding rate was 31.6% among those receiving PAD. Currently, it is estimated that the number of AEDs installed in public places exceeds 300,000.

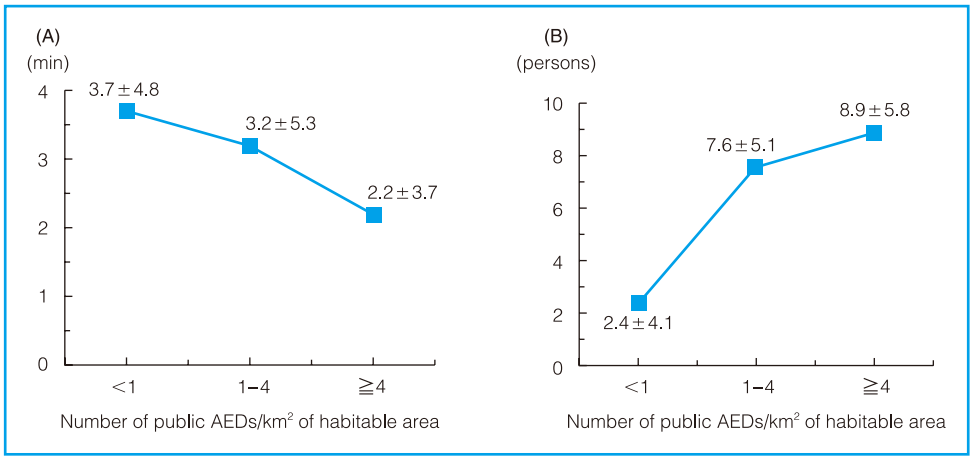

Fig. 2 Mean time until defibrillation by public bystander using an AED (A) and the number of patients with neurologically intact survival per 10 million population per year (B) by the density of public AEDs in the community

When factors affecting outcomes were evaluated by multivariate analysis, early defibrillation was found to correlate with neurologically intact survival regardless of who conducted the defibrillation (a public bystander or emergency personnel), showing an adjusted odds ratio of 0.91 for every minute of delay until defibrillation.[6] This means that every minute of delay until defibrillation causes a 9% decrease in neurologically intact survival, indicating how important prompt implementation of defibrillation is, rather than who performs the defibrillation.

As the number of public AEDs installed per habitable area increased from less than 1/km^2 (1 AED per square kilometer) to 4/km^2 (1 AED per 500 square meters), the mean time until defibrillation decreased from 3.7 min to 2.2 min, with an increase in the number of patients who were neurologically intact survival at 1 month from 2.4 to 8.9 per 10 million population per year (**Fig. 2**).

These results have shown for the first time that nationwide spread of public AEDs enables early defibrillation in patients with out-of-hospital cardiac arrest and improves the neurologically intact survival among such patients. Based on these findings, it would be advisable to further promote the distribution of AEDs worldwide.

Issues Involved in Further Improvement of the Neurologically Intact Survival by Making Good Use of AEDs

Further spread of AEDs and presentation of specific installation criteria

Although the aforementioned data indicate that spread of public AEDs leads to increased implementation of early defibrillation and improved neurologically intact survival among patients with out-of-hospital cardiac arrest, it is also apparent that there are differences in the spread of AEDs among various regions. The number of public AEDs equal to or exceeding 4/km^2 of habitable area has been achieved only in Tokyo and Osaka among the 47 prefectures of Japan. The density of installed AEDs is still insufficient in many less populous regions.

A number of issues remain to be clarified, including specifically where to install AEDs, whether AED installation is effective even in thinly populated regions, and the optimal density of AED installations. Although it has been reported that cardiac arrests were frequent in stations, physical exercise facilities including golf courses, and workplaces,[7] these issues need to be studied in detail to help formulate more specific installation criteria for AEDs.

Training of public rescuers in CPR and AED use

How to increase the number of persons who can carry out emergency care by means of AED is an important issue for optimizing the use of AEDs that are increasingly being installed and to increase neurologically intact survival of patients suffering out-of-hospital cardiac arrests. Although implementation of CPR by public bystanders who witness cardiac arrest has tended to increase, the percentage of such cases is still only about 40%, and the other 1/2 to 2/3 of patients are currently left without CPR until emergency personnel arrive at the scene.[2]

Based on a study of about 5,000 out-of-hospital cardiac arrest cases in Osaka, we have shown that bystander CPR by chest compression alone (4.3%) improves neurological outcomes in cases with out-of-hospital cardiac arrest as effectively as conventional CPR with rescue breathing (4.1%), in comparison with the absence of CPR (2.5%), provided that not more than 15 min have passed since collapse (**Fig. 3**).[8] The efficacy of CPR by chest compression alone in adult patients with cardiac arrest has also been documented in a number of other reports.

In the SOS-KANTO study, a large-scale hospital-based Utstein-style registration study in the Kanto area, the results suggested that chest-compression-only CPR is more effective than conventional CPR with rescue breathing in patients with VF and those with cardiac arrest within 4 min of onset.[9] Recent reports indicate that chest-compression-only CPR is associated with better outcomes than CPR with rescue breathing when CPR is carried out by a public rescuer[10] or under vocal instruction by phone.[11] Thus, the efficacy of CPR by chest compression alone may well be established. In particular, when an AED is used for resuscitation, the CPR procedure may be necessary only for a short period of time. The CPR procedure using only chest compression seems to be more extensively applicable in the current era of AED.

Like the "call & push" procedure recommended by the American Heart Association (AHA)[12] and the Japanese Circulation Society (**Fig. 4**),[13] if training programs focused on chest-compression-

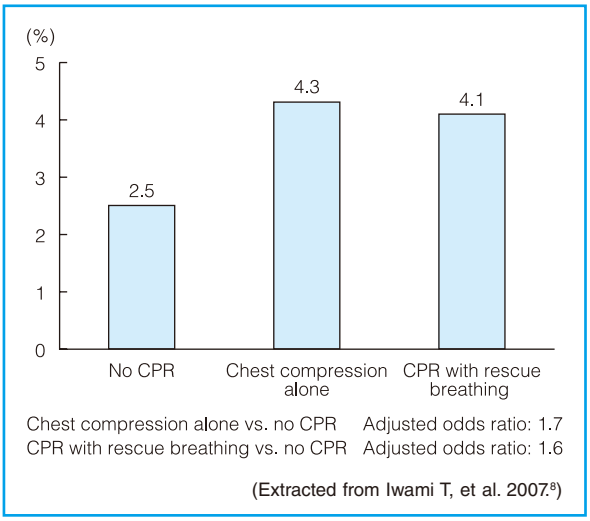

Fig. 3 Neurologically intact survival at 1 year among patients with witnessed cardiogenic cardiac arrest in relation to the type of bystander CPR (restricted to patients receiving CPR by emergency personnel within 15 min after witnessed cardiac arrest)

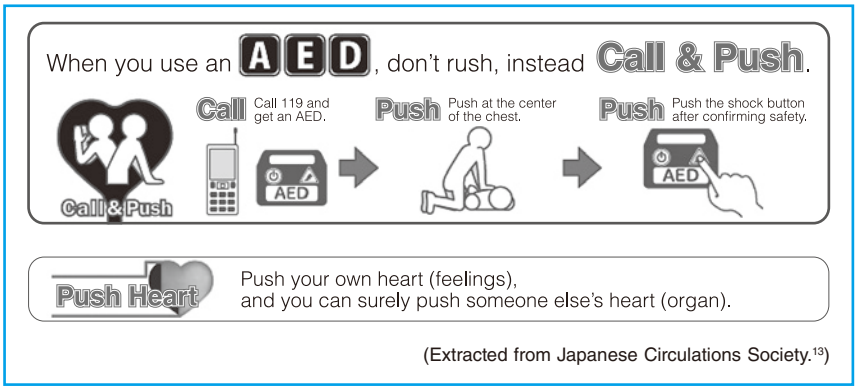

Fig. 4 Call & push recommended by the Japanese Circulation Society

only CPR and AED use are provided, their simple procedures may spread among many citizens within a short period of time. The new cardiopulmonary resuscitation guideline issued in October 2010, entitled the "2010 Japan Resuscitation Council (JRC) Guideline," states that chest-compression-only CPR may be useful in training programs mainly targeting the general public to facilitate bystander CPR, if participation in conventional training programs is limited because of temporal restrictions and the ages of participants, referring to the advantages of providing simplified training programs focused on chest-compression-only CPR (http://jrc.umin.ac.jp/) (Japanese only).

In Japan, a new attempt called the PUSH project that takes advantage of chest-compression only CPR started from Osaka Prefecture in order to educate and promote CPR among greater number of people. The non-profit organization Osaka Life Support Association, which aims to promote AED and CPR among the citizens of Osaka prefecture, played a major role for its launch. (PUSH project: http://osakalifesupport.jp/push/index.html). This project provides CPR training programs for 5% of the local population

Fig. 5 Scene of chest-compression-only CPR training using simplified training kits at a school

The use of simplified training kits (http://osakalifesupport.jp/img-top/cpr.pdf) provides an efficient practice experience with the chest compression procedure and AED use in a class hour.

every year through, e.g., promotion of CPR training in schools (**Fig. 5**), and sets the goal of achieving a bystander CPR implementation rate of at least 50% and an at least 3% increase in the neurologically intact survival among patients with witnessed cardiogenic cardiac arrests.

In addition, a study project on control of lifestyle-related diseases including cardiovascular diseases supported by a Ministry of Health, Labour and Welfare Grant-in-Aid for Scientific Research "Study of the spread of and education for effective emergency resuscitation for improvement of the neurologically intact survival among patients with cardiovascular diseases, etc."; (principal investigator, Seishiro Marukawa. http://kouroukaken-kyukyusosei.info/) (Japanese only) is employing a training program that provides efficient education on the procedures of chest compression and AED use over a short period of time in model regions, and is verifying the efficacy of the program.

Infrastructure development for promoting AED use (e.g., providing information on installed AEDs)

Installation of AEDs has been increased mainly in educational institutions and public facilities, providing more opportunities for citizens to see AEDs. However, most citizens remain unaware of where AEDs are installed, with no means available to find the nearest AED. In recent years, some local governments have shown maps of the locations of installed AEDs on their websites, and this has made it possible for the general public to ascertain the locations of AEDs easily (http://osakaaed.jp/) (Japanese only). Some of these maps are accessible via mobile terminals, and there are also some systems that allow a search of nearby AEDs even at the site of an emergency. Grasping the situation of AED installation and making it known to the general public is indispensable for promoting the use of AEDs. To this end, it is important for the individuals responsible for AED installation, fire service providers, local governments, etc., to cooperate in recognizing the current situation of AED installation and share all relevant information.

Conclusion

The advent of AEDs has caused citizens to play the leading role in resuscitation of patients with out-of-hospital cardiac arrest due to VF, the most serious type of arrhythmia, raising expectations of dramatic effects. On the other hand, implementation of AED use and CPR by public bystanders has not been sufficiently frequent despite having become more common than before. The need for emergency care training including the use of AEDs by public bystanders has been rising at an unprecedented rate, and efficient placement and operation of AEDs should be considered future priorities.

To achieve effective functioning of installed AEDs and promote further improvement of the neurologically intact survival for patients with out-of-hospital cardiac arrests, it is required that educational activities and practical programs be introduced in the community setting and to verify their effects.

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