# Effectiveness of Bystander-Initiated Cardiac-Only Resuscitation for Patients With Out-of-Hospital Cardiac Arrest

Taku Iwami, MD, PhD; Takashi Kawamura, MD, PhD; Atsushi Hiraide, MD, PhD; Robert A. Berg, MD; Yasuyuki Hayashi, MD, PhD; Tatsuya Nishiuchi, MD; Kentaro Kajino, MD; Naohiro Yonemoto, MPH; Hidekazu Yukioka, MD, PhD; Hisashi Sugimoto, MD, PhD; Hiroyuki Kakuchi, MD, PhD; Kazuhiro Sase, MD, PhD; Hiroyuki Yokoyama, MD, PhD; Hiroshi Nonogi, MD, PhD

***Background*—**Previous animal and clinical studies suggest that bystander-initiated cardiac-only resuscitation may be superior to conventional cardiopulmonary resuscitation (CPR) for out-of-hospital cardiac arrests. Our hypothesis was that both cardiac-only bystander resuscitation and conventional bystander CPR would improve outcomes from out-of-hospital cardiac arrests of ≤15 minutes' duration, whereas the addition of rescue breathing would improve outcomes for cardiac arrests lasting >15 minutes.

***Methods and Results*—**We carried out a prospective, population-based, observational study involving consecutive patients with emergency responder resuscitation attempts from May 1, 1998, through April 30, 2003. The primary outcome measure was 1-year survival with favorable neurological outcome. Multivariable logistic regression analysis was performed to evaluate the relationship between type of CPR and outcomes. Among the 4902 witnessed cardiac arrests, 783 received conventional CPR, and 544 received cardiac-only resuscitation. Excluding very-long-duration cardiac arrests (>15 minutes), the cardiac-only resuscitation yielded a higher rate of 1-year survival with favorable neurological outcome than no bystander CPR (4.3% versus 2.5%; odds ratio, 1.72; 95% CI, 1.01 to 2.95), and conventional CPR showed similar effectiveness (4.1%; odds ratio, 1.57; 95% CI, 0.95 to 2.60). For the very-long-duration arrests, neurologically favorable 1-year survival was greater in the conventional CPR group, but there were few survivors regardless of the type of bystander CPR (0.3% [2 of 624], 0% [0 of 92], and 2.2% [3 of 139] in the no bystander CPR, cardiac-only CPR, and conventional CPR groups, respectively; $P<0.05$).

***Conclusions*—**Bystander-initiated cardiac-only resuscitation and conventional CPR are similarly effective for most adult out-of-hospital cardiac arrests. For very prolonged cardiac arrests, the addition of rescue breathing may be of some help. **(*Circulation*. 2007;116:2900-2907.)**

**Key Words:** cardiopulmonary resuscitation ■ death, sudden ■ heart arrest ■ ventricular fibrillation

Sudden cardiac arrest is a leading cause of death in the industrialized world.[1] A strong chain of survival with early activation of emergency medical services (EMS), early cardiopulmonary resuscitation (CPR), early defibrillation, and early advanced life support measures has improved outcomes substantially in some smaller cities such as Seattle (Wash),[2] Gotëborg (Sweden),[3] and Rochester (Minn).[4] However, survival rates from out-of-hospital sudden cardiac arrest in large urban populations are generally <3%.[5–7]

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Although bystander CPR can substantially improve outcomes from cardiac arrest, it typically is provided to <25% of cardiac arrest victims.[8–10] This low rate of bystander CPR can be explained by fear of causing harm, difficulty in learning and performing this complex psychomotor task, and aversion to mouth-to-mouth rescue breathing.[11–13] Cultural factors in Japan may increase the unwillingness to provide mouth-to-mouth

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From the Division of Cardiology, National Cardiovascular Center, Suita, Japan (T.I., H. Yokoyama, H.N.); Kyoto University Health Service, Kyoto, Japan (T.K.); Center for Medical Education, Kyoto University Graduate School of Medicine, Kyoto, Japan (A.H.); Sarver Heart Center, University of Arizona, College of Medicine, Tucson (R.A.B.); Senri Critical Care Medical Center, Osaka Saiseikai Senri Hospital, Suita, Japan (Y.H.); Osaka Prefectural Senshu Critical Care Medical Center, Izumisano, Japan (T.N.); Department of Traumatology and Acute Critical Medicine, Osaka University Graduate School of Medicine, Suita, Japan (K.K., H.S.); Department of Biostatistics, Kyoto University School of Public Health, Kyoto, Japan (N.Y.); Yukioka Hospital, Osaka, Japan (H. Yukioka); Department of Cardiology, Tokai University Hachioji Hospital, Hachioji, Japan (H.K.); and Department of Clinical Pharmacology, Juntendo University Medical School, Tokyo, Japan (K.S.).

Correspondence to Taku Iwami, MD, PhD, Kyoto University Health Service, Yoshida Honmachi, Sakyo-Ku, Kyoto 606–8501, Japan. E-mail iwamit2000@yahoo.co.jp



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rescue breathing.[14] Our clinical observations indicated that many Japanese lay rescuers provided chest compressions without rescue breathing even though this approach had not been taught in any resuscitation training program in Japan.

Animal and clinical investigations suggest that bystander-initiated cardiac-only resuscitation is at least as effective as conventional CPR for ventricular fibrillation (VF).[15–18] In addition, the recent SOS-KANTO (Survey of Survivors of Out-of-Hospital Cardiac Arrest in the Kanto Region of Japan) study demonstrated that cardiac-only resuscitation might be the preferable approach to resuscitation for adult patients with witnessed out-of-hospital cardiac arrests, especially those with a shockable rhythm or short periods of untreated arrest.[19]

The Utstein Osaka Project is a large, prospective, population-based cohort study of out-of-hospital cardiac arrest in Osaka, Japan.[20,21] Among almost 5000 witnessed cardiac arrests of presumed cardiac origin over 5 years, >500 victims were provided cardiac-only resuscitation. We hypothesized that bystander CPR with either cardiac-only resuscitation or conventional CPR would improve outcomes from cardiac arrests of ≤15 minutes' duration with a presumed cardiac origin. Because of probable progressive atelectasis and hypoxemia after very long cardiac arrests, we further hypothesized that only conventional CPR with rescue breathing would improve outcomes after very prolonged cardiac arrests of >15 minutes' duration.

## Methods

### The EMS System in Osaka

Osaka Prefecture has ≈8.8 million residents in a 1892-km$^2$ area of both urban and rural communities and 35 fire stations with a corresponding number of emergency dispatch centers. The EMS system is operated by the local fire stations and activated by dialing 119 on the telephone. Life support is provided 24 hours each day by the local EMS system, which is single tiered in 33 stations and 2 tiered in 2 stations. The most highly trained prehospital emergency care providers are the emergency lifesaving technicians, who were allowed only to insert an intravenous line and an adjunct airway and to use a semiautomated external defibrillator for out-of-hospital cardiac arrest patients under a physician's online medical directions during this study period. These EMS providers were not permitted to administer any medication, including epinephrine. Each ambulance has 3 providers with at least 1 emergency lifesaving technician. Systematic CPR training for citizens has been offered mainly by local fire departments and the Japan Red Cross, Inc. In Osaka, ≈115 000 citizens per year participated in the conventional CPR training, consisting of chest compressions and mouth-to-mouth ventilation.

### Study Participants

This cohort study enrolled all persons ≥18 years of age who suffered out-of-hospital cardiac arrest of presumed cardiac origin, were witnessed by bystanders, and were treated by EMS in Osaka Prefecture from May 1, 1998, through April 30, 2003. The research protocol was approved by the institutional review board of Osaka University, with the assent of the EMS authorities and local governments in Osaka prefecture.

Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.[22] The arrest was presumed to be of cardiac origin unless it was caused by trauma, drowning, drug overdose, asphyxia, exsanguination, or any other noncardiac cause determined by the responsible physician in collaboration with the EMS rescuers.

### Data Collection

Data were collected prospectively with a data form that included all core data recommended in the Utstein-style reporting guidelines for cardiac arrests[22] such as sex; age; initial cardiac rhythm; time course of resuscitation; type of bystander-initiated CPR; return of spontaneous circulation; hospital admission; 1-week, 1-month, and 1-year survival; and neurological status 1 year after the event.

The presence and type of bystander-initiated CPR were documented by the EMS personnel on the scene. Initial rhythm was recorded and diagnosed by the EMS personnel with semiautomated defibrillators on the scene and confirmed by the physician responsible for the online medical direction. Special emphasis was placed on determining the time course of resuscitation. The times of EMS call receipt and vehicle arrival at the scene were recorded automatically at the dispatch center. The times of collapse and initiation of bystander CPR were obtained by EMS interview with the bystander before leaving the scene. The time of defibrillation was recorded in the semiautomated defibrillator. Watches of EMS personnel were synchronized with the clock of their dispatch center.

The data form was filled out by the EMS personnel in cooperation with the physicians in charge of the patient, 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. All survivors were followed up for up to 1 year after the event by the investigators with the cooperation of the Osaka Medical Association and medical institutes in this area. Neurological outcome was determined by a follow-up letter and/or telephone interview 1 year after successful resuscitation using the cerebral performance category scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death.[22]

### Statistical Analysis

The primary outcome measure was neurologically favorable 1-year survival. Favorable neurological outcome was defined as cerebral performance categories 1 or 2.[22] Secondary outcome measures included return of spontaneous circulation; admission to hospital; and 1-week, 1-month, and 1-year survival. VF as the initial recorded rhythm was evaluated as a process variable because VF can be maintained for a longer time with adequate myocardial perfusion during CPR.[10,23] When the type of bystander-initiated CPR was not described, the data were not included in either the cardiac-only resuscitation group or the conventional CPR group. Patients with very-long-duration cardiac arrests (>15 minutes) were analyzed separately because these patients are pathophysiologically quite different and have very poor outcomes.[24,25] In particular, they suffer from progressive atelectasis and hypoxemia, presumably limiting the opportunity for good outcomes with cardiac-only resuscitation.

Patient characteristics were evaluated with ANOVA for numerical variables and a $\chi^2$ test for categorical variables. Logistic regression analysis was performed on the relationship between type of bystander-initiated CPR and outcomes, and odds ratios (ORs) and their 95% CIs were calculated. In multivariable analyses, potential confounding factors significantly associated with survival in the univariable analyses were incorporated. Statistical analyses were performed with SPSS statistical package version 12.0J (SPSS, Inc, Chicago, Ill) and in part with SAS software version 9.13 (SAS Institute Inc, Cary, NC). A 2-sided value of $P \leq 0.05$ was regarded as statistically significant.

The authors had full access to and take responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

## Results

The mean population-based incidence of adult out-of-hospital cardiac arrest in the Osaka prefecture during this time period was 63 per 100 000 person-years, and the mean incidence of cardiac arrest of presumed cardiac origin was 36 per 100 000 person-years, of which 13 per 100 000 person-years were witnessed (Figure 1). Initial VF was noted in 2.2 per 100 000 person-years. These data were similar from year to year (Figure 1).

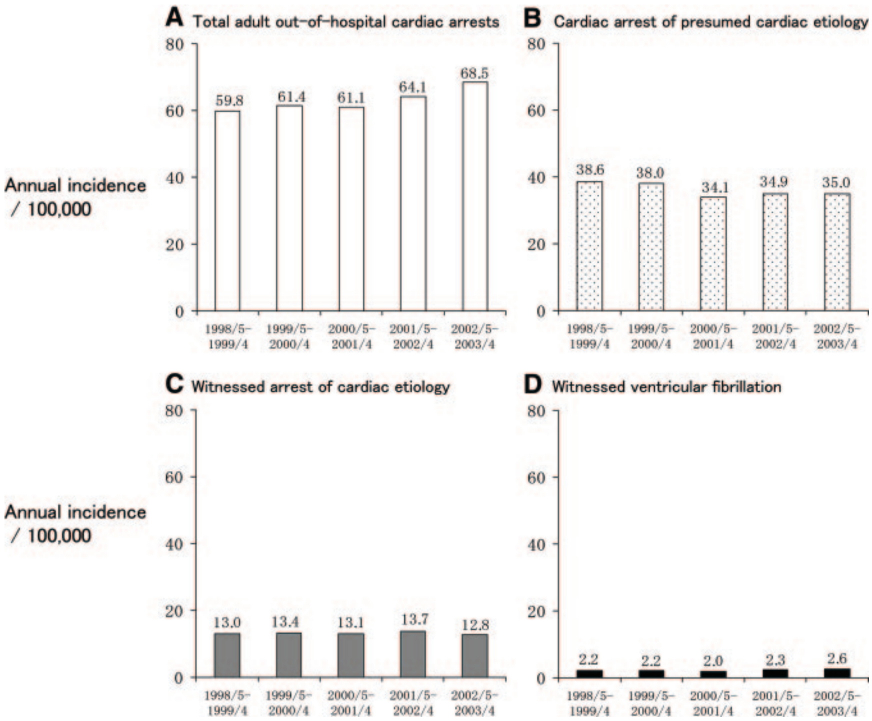


**Figure 1.** Temporal trend of adult out-of-hospital cardiac arrests in Osaka. Bars show the population-based incidence of adult out-of-hospital cardiac arrest (A), cardiac arrest of presumed cardiac origin (B), witnessed arrest of cardiac origin (C), and witnessed VF (D) in the Osaka prefecture during the study period.

Over these 5 years, 24 347 adult out-of-hospital cardiac arrests were documented, resuscitation was attempted in 23 436, and 13 444 were presumed to be of cardiac origin. Figure 2 provides an overview of the arrests with the important outcomes. Of these out-of-hospital cardiac arrests with presumed cardiac origin, 4902 were witnessed. Among them, 783 (16%) received conventional CPR, and 544 (11%) received cardiac-only resuscitation. Data on the type of bystander-initiated CPR were not available for 25 cases (0.5%). We could not obtain 1-year survival or neurological outcome data for 25 patients among the 23 436 patients resuscitated, of whom 4468 survived to hospital admission. In addition, we could not obtain neurological outcome data for 4 of 419 known 1-year survivors.

Demographic characteristics of patients with witnessed cardiac arrest of presumed cardiac origin and witnessed VF arrests are noted in Table 1. The cardiac-only resuscitation, conventional CPR, and no bystander CPR groups were generally similar except that the no bystander CPR group was more likely to have their arrests at home and less likely to have them in healthcare facilities. These similarities of patients' characteristics were essentially unaltered when patients were divided into cardiac arrests lasting ≤15 minutes and very-long-duration cardiac arrests (>15 minutes). The mean time intervals from collapse to CPR by EMS personnel also were similar among the 3 groups when they were divided into cardiac arrests ≤15 minutes' duration (8.7, 8.9, and 9.1 minutes in the no bystander CPR, cardiac-only resuscitation, and conventional CPR groups, respectively) and very-long-duration cardiac arrests (23.6, 23.0, and 22.5 minutes, respectively). Factors associated with 1-year survival with favorable

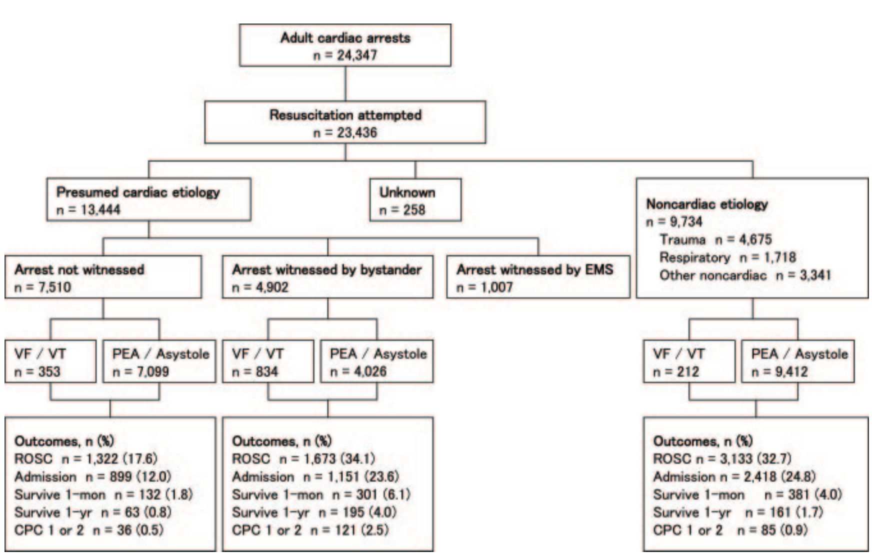


**Figure 2.** Overview of EMS-treated cardiac arrests with an abridged Utstein template (May 1998 to April 2003). VT indicates ventricular tachycardia; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; and CPC, cerebral performance category.

**Table 1. Characteristics of the 4877 Study Patients**

| | No CPR | Cardiac Only | Conventional CPR | *P* |
|---|---|---|---|---|
| Witnessed cardiac arrests of presumed cardiac origin, n | 3550 | 544 | 783 | |
| Age, mean (SD), y | 70.0 (15.0) | 68.2 (15.3) | 69.1 (16.1) | 0.01 |
| Men, n (%) | 2237 (63.3) | 359 (66.2) | 483 (61.8) | 0.25 |
| Location of arrests, n (%) | | | | |
| Home | 2640 (74.8) | 329 (60.9) | 416 (53.4) | |
| Public space | 487 (13.8) | 77 (14.3) | 97 (12.5) | |
| Work place | 142 (4.0) | 28 (5.2) | 27 (3.5) | <0.001 |
| Healthcare facility* | 95 (2.7) | 69 (12.8) | 173 (22.2) | |
| Others | 165 (4.7) | 37 (6.9) | 66 (8.5) | |
| Activity of daily life before arrests, n (%) | | | | |
| Good | 2593 (77.9) | 384 (74.7) | 543 (73.2) | |
| Mild disability | 392 (11.8) | 61 (11.9) | 104 (14.0) | 0.02 |
| Severe disability | 345 (10.4) | 69 (13.4) | 94 (12.7) | |
| Vegetative state | 0 (0.0) | 0 (0.0) | 1 (0.1) | |
| Collapse to CPR by EMS personnel, mean (SD), min | 10.5 (7.3) | 10.6 (7.1) | 11.0 (6.8) | 0.21 |
| Witnessed VF cardiac arrests, n | 535 | 122 | 161 | |
| Age, mean (SD), y | 63.2 (13.2) | 60.3 (14.7) | 62.4 (15.7) | 0.11 |
| Men, n (%) | 411 (77.3) | 97 (79.5) | 121 (75.2) | 0.69 |
| Location of arrests, n (%) | | | | |
| Home | 272 (51.5) | 48 (40.3) | 76 (47.5) | |
| Public space | 155 (29.4) | 38 (31.9) | 36 (22.5) | |
| Work place | 56 (10.6) | 14 (11.8) | 9 (5.6) | <0.001 |
| Healthcare facility* | 10 (1.9) | 6 (5.0) | 16 (10.0) | |
| Others | 35 (6.6) | 13 (10.9) | 23 (14.4) | |
| Activity of daily life before arrests, n (%) | | | | |
| Good | 451 (92.0) | 109 (96.5) | 129 (83.2) | |
| Mild disability | 30 (6.1) | 4 (3.5) | 20 (12.9) | 0.002 |
| Severe disability | 9 (1.8) | 0 (0.0) | 6 (3.9) | |
| Vegetative state | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Collapse to CPR by EMS personnel, mean (SD), min | 8.9 (4.4) | 9.7 (5.9) | 10.3 (4.8) | 0.005 |
| Collapse to defibrillation by EMS personnel, mean (SD), min | 15.4 (6.6) | 15.5 (7.0) | 16.7 (6.1) | 0.12 |

*Includes chronic care facilities and medical clinics.

neurological outcome included sex, age, activity of daily living before arrest, year of arrest, location of arrest, and time interval from collapse to the initiation of CPR by EMS personnel.

Crude 1-year survival with favorable neurological outcome after witnessed cardiac arrests of presumed cardiac origin was more frequent in the cardiac-only resuscitation group (3.5%) and the conventional CPR group (3.6%) than the no bystander CPR group (2.1%). Overall 1-year survival also was more frequent in both bystander resuscitation groups (Table 2). Similarly, VF was more likely to be the initial ECG rhythm in the cardiac-only resuscitation group (23%) and conventional CPR group (21%) than the no bystander CPR group (15%). The outcomes of witnessed VF cardiac arrests were similarly improved with both cardiac-only resuscitation and conventional CPR (Table 2).

Table 3 shows the major results addressing our first hypothesis that either bystander CPR technique would improve outcome after cardiac arrests of ≤15 minutes' duration of a presumed cardiac origin after adjustment for potential confounding variables. As hypothesized, the cardiac-only resuscitation group had a higher rate of 1-year survival with favorable neurological outcome compared with the no bystander CPR group (4.3% versus 2.5%; OR, 1.72; 95% CI, 1.01 to 2.95). The conventional CPR group had a similar rate (4.1% versus 2.5%; OR, 1.57; 95% CI, 0.95 to 2.60). This finding was more prominent for very-short-duration cardiac arrests (<5 minutes), even suggesting the superiority of cardiac-only resuscitation over conventional CPR (OR, 2.22 versus 1.67).

Table 3 also shows the results for the second hypothesis that conventional CPR would improve outcomes for very prolonged

**Table 2. Outcomes After Cardiac Arrests of Presumed Cardiac Origin**

| | No CPR | Cardiac Only | Conventional CPR |
|---|---|---|---|
| Witnessed cardiac arrests, n | 3550 | 544 | 783 |
| Primary outcome | | | |
| Favorable 1-y neurological outcome, n (%) | 74 (2.1) | 19 (3.5) | 28 (3.6) |
| OR (95% CI) | Reference | 1.70 (1.02–2.84) | 1.74 (1.12–2.71) |
| Secondary outcomes | | | |
| VF as initial rhythm, n (%) | 544 (15.4) | 123 (22.9) | 166 (21.4) |
| OR (95% CI) | Reference | 1.62 (1.30–2.03) | 1.50 (1.23–1.82) |
| ROSC, n (%) | 1206 (34.6) | 188 (35.2) | 273 (35.4) |
| OR (95% CI) | Reference | 1.03 (0.85–1.24) | 1.03 (0.88–1.22) |
| Admission, n (%) | 824 (23.2) | 129 (23.7) | 202 (25.8) |
| OR (95% CI) | Reference | 1.03 (0.83–1.27) | 1.15 (0.96–1.37) |
| Survival at 1 wk, n (%) | 311 (8.9) | 52 (9.6) | 80 (10.3) |
| OR (95% CI) | Reference | 1.09 (0.80–1.49) | 1.17 (0.91–1.52) |
| Survival at 1 mo, n (%) | 204 (5.9) | 37 (6.9) | 60 (7.8) |
| OR (95% CI) | Reference | 1.19 (0.83–1.71) | 1.35 (1.00–1.82) |
| Survival at 1 y, n (%) | 125 (3.5) | 27 (5.0) | 43 (5.5) |
| OR (95% CI) | Reference | 1.43 (0.93–2.19) | 1.59 (1.12–2.27) |
| Witnessed VF cardiac arrests, n | 535 | 122 | 161 |
| Primary outcome | | | |
| Favorable 1-y neurological outcome, n (%) | 44 (8.2) | 14 (11.5) | 18 (11.2) |
| OR (95% CI) | Reference | 1.45 (0.77–2.73) | 1.40 (0.71–2.51) |
| Secondary outcomes | | | |
| ROSC, n (%) | 247 (47.1) | 58 (48.3) | 71 (44.7) |
| OR (95% CI) | Reference | 1.05 (0.71–1.56) | 0.90 (0.63–1.29) |
| Admission, n (%) | 187 (35.0) | 48 (39.3) | 57 (35.4) |
| OR (95% CI) | Reference | 1.21 (0.81–1.81) | 1.02 (0.71–1.47) |
| Survival at 1 wk, n (%) | 123 (23.3) | 33 (27.5) | 36 (22.5) |
| OR (95% CI) | Reference | 1.25 (0.80–1.96) | 0.96 (0.63–1.46) |
| Survival at 1 mo, n (%) | 103 (19.5) | 23 (19.5) | 31 (19.5) |
| OR (95% CI) | Reference | 1.00 (0.60–1.65) | 1.00 (0.64–1.56) |
| Survival at 1 y, n (%) | 67 (12.5) | 19 (15.6) | 24 (14.9) |
| OR (95% CI) | Reference | 1.29 (0.74–2.24) | 1.22 (0.74–2.02) |

ROSC indicates return of spontaneous circulation.

cardiac arrests. The conventional CPR group had a higher rate of 1-year survival with favorable neurological outcome, but there were few survivors regardless of the type of bystander CPR (0.3% [2 of 624], 0% [0 of 92], and 2.2% [3 of 139] in the no bystander CPR, cardiac-only, and conventional CPR groups, respectively; $P<0.05$). The OR was not calculated because of the small number of the survivors in the reference group. Among these patients with very prolonged cardiac arrests, VF was documented by EMS in 24 of 621 (3.9%) in the no bystander CPR group, 9 of 91 (9.9%) in the cardiac-only group, and 21 of 138 (15.2%) in the conventional CPR group.

## Discussion

Consistent with our a priori hypothesis, the Utstein Osaka study demonstrates that bystander-initiated CPR with either cardiac-only resuscitation or conventional CPR improves outcomes from witnessed cardiac arrests of ≤15 minutes' duration. Our observations are consistent with previous studies in Belgium and the Netherlands with substantially fewer cases of cardiac-only resuscitation (116 and 41, respectively) (Table 4).[26–28] Furthermore, Hallstrom and colleagues[29] demonstrated that dispatcher-directed bystander cardiac-only resuscitation was at least as effective as dispatcher-initiated bystander conventional CPR. The substantial differences in study designs, patient populations, and EMS systems in these clinical investigations indicate that the clinical data supporting the effectiveness of cardiac-only resuscitation are quite robust.

Our data suggest the time dependency of the effectiveness of each type of bystander CPR. Cardiac-only resuscitation may be superior to conventional CPR when provided within 5 minutes of the cardiac arrest, and rescue breathing may be of some help for very prolonged cardiac arrests (>15 minutes from collapse to EMS resuscitation). These findings are consistent with animal experiments showing that perfusion is better with cardiac-only resuscitation and oxygen content is better with conventional CPR.[11,17,18,30] Although there were many (864 of 4902) pro-

**Table 3. One-Year Survival With Favorable Neurological Outcome Among Bystander CPR Groups**

| | No CPR | Cardiac Only | Conventional CPR |
|---|---|---|---|
| EMS CPR 0–15 min (n=3888) | | | |
| Favorable 1-y neurological outcome, n (%) | 70/2817 (2.5) | 19/441 (4.3) | 25/617 (4.1) |
| Adjusted OR (95% CI) | Reference | 1.72 (1.01–2.95) | 1.57 (0.95–2.60) |
| EMS CPR 0–5 min (n=623) | | | |
| Favorable 1-y neurological outcome, n (%) | 22/455 (4.8) | 7/73 (9.6) | 7/91 (7.7) |
| Adjusted OR (95% CI) | Reference | 2.22 (0.88–5.65) | 1.67 (0.66–4.28) |
| EMS CPR 6–15 minutes (n=3265) | | | |
| Favorable 1-y neurological outcome, n (%) | 48/2362 (2.0) | 12/368 (3.3) | 18/526 (3.4) |
| Adjusted OR (95% CI) | Reference | 1.46 (0.75–2.83) | 1.45 (0.80–2.64) |
| EMS CPR >15 min (n=864) | | | |
| Favorable 1-y neurological outcome, n (%) | 2/624 (0.3) | 0/92 (0.0) | 3/139 (2.2) |
| Adjusted OR (95% CI) | N/A | N/A | N/A |

longed cardiac arrests, <1% of those (5 of 864) survived to 1 year with favorable neurological outcomes. Even when conventional CPR was provided to these patients with very prolonged arrests, the proportion of 1-year survivors with favorable neurological outcome was only 2% (3 of 139). Therefore, the absolute number of patients who benefited from conventional CPR was quite small. Because of the small number of survivors from cardiac arrests of >15 minutes' duration, we cannot confirm the effectiveness of rescue breathing for these very prolonged arrests. Further investigation is needed.

The SOS-KANTO study reported that cardiac-only resuscitation was the preferable approach for adults with witnessed VF cardiac arrests, the group with the greatest likelihood of good outcomes.[19] In contrast, our study showed no difference in outcomes between cardiac-only resuscitation and conventional CPR for witnessed VF (Table 4). Although both studies were carried out in Japan and backgrounds like race of the participants and the EMS systems were quite similar, the Utstein Osaka Project is population based and the SOS-KANTO is hospital based, suggesting some inherent differences between the studies. For example, ≈40% of cardiac arrests in the SOS-KANTO study but only 18% in the Utstein Osaka study occurred at public locations. This patient profile might affect the results because it is well established that outcomes from out-of-hospital arrests are better in public locations.[21]

If cardiac-only resuscitation is simply as effective as conventional CPR, is there any reason to change lay CPR programs to focus on cardiac-only resuscitation? Perhaps. Conventional CPR is a complex psychomotor task,[11,12,31,32] and it typically is provided for <25% of out-of-hospital arrests. Consistent with studies throughout the world, the Utstein Osaka bystanders generally provided no CPR before EMS arrival. Cardiac-only resuscitation is a much simpler technique that is easier to teach, learn, remember, and perform.[13,29,32] Specific educational campaigns to teach cardiac-only resuscitation may increase the rate of bystander CPR and improve the quality of cardiac-only resuscitation, thereby improving survival from out-of-hospital cardiac arrest.

In addition, potential lay rescuers, EMS personnel, and medical personnel generally claim that they would be more

**Table 4. Comparison of Survival From Out-of-Hospital Cardiac Arrests in Osaka With Previous Reports**

| | No CPR, n (%) | Cardiac Only, n (%) | Conventional CPR, n (%) |
|---|---|---|---|
| Survival from out-of-hospital cardiac arrests | | | |
| Osaka (1998–2003)* | 70/2817 (3) | 19/441 (4) | 25/617 (4) |
| Belgium (1989)†[26,27] | 123/2055 (6) | 17/116 (15) | 71/443 (16) |
| Netherlands (2001)‡[28] | 26/429 (6) | 6/41 (15) | 61/437 (14) |
| Seattle (2000)§[29] | ... | 35/240 (15) | 29/278 (10) |
| SOS-KANTO (2002–2003)¶[19] | 54/1836 (3) | 26/305 (9) | 27/501 (5) |
| Survival from witnessed VF cardiac arrests | | | |
| Osaka (1998–2003) | 44/535 (8) | 14/122 (12) | 18/161 (11) |
| SOS-KANTO (2002–2003)[19] | 45/549 (8) | 24/124 (19) | 23/205 (11) |

*Neurologically favorable 1-year survival from witnessed out-of-hospital cardiac arrests of presumed cardiac origin.
†Fourteen-day survival from all (cardiac and noncardiac) out-of-hospital cardiac arrests, comparing good-quality cardiac-only resuscitation with good-quality conventional CPR and no CPR.
‡Discharged alive from all witnessed out-of-hospital cardiac arrests.
§Discharged alive from all out-of-hospital cardiac arrests, with or without dispatcher-assisted bystander CPR.
¶Neurologically favorable 30-day survival from witnessed out-of-hospital cardiac arrests of presumed cardiac origin.

willing to provide CPR if mouth-to-mouth rescue breathing were not necessary.[12,33,34] Interestingly, many Japanese bystanders choose to provide CPR without rescue breathing despite the lack of any Japanese training programs with this CPR technique. Willingness to perform mouth-to-mouth rescue breathing appears to differ among different cultures. In a Japanese study, only 2% of high school students, 3% of teachers and nurses, and 16% of medical students claimed that they were willing to provide mouth-to-mouth resuscitation for a stranger in cardiac arrest.[14] Nearly 40% of rescuers who provided bystander CPR did not provide mouth-to-mouth resuscitation. Presumably, other potential rescuers decided against providing any bystander CPR because they were unwilling to provide mouth-to-mouth rescue breathing.

### Study Limitations

As with all multisite epidemiological studies, data integrity, validity, and ascertainment bias are potential limitations. The data collected by EMS providers included relatively few data points that were easy to attain accurately at the scene with the clear and concise Utstein-style guidelines for reporting cardiac arrest.[22] The uniform data collection, consistent definitions, time synchronization process, and large sample size were intended to minimize these potential sources of bias. In addition, the Utstein Osaka project is a population-based cohort study that includes all adult known out-of-hospital cardiac arrests in the Osaka Prefecture. The only arrests that may have been missed could be those associated with illegal activities that were not reported.

The 2 most important limitations of this study are the lack of data on the quality of bystander CPR and the potential biases involved in providing cardiac-only resuscitation, conventional CPR, or no bystander CPR. Evaluating the quality of CPR before EMS arrival is not feasible. Moreover, the EMS providers' first responsibility is to resuscitate the victim, not to evaluate the bystanders' effectiveness at the time of their arrival. It is well known that the critical issues for blood flow during CPR are force of compressions, rate of compressions, and avoidance of interruptions in compressions.[1,11,16–18,35] These technical issues are taught during standard CPR training in Japan. However, cardiac-only resuscitation is not taught. Rescuers who do not provide rescue breathing may be less well trained and may provide less effective chest compressions. If so, this may explain the discrepancy between the Utstein Osaka data and animal studies that show better outcomes with cardiac-only resuscitation than conventional CPR in models of out-of-hospital single-rescuer CPR for VF.[35] Nevertheless, our data cannot explicitly address these potential biases.

### Conclusions

Data from a large-scale population-based cohort in Osaka indicate that cardiac-only resuscitation and conventional CPR as provided by citizens are similarly effective for most adult out-of-hospital cardiac arrests of presumed cardiac origin. For very prolonged cardiac arrests, the addition of rescue breathing may be of some help, but the outcomes were poor regardless of the type of bystander CPR.

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## Disclosures

None.

## References


1. 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2005; 112(suppl IV):IV-1–IV-203.
2. Rea TD, Eisenberg MS, Becker LJ, Murray JA, Hearne T. Temporal trends in sudden cardiac arrest: a 25-year emergency medical services perspective. *Circulation*. 2003;107:2780–2785.
3. Herlitz J, Andersson E, Bang A, Engdahl J, Holmberg M, lindqvist J, Karlson BW, Waagstein L. Experiences from treatment of out-of-hospital cardiac arrest during 17 years in Goteborg. *Eur Heart J*. 2000;21:1251–1258.
4. Bunch TJ, White RD, Gersh BJ, Meverden RA, Hodge DO, Ballman KV, Hammill SC, Shen WK, Packer DL. Long-term outcomes of out-of-hospital cardiac arrest after successful early defibrillation. *N Engl J Med*. 2003;348:2626–2633.
5. Eckstein M, Stratton SJ, Chan LS. Cardiac Arrest Resuscitation Evaluation in Los Angeles: CARE-LA. *Ann Emerg Med*. 2005;45:504–509.
6. Lombardi G, Gallagher J, Gennis P. Outcome of out-of-hospital cardiac arrest in New York City: the Pre-Hospital Arrest Survival Evaluation (PHASE) Study. *JAMA*. 1994;271:678–683.
7. Becker LB, Ostrander MP, Barrett J, Kondos GT. Outcome of CPR in a large metropolitan area: where are the survivors? *Ann Emerg Med*. 1991; 20:355–361.
8. Wenzel V, Krismer AC, Arntz HR, Sitter H, Stadlbauer KH, Lindner KH. A comparison of vasopressin and epinephrine for out-of-hospital cardiopulmonary resuscitation. *N Engl J Med*. 2004;350:105–113.
9. Stiell IG, Wells GA, Field B, Spaite DW, Nesbitt LP, De Maio VJ, Nichol G, Cousineau D, Blackburn J, Munkley D, Luinstra-Toohey L, Campeau T, Dagnone E, Lyver M. Advanced cardiac life support in out-of-hospital cardiac arrest. *N Engl J Med*. 2004;351:647–656.
10. Herlitz J, Ekstrom L, Wennerblom B, Axelsson A, Bang A, Holmberg S. Effect of bystander initiated cardiopulmonary resuscitation on ventricular fibrillation and survival after witnessed cardiac arrest outside hospital. *Br Heart J*. 1994;72:408–412.
11. Becker LB, Berg RA, Pepe PE, Idris AH, Aufderheide TP, Barnes TA, Stratton SJ, Chandra NC. A reappraisal of mouth-to-mouth ventilation during bystander-initiated cardiopulmonary resuscitation: a statement for healthcare professionals from the Ventilation Working Group of the Basic Life Support and Pediatric Life Support Subcommittees, American Heart Association. *Circulation*. 1997;96:2102–2112.
12. Locke CJ, Berg RA, Sanders AB, Davis MF, Milander MM, Kern KB, Ewy GA. Bystander cardiopulmonary resuscitation: concerns about mouth-to-mouth contact. *Arch Intern Med*. 1995;155:938–943.
13. Heidenreich JW, Sanders AB, Higdon TA, Kern KB, Berg RA, Ewy GA. Uninterrupted chest compression CPR is easier to perform and remember than standard CPR. *Resuscitation*. 2004;63:123–130.
14. Shibata K, Taniguchi T, Yoshida M, Yamamoto K. Obstacles to bystander cardiopulmonary resuscitation in Japan. *Resuscitation*. 2000;44:187–193.

15. Berg RA, Kern KB, Sanders AB, Otto CW, Hilwig RW, Ewy GA. Bystander cardiopulmonary resuscitation: is ventilation necessary? *Circulation*. 1993;88:1907–1915.
16. Berg RA, Wilcoxson D, Hilwig RW, Kern KB, Sanders AB, Otto CW, Eklund DK, Ewy GA. The need for ventilatory support during bystander CPR. *Ann Emerg Med*. 1995;26:342–350.
17. Berg RA, Kern KB, Hilwig RW, Berg MD, Sanders AB, Otto CW, Ewy GA. Assisted ventilation does not improve outcome in a porcine model of single-rescuer bystander cardiopulmonary resuscitation. *Circulation*. 1997;95:1635–1641.
18. Berg RA, Kern KB, Hilwig RW, Ewy GA. Assisted ventilation during "bystander" CPR in a swine acute myocardial infarction model does not improve outcome. *Circulation*. 1997;96:4364–4371.
19. SOS-KANTO study group. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an observational study. *Lancet*. 2007;369:920–926.
20. Iwami T, Hiraide A, Nakanishi N, Hayashi Y, Nishiuchi T, Yukioka H, Yoshiya I, Sugimoto H. Age and sex analyses of out-of-hospital cardiac arrest in Osaka, Japan. *Resuscitation*. 2003;57:145–152.
21. Iwami T, Hiraide A, Nakanishi N, Hayashi Y, Nishiuchi T, Uejima T, Morita H, Shigemoto T, Ikeuchi H, Matsusaka M, Shinya H, Yukioka H, Sugimoto H. Outcome and characteristics of out-of-hospital cardiac arrest according to location of arrest: a report from a large-scale, population-based study in Osaka, Japan. *Resuscitation*. 2006;69:221–228.
22. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L, Cassan P, Coovadia A, D'Este K, Finn J, Halperin H, Handley A, Herlitz J, Hickey R, Idris A, Kloeck W, Larkin GL, Mancini ME, Mason P, Mears G, Monsieurs K, Montgomery W, Morley P, Nichol G, Nolan J, Okada K, Perlman J, Shuster M, Steen PA, Sterz F, Tibballs J, Timerman S, Truitt T, Zideman D. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, Inter-American Heart Foundation, Resuscitation Councils of Southern Africa). *Circulation*. 2004;110:3385–3397.
23. Swor RA, Jackson RE, Cynar M, Sadler E, Basse E, Boji B, Rivera-Rivera EJ, Maher A, Grubb W, Jacobson R. Bystander CPR, ventricular fibrillation, and survival in witnessed, unmonitored out-of-hospital cardiac arrest. *Ann Emerg Med*. 1995;25:780–784.
24. Valenzuela TD, Roe DJ, Cretin S, Spaite DW, Larsen MP. Estimating effectiveness of cardiac arrest interventions: a logistic regression survival model. *Circulation*. 1997;96:3308–3313.
25. Ewy GA. Cardiocerebral resuscitation: the new cardiopulmonary resuscitation. *Circulation*. 2005;111:2134–2142.
26. Bossaert L, Van Hoeyweghen R. Bystander cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest: the Cerebral Resuscitation Study Group. *Resuscitation*. 1989;17:S55–S69.
27. Van Hoeyweghen RJ, Bossaert LL, Mullie A, Calle P, Martens P, Buylaert WA, Delooz H. Quality and efficiency of bystander CPR: Belgian Cerebral Resuscitation Study Group. *Resuscitation*. 1993;26:47–52.
28. Waalewijn RA, Tijssen JG, Koster RW. Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARRESUST). *Resuscitation*. 2001;50:273–279.
29. Hallstrom A, Cobb L, Johnson E, Copass M. Cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation. *N Engl J Med*. 2000;342:1546–1553.
30. Berg RA, Sanders AB, Kern KB, Hilwig RW, Heidenreich JW, Porter ME, Ewy GA. Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. *Circulation*. 2001;104:2465–2470.
31. Heidenreich JW, Higdon TA, Kern KB, Sanders AB, Berg RA, Niebler R, Hendrickson J, Ewy GA. Single-rescuer cardiopulmonary resuscitation: "two quick breaths": an oxymoron. *Resuscitation*. 2004;62:283–289.
32. Assar D, Chamberlain D, Colquhoun M, Donnelly P, Handley AJ, Leaves S, Kern KB. Randomised controlled trials of staged teaching for basic life support, 1: skill acquisition at bronze stage. *Resuscitation*. 2000;45:7–15.
33. Ornato JP, Hallagan LF, McMahan SB, Peeples EH, Rostafinski AG. Attitudes of BCLS instructors about mouth-to-mouth resuscitation during the AIDS epidemic. *Ann Emerg Med*. 1990;19:151–156.
34. Brenner BE, Kauffman J. Reluctance of internists and medical nurses to perform mouth-to-mouth resuscitation. *Arch Intern Med*. 1993;153:1763–1769.
35. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. *Circulation*. 2002;105:645–649.

## CLINICAL PERSPECTIVE

This study addresses 2 important clinical issues regarding bystander cardiopulmonary resuscitation. First, cardiac-only bystander resuscitation was as effective as conventional bystander cardiopulmonary resuscitation with rescue breathing for cardiac arrests that had a ≤15-minute interval from collapse to emergency medical service resuscitation. These data from nearly 5000 witnessed cardiac arrests provide important new support for the effectiveness of cardiac-only resuscitation. This is the only large-scale population-based study of out-of-hospital cardiac arrest to address this issue. This population-based study design is intended to minimize potential selection biases. Our observations are consistent with previous studies despite the substantial differences in study designs, patient populations, and emergency medical service, which indicate that the clinical data supporting the effectiveness of cardiac-only bystander resuscitation are quite robust. The second interesting issue addressed by this study is that rescue breathing may be of some help for very prolonged cardiac arrests (>15 minutes); however, the limited number of survivors from such arrests precluded a simple answer to this issue. Even if rescue breathing is important for very prolonged arrests, our data show that there are few survivors from very prolonged cardiac arrests regardless of the type of bystander cardiopulmonary resuscitation. In light of these data and the disappointingly low rates of bystander cardiopulmonary resuscitation, efforts to teach and encourage lay rescuers to perform cardiac-only resuscitation may improve survival from out-of-hospital cardiac arrest.

**Effectiveness of Bystander-Initiated Cardiac-Only Resuscitation for Patients With Out-of-Hospital Cardiac Arrest**

Taku Iwami, Takashi Kawamura, Atsushi Hiraide, Robert A. Berg, Yasuyuki Hayashi, Tatsuya Nishiuchi, Kentaro Kajino, Naohiro Yonemoto, Hidekazu Yukioka, Hisashi Sugimoto, Hiroyuki Kakuchi, Kazuhiro Sase, Hiroyuki Yokoyama and Hiroshi Nonogi

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