Incidence of Ventricular Fibrillation in Patients With Out-of-Hospital Cardiac Arrest in Japan
— Survey of Survivors After Out-of-Hospital Cardiac Arrest in Kanto Area (SOS-KANTO) —

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Background Although there is a close connection between emergency medical services (EMS) system and the outcome of out-of-hospital ventricular fibrillation (VF), few data are available regarding the situation in Japan. Methods and Results A prospective multicenter study of out-of-hospital cardiac arrest was conducted according to the Utstein guidelines. A total of 4,383 patients who were given cardiopulmonary resuscitation (CPR) by EMS personnel for out-of-hospital cardiac arrest were enrolled. The proportion of VF or pulseless ventricular tachycardia (VT) as the first cardiac rhythm after cardiac arrest was 16.2% with a mean call-to-initial-recorded-electrocardiogram (ECG) interval of 11.1 min. In a subgroup of patients with witnessed collapse, the predicted incidence of VF or pulseless VT was 62.7% at the time of cardiac arrest, and the decline accelerated with every minute that the collapse-to-initial ECG interval was delayed. Multivariate analysis showed that the odds ratio for VF or pulseless VT at collapse-to-initial ECG interval was 0.91 (95% confidence interval (CI), 0.89–0.94, p<0.001), and 1.54 (95% CI, 1.24–1.97, p<0.001) after bystander CPR.

Conclusions In Japan, VF occurred in 63% of cases at the time of cardiac arrest and the performance of bystander CPR appeared to prolong VF. (Circ J 2005; 69: 1157–1162)

Key Words: Automated external defibrillator; Emergency medical services; Out-of-hospital cardiac arrest; SOS-KANTO; Ventricular fibrillation

Ventricular fibrillation (VF) is the most common cause of out-of-hospital cardiac arrest in Europe and the USA. The guidelines 2000 for cardiopulmonary resuscitation (CPR) and emergency cardiovascular care reported that the use of public access defibrillators in the hands of trained laypersons has the potential to be the single greatest advance in the treatment of VF-induced cardiac arrest since the development of CPR, because victims of cardiac arrest can be defibrillated within a few minutes and in fact, extraordinary survival rates have been reported by public access defibrillation programs.

In 2004, a public access defibrillation program was authorized by the Ministry of Health, Labor and Welfare in Japan. Three large-scale studies of out-of-hospital cardiac arrest, conducted using the Utstein guidelines for cardiac arrest, are intended to provide a structure for evaluating an emergency medical services (EMS) system. have reported that the proportion of patients with VF or pulseless ventricular tachycardia (VT) as the first cardiac rhythm at the time of arrival of EMS personnel was approximately 10%, which is one-quarter of the incidence in the USA and Europe.

Although there are close connections between the outcome of VF or pulseless VT and the time interval from collapse to initial recorded electrocardiogram (ECG), the cause of cardiac arrest and whether there are witnesses to the patient’s collapse and bystander instituted CPR are 1.54 (95%CI, 1.24–1.97, p<0.001) after bystander CPR.

Conclusions In Japan, VF occurred in 63% of cases at the time of cardiac arrest and the performance of bystander CPR appeared to prolong VF. (Circ J 2005; 69: 1157–1162)

Key Words: Automated external defibrillator; Emergency medical services; Out-of-hospital cardiac arrest; SOS-KANTO; Ventricular fibrillation

Methods

Study Population
The Survey Of Survivors after out-of-hospital cardiac arrest in the KANTO area (SOS-KANTO) was a prospective multicenter study of patients with out-of-hospital cardiac arrest, conducted according to the Utstein guidelines. Between September 2002 and April 2003, 7,138 patients with out-of-hospital cardiac arrest were given CPR by EMS personnel and transported to the emergency hospitals participating in SOS-KANTO. The present study included 4,138 patients who were enrolled in the SOS-KANTO and who had documented cardiac arrest from a cardiac cause and were aged 8 years or older.

Investigation and Data Collection
We investigated the incidence of VF or pulseless VT as the first cardiac rhythm after cardiac arrest, based on the tracings obtained from the automated external defibrillators used by emergency life-saving technicians or from the ECG.
used by EMS personnel without emergency life-saving technicians. The diagnosis of cardiac arrest from cardiac cause was determined by physicians, according to the Utstein guidelines, and the cardiac etiology was categorized.\textsuperscript{5,18} Because the treatment for pulseless VT has the same algorithm as VF, 5 patients with pulseless VT were included with those whose first cardiac rhythm was VF.

The data for the cases of out-of-hospital cardiac arrest were entered into a database according to the Utstein guidelines\textsuperscript{5} by the SOS-KANTO members of each hospital and were collected by the SOS-KANTO committee under the conditions of patient anonymity and impossible connections, according to the guideline of the ethics for epidemiological surveys from the Ministry of Health, Labor and Welfare in Japan.\textsuperscript{19}

**Statistical Analysis**

Statistical analyses were carried out using Stat View 5.0 (SAS Institute Inc, Cary, NC, USA). Continuous variables were reported as means and standard deviation, as well as medians, and were compared between the 2 groups (VF group vs non VF group) by Mann-Whitney U-test. The Kruskal-Wallis test and the nonlinear regression analysis were used to illustrate the relationship between the incidence of VF or pulseless VT and the collapse-to-initial ECG interval. The incidence of VF or pulseless VT was compared between the 2 groups (bystander CPR group vs no bystander CPR group, which were classified by 3-min time intervals between collapse and the initial recorded ECG) by the two-way ANOVA. In addition, Fisher’s exact test was used to compare the proportion of cases of VF or pulseless VT between those groups of each time interval. Finally, the independent factors associated with the incidence of VF or pulseless VT were estimated from a multiple logistic-regression model.

**Results**

The results are summarized in Table 1. Of the 4,383 patients enrolled, cardiac arrest occurred after the arrival of EMS personnel in 4.0% of cases, 47.2% were witnessed by bystanders, and 30.9% had CPR performed by bystanders. The first cardiac rhythm after cardiac arrest was VF in 15.0%, pulseless VT in 1.2%, pulseless electrical activity (PEA) in 16.9%, asystole in 63.7%, and omission in 3.2%. The time interval from the call to initial recorded ECG ranged from 1 to 55 min, with a mean (± SD) of 11.1±4.7 min, a median of 10 min, and 25th and 75th of percentile values of 8 and 13 min, respectively.

In the subgroup of 2,244 patients whose collapse was witnessed by bystanders or EMS personnel, cardiac arrest after arrival of the EMS personnel in 7.9% and 36.3% had CPR performed by bystanders. The first cardiac rhythm after cardiac arrest was VF in 23.1%, pulseless VT in 1.7%, PEA in 21.9%, asystole in 48.3%, and omission in 5%. The collapse-to-initial ECG interval was shorter for patients with VF or pulseless VT than for those with PEA or asystole (mean±SD: 12.0±5.3 vs 16.0±8.9 min; median: 12 vs 14 min, p<0.0001). This association remained significant in the subgroups of patients with or without bystander instituted CPR (p<0.0001, respectively) (Fig 1).

**Relationship Between the Incidence of VF or Pulseless VT and the Collapse-to-Initial-Recorded ECG Interval in Patients With Out-of-Hospital Witnessed Collapse From Cardiac Causes**

The incidence of VF or pulseless VT decreased in a stepwise fashion among patients with every 3 min that the collapse-to-initial ECG interval was delayed (the time interval from 0 to 3 min vs 4–6 min vs 7–9 min vs 10–12 min vs 13–15 min vs 16–18 min vs 19–21 min vs 22–24 min vs 25–27 min vs 28–30 min; 59% vs 44% vs 37% vs 33% vs 25% vs 19% vs 15% vs 11% vs 7% vs 4% vs 3%; p<0.001). The trend remained significant in the subgroups of patients with or without bystander CPR (p<0.0001, respectively) (Fig 1).
Out-of-Hospital VF

Circulation Journal Vol.69, October 2005

26% vs 25% vs 19% vs 23% vs 15% vs 4%, p<0.0001) (Fig 2a). The predicted incidence of VF or pulseless VT was 62.7% in patients whose initial ECG were recorded at the time of cardiac arrest, and the decline accelerated with every minute that the collapse-to-initial ECG interval was delayed (p<0.0001) (Fig 2b).

In the multiple logistic regression analysis for independent predictors of witnessed collapse with VF or pulseless VT, including age, gender, the location of collapse and the presence or absence of bystander instituted CPR, the collapse-to-initial ECG interval remained significantly associated with an incidence of VF or pulseless VT. The adjusted odds ratios for VF or pulseless VT for age, male gender, collapse in a public place, the presence of bystander instituted CPR and the collapse-to-initial ECG interval were 0.99 (95% confidence interval (CI), 0.98–0.99, p<0.0001), 2.0 (95% CI, 1.48–2.67, p<0.0001), 1.72 (95% CI, 1.33–2.21, p<0.0001), 1.54 (95% CI, 1.24–1.97, p<0.0001) and 0.91 (95% CI, 0.89–0.94, p<0.0001), respectively (Fig 3).

Relationship Between the Incidence of VF or Pulseless VT and the Presence or Absence of Bystander Instituted CPR in Patients With Out-of-Hospital Witnessed Collapse From Cardiac Causes

The incidence of VF or pulseless VT was higher among
patients with bystander instituted CPR than among those without bystander CPR (261 of 815 patients [32.0%] vs 320 of 1,429 patients [22.4%], p<0.0001). In the two-way ANOVA, the incidence of VF or pulseless VT with every 3 min of collapse-to-initial ECG interval was higher among patients with bystander instituted CPR than among those without bystander CPR (0–3 min; 59% vs 58%, 4–6 min; 46% vs 43%, 7–9 min; 49% vs 30%, 10–12 min; 40% vs 29%, 13–15 min; 31% vs 23%, 16–18 min; 33% vs 21%, 19–21 min; 20% vs 19%, 22–24 min; 31% vs 17%, 25–27 min; 32% vs 0%, 28–30 min; 11% vs 0%, p<0.0001) (Fig 4a), and these incidences for the time intervals 7–9 min, 10–12 min, 16–18 min and 24–27 min were higher among patients with bystander instituted CPR than among those without bystander CPR (p<0.05, respectively). The predicted incidence of VF or pulseless VT decreased with every minute that the collapse-to-ECG interval was delayed in each group (Bystander CPR group; p<0.0001, and No bystander CPR group; p=0.0002), and changed the upper level among patients with bystander instituted CPR compared with those without bystander CPR (Fig 4b).

Discussion

We investigated the relationship between the incidence of out-of-hospital VF from cardiac causes and the EMS system, including the collapse-to-initial ECG interval, because few data were available about whether or not the public access defibrillation programs have a benefit in Japan. The present study demonstrated that the proportion
of cases of VF or pulseless VT as the first cardiac rhythm after out-of-hospital cardiac arrest from cardiac causes was 16.2% with a mean (± SD) call-to-initial-recorded-ECG interval of 11.1±4.7 min. In a subgroup of patients with witnessed collapse, the predicted incidence of VF or pulseless VT at the time of cardiac arrest was 62.7% and its incidence decreased with every minute that the collapse-to-initial ECG interval was delayed. Multiple logistic-regression analysis showed the collapse-to-initial ECG interval and the performance of bystander CPR to be independent factors for out-of-hospital VF or pulseless VT. In addition, the performance of bystander CPR maintained VF or pulseless VT for about 27 min after cardiac arrest.

The majority of cases of sudden cardiac arrest without trauma are caused by acute ventricular tachyarrhythmias, often triggered by acute coronary events. Common characteristics of fatal arrhythmias in patients with ischemic heart disease are: a ventricular tachyarrhythmia triggered by acute myocardial ischemia in patients with or without preexisting myocardial scarring, or ventricular tachyarrhythmia related to an anatomical substrate without active or clinically obvious myocardial ischemia. Epidemiologic data indicate that structural coronary abnormalities and their consequences cause 80% of the cases of VF or pulseless VT, dilated and hypertrophic cardiomyopathies account for the second largest proportion of 10–15%, and other cardiac disorders, such as primary electrical and genetic ion-channel abnormalities, valvular or congenital heart disease, account for only a small proportion.

Although small-scale studies of sudden cardiac death, such as those involved in the WHO-MONICA project or autopsy, have reported that the incidence of sudden cardiac death from acute coronary syndrome is lower among patients with out-of-hospital cardiac arrest in Japan than in Europe and the USA, 3 large-scale Japanese studies that used the Utstein guidelines have demonstrated that cardiac etiology accounted for the largest proportion (>50%) of patients with out-of-hospital cardiac arrest and the proportion of cases of VF or pulseless VT as the first cardiac rhythm was approximately 10% of those who were in cardiac arrest before the arrival of EMS personnel who gave CPR. On the other hand, Nagao et al also used the Utstein guidelines and showed that the proportion of VF or pulseless VT as the first cardiac rhythm was 38% with a mean call-to-scene interval of approximately 5.5 min and the cause of VF was acute coronary syndrome in 78%, which included the initial angiogram of the acute coronary syndrome related artery that had Thrombolysis in Myocardial Infarction flow grade 0–2 in 77%.

The Utstein guidelines for cardiac arrest are intended to provide a structure for evaluating an EMS system and the usefulness of the Utstein style has been confirmed by the many communities that have identified weakness in the “Chain of Survival” of their emergency cardiovascular care. The studies conducted according to the Utstein style have indicated that there are several characteristics of the EMS system in Japan that account for the low proportion of VF or pulseless VT as the first cardiac rhythm. (1) The criteria of CPR attempt by EMS personnel is broad: more than 93% of patients with out-of-hospital cardiac arrest had a CPR attempt by EMS personnel; compared with approximately 50% in Seattle, Washington. (2) The frequency of bystander instituted CPR is low in Japan, despite the knowledge that CPR will prolong VF. In Japan, approximately 25% of patients with cardiac arrest on arrival of the EMS personnel have received bystander CPR; compared with more than 50% of those in Seattle, Washington. (3) The time interval from the call to initial recorded ECG by EMS personnel is a mean of 11.1 min compared with 4 min in Seattle, Washington.

In the present study, the predicted incidence of VF or pulseless VT was 63% at the time of cardiac arrest in patients with witnessed collapse. This ratio of VF or pulseless VT was slightly lower than that in the study by Valenzuela et al whose patients were treated in casinos but was similar to the report of King County, Washington and the study by Bunch et al.

A recent study showed that advanced cardiac life support with endotracheal intubation and administration of intravenous drugs by paramedics did not improve the rate of survival after out-of-hospital cardiac arrest in a previously optimized EMS system of rapid defibrillation and another showed that training and equipping volunteers to attempt early defibrillation within a structured response system could increase the number of survivors to hospital discharge after cardiac arrest in a public location. In addition, the present study showed that the performance of bystander CPR appeared to prolong VF or pulseless VT for about 27 min after cardiac arrest. These findings suggest that achieving the optimal survival rate for out-of-hospital cardiac arrest from cardiac causes is training Japanese citizens in basic life support and the use of public defibrillators.

**Study Limitations**

The present study was not a population-based survey, which would permit calculation of the population-based incidence of cardiac arrest as well as the population-based survival rate. However, the outcomes of the present study, such as the proportion of patients with cardiac arrest from cardiac causes, witnessed collapse, bystander instituted CPR and VF or pulseless VT as the first cardiac rhythm, and the time intervals between events were similar to those of the population-based survey in Osaka prefecture, Japan. The present study could not demonstrate where to locate public access defibrillators, although the number of cases of VF or pulseless VT in public place was higher than in home.

In conclusion, the incidence of VF or pulseless VT was 63% at the time of cardiac arrest in patients with out-of-hospital cardiac arrest from cardiac causes. Although the incidence of VF or pulseless VT declined every minute that the collapse-to-initial ECG interval was delayed, performance of CPR by bystanders appeared to prolong VF or pulseless VT for about 27 min after cardiac arrest. Based on these findings, the EMS system in Japan needs to include immediate bystander CPR plus early defibrillation for achievement of the optimal survival rate.

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Appendix I
The investigators who participated in the SOS-KANTO.

Appendix II

Circulation Journal Vol. 69, October 2005