

# Different Impacts of Time From Collapse to First Cardiopulmonary Resuscitation on Outcomes After Witnessed Out-of-Hospital Cardiac Arrest in Adults

Masahiko Hara, MD; Kenichi Hayashi, PhD; Shungo Hikoso, MD, PhD;  
Yasushi Sakata, MD, PhD; Tetsuhisa Kitamura, MD, MSc, DrPH

**Background**—It is well known that cardiopulmonary resuscitation (CPR) should be attempted as early as possible after out-of-hospital cardiac arrest (OHCA). However, it is unclear about the impact of time to CPR on OHCA outcome by first documented rhythm (pulseless ventricular tachycardia/ventricular fibrillation [pVT/VF], pulseless electric activity [PEA], and asystole).

**Methods and Results**—We enrolled 257 354 adult witnessed OHCA patients between 2007 and 2012 from a prospective nationwide population-based cohort database in Japan. We evaluated relationships between time from collapse to first CPR and neurologically favorable 1-month survival defined as Glasgow–Pittsburg cerebral performance category 1 or 2 by first documented rhythm after witnessed OHCA. We used logistic model for the estimation of prognosis. The number of OHCA patients with pVT/VF, PEA, and asystole were 38 661, 96 906, and 121 787, respectively. The overall neurologically favorable 1-month survival rates were 21.3% in patients with pVT/VF, 2.7% PEA, and 0.6% asystole. The proportion of asystole increased as the time from collapse to CPR delayed, whereas those of pVT/VF and PEA decreased (trend  $P < 0.001$ ). Estimated incidences of end-point after OHCA became lower as first CPR delayed irrespective of type of first documented rhythm, but were different by the rhythm. The average percentage point decreases in neurologically favorable 1-month survival probability for each incremental minute of CPR delay were 8.3%, 4.4%, and 6.4% for patients with pVT/VF, PEA, and asystole, respectively.

**Conclusions**—The OHCA outcome differed by time to first CPR and first documented rhythm. Shortening of time to first CPR is crucial for improving the OHCA outcome. (*Circ Cardiovasc Qual Outcomes*. 2015;8:277-284. DOI: 10.1161/CIRCOUTCOMES.115.001864.)

**Key Words:** cardiopulmonary resuscitation ■ out-of-hospital cardiac arrest ■ ventricular fibrillation

Sudden cardiac arrest (SCA) is one of the leading causes of death and is an important public health problem in the world.<sup>1</sup> The American Heart Association (AHA) guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiovascular care classify SCA into the following 2 categories and recommend mainly the 2 therapeutic algorithms for SCA based on first documented rhythms: shockable ventricular tachyarrhythmia, including pulseless ventricular tachycardia and ventricular fibrillation (pVT/VF), and nonshockable rhythms, including pulseless electric activity (PEA) and asystole.<sup>1</sup> In the guidelines, AHA also recommends attempting CPR as early as possible after SCA in the chain of survival based on the evidence that demonstrated the close relationship between delayed CPR and poor outcomes after SCA.<sup>2-4</sup>

Although prognoses after SCA are different based on first documented rhythms, the relationships between time to CPR and out-of-hospital cardiac arrest (OHCA) outcomes by the type of first documented rhythm has poorly been understood.<sup>5,6</sup> Especially, evidence from large-scale population-based cohort is needed to assess and confirm the relationship for improving resuscitation science worldwide. The All-Japan Utstein Registry is a prospective, nationwide population-based cohort database of OHCA in Japan, which covered ≈127 million residents. During the 6 years, there were >250 thousand witnessed OHCA patients. The purpose of the present study is to assess and compare the relationships between time to CPR and outcomes after OHCA by type of first documented rhythm using this database.<sup>7-10</sup>

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From the Department of Cardiovascular Medicine (M.H., S.H., Y.S.), Department of Public Health (K.H.), Department of Medical Therapeutics for Heart Failure (S.H.), and Division of Environmental Medicine and Population Sciences, Department of Social and Environmental Medicine (T.K.), Osaka University Graduate School of Medicine, Suita, Japan.

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Correspondence to Masahiko Hara, MD, Department of Cardiovascular Medicine, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita, Osaka 565-0871, Japan. E-mail [masahikohara@cardiology.med.osaka-u.ac.jp](mailto:masahikohara@cardiology.med.osaka-u.ac.jp), or Tetsuhisa Kitamura, MD, MSc, DrPH, Division of Environmental Medicine and Population Sciences, Department of Social and Environmental Medicine, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita, Osaka 565-0871, Japan. E-mail [lucky\\_unatan@yahoo.co.jp](mailto:lucky_unatan@yahoo.co.jp)

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**WHAT IS KNOWN**

- Cardiopulmonary resuscitation should be attempted as early as possible after out-of-hospital cardiac arrest.

**WHAT THE STUDY ADDS**

- The proportion of out-of-hospital cardiac arrest patients with asystole increased as the time from collapse to cardiopulmonary resuscitation delayed, whereas those with ventricular arrhythmia and pulseless electric activity decreased after out-of-hospital cardiac arrest.
- Prognoses became worse as first cardiopulmonary resuscitation by bystanders or emergency medical service personnel delayed irrespective of type of first documented rhythm but were different by the rhythm both in total population and in patients who achieved prehospital recovery of spontaneous circulation.

**Methods****Study Patients**

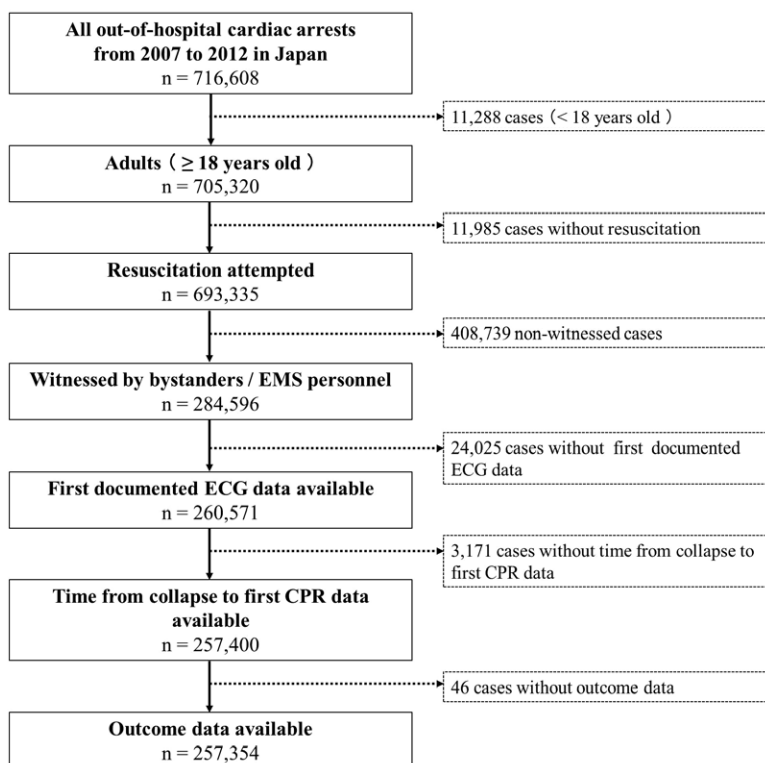
We enrolled 257 354 adult witnessed OHCA patients between 2007 and 2012 from the All-Japan Utstein Registry of the Fire and Disaster Management Agency (Figure 1). The All-Japan Utstein Registry is a prospective nationwide population-based cohort database of all OHCA patients in Japan, which is based on the Utstein-style guidelines for reporting OHCA.<sup>7-10</sup> It has launched since 2005 by the Fire and Disaster Management Agency of Japan and has been contributed to elucidating the epidemiology of OHCA in Japan.<sup>9,10</sup> We first registered all OHCA patients of cardiac and noncardiac origins

between 2007 and 2012 because the Japanese CPR guidelines have been performed based on the 2005 AHA guidelines since October 2006 (n=716 608). After excluding pediatric patients aged <18 years and those who without resuscitation attempted, we finally enrolled 257 354 witnessed OHCA patients by bystanders or emergency medical service (EMS) personnel because of the availability of information on the time to CPR. Patients without first documented ECG information, without data on the time from collapse to first CPR, or without outcome data were also excluded (Figure 1). More details of the All-Japan Utstein Registry such as data collection and quality control and Japanese EMS system were previously described elsewhere.<sup>9,10</sup>

Shortly, cardiac arrest was defined as the cessation of cardiac mechanical activity without signs of circulation. Cardiac or noncardiac origins were clinically determined by the physicians in collaboration with the EMS personnel. EMS is available 24 hours 365 days in Japan. When people give an emergency telephone call for an ambulance, it will be dispatched from the nearest fire station with 3 emergency providers including at least 1 emergency life-saving technician, a highly trained prehospital emergency care provider who can care OHCA patients with intravenous line, epinephrine, advanced airway management, and semiautomated external defibrillators. EMS providers were not permitted to terminate resuscitation before patient transportation to a hospital except for cases with decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis. All EMS providers perform CPR according to the Japanese CPR guidelines in the study period.<sup>11</sup> The emergency telephone dispatchers give bystanders with conventional CPR instruction before EMS arrival. They can also encourage bystanders to provide chest compression-only CPR if it is difficult for bystanders to administer rescue breathing.<sup>11</sup>

**Data Collection and Study End Points**

The following data were prospectively collected using an Utstein-style reporting form and used in the present study: age, sex, enrollment date, origin of cardiac arrest, type of bystander witness status, first documented rhythm, usage of public-access automated external defibrillator, implementation of advanced airway management, usage of intravenous fluids at any dose before hospital arrival by EMS personnel for OHCA patients who did not respond to basic life support,



**Figure 1.** Patient selection flow. CPR indicates cardiopulmonary resuscitation; and EMS, emergency medical service.

and usage of epinephrine at any dose before hospital arrival by EMS personnel for OHCA patients who did not respond to basic life support as well as a timeline information of the event such as EMS response time (time from emergency call to first contact with a patient), hospital arrival time (time from emergency call to a patient transportation to a hospital), and time from collapse to first CPR by bystanders or EMS personnel (maximum time 30 minutes indicates  $\geq 30$  minutes in the present study). Both conventional and chest compression-only CPR were considered as bystander CPR. The time of collapse and initiation of bystander CPR were obtained by EMS interview with the bystander before leaving the scene and were measured in minutes on the scene. The time of collapse and initiation of CPR by EMS personnel were obtained from the timeline record of EMS system and were measured in minutes on the scene. The time from collapse to first CPR was calculated by subtracting the time of witnessed collapse from the time of CPR by bystanders or EMS personnel. First documented rhythm was recorded and diagnosed by the EMS personnel with semiautomated defibrillators on the scene. We classified first documented rhythm into 3 categories in this study. Those include pVT/VF, PEA, and asystole. When bystanders delivered shocks using public-access automated external defibrillators, the patients' first documented rhythm was regarded as pVT/VF. All survivors were evaluated 1 month after the event for their neurological outcome by the EMS personnel in charge.

The end points were set as prehospital return of spontaneous circulation (ROSC), 1-month survival, and neurologically favorable 1-month survival. We defined the Glasgow-Pittsburg cerebral performance category scale 1 and 2 as neurologically favorable and 3 to 5 as nonfavorable. The Glasgow-Pittsburg cerebral performance category has 5 categories: 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.<sup>7,8</sup> ROSC was defined as the restoration of a sustained spontaneous perfusing rhythm.

**Statistical Analysis**

Categorical variables were expressed as numbers (%) and compared using the  $\chi^2$  test among first documented rhythm categories. Continuous variables were expressed as median (25th–75th percentile) and compared with the Kruskal–Wallis test. The proportional trends of first documented rhythms with each passing minutes were assessed by the Cochran–Armitage trend test.

We evaluated relationships between time from collapse to first CPR by bystanders or EMS personnel and study end points both in whole study population and in patients who achieved ROSC by first documented rhythm. We used the logistic regression model. The impacts of time from collapse to first CPR were expressed as odds ratio (OR) and its 95% confidence interval in each first documented rhythm and in total population. We also evaluated adjusted OR using the multivariable logistic regression model including following variables as possible confounders: age, sex, cardiac origin, bystander CPR, intravenous fluid, epinephrine, and advanced airway management, as well as first documented rhythm when calculating OR in total population. The estimated probability of prognoses for each time to CPR and its 95% confidence intervals were calculated. The accuracy of probabilistic predictions of those models was assessed by Brier.<sup>12,13</sup> The Brier score is defined as the mean of the squared difference between the observed and predicted event rates, which is equivalent to the mean squared error of a linear regression model. Statistical analyses were performed using R software packages (version 3.1.0; R Development Core Team). The significance level of a statistical hypothesis testing was set at 0.05 and the alternative hypothesis was 2 sided.

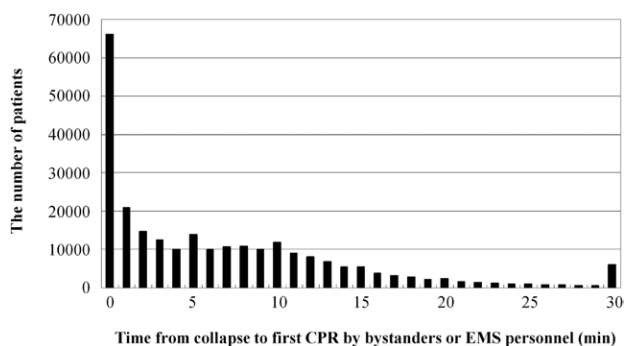
The study protocol complied with the Helsinki Declaration and was approved by the ethical committee of Osaka University Graduate School of Medicine. The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the article as written.

**Table 1. Patient Characteristics**

Parameter	Missing	Total (n=257 354)	pVT/VF (n=38 661)	PEA (n=96 906)	Asystole (n=121 787)	P Value
Age, y	0	77 (65–85)	67 (57–77)	78 (68–86)	79 (68–87)	<0.001
Male	0	155 009 (60.2)	29 844 (77.2)	55 991 (57.8)	69 174 (56.8)	<0.001
Enrollment	0	...	...	...	...	<0.001
2007	...	37 896 (14.7)	5694 (14.7)	14 047 (14.5)	18 155 (14.9)	...
2008	...	40 477 (15.7)	6165 (15.9)	15 271 (15.8)	19 041 (15.6)	...
2009	...	41 723 (16.2)	6611 (17.1)	15 584 (16.1)	19 528 (16.0)	...
2010	...	45 053 (17.5)	6751 (17.5)	16 932 (17.5)	21 370 (17.5)	...
2011	...	45 783 (17.8)	6622 (17.1)	17 434 (18.0)	21 727 (17.8)	...
2012	...	46 422 (18.0)	6818 (17.6)	17 638 (18.2)	21 966 (18.0)	...
Cardiac	0	143 994 (56.0)	33 635 (87.0)	49 649 (51.2)	60 710 (49.8)	<0.001
Witnessed by	0	...	...	...	...	...
Bystanders	...	220 479 (85.7)	34 214 (88.5)	74 584 (77.0)	111 681 (91.7)	<0.001
Perform CPR	...	102 172 (47.0)*	19 455 (56.9)*	32 039 (43.0)*	52 065 (46.6)*	<0.001
EMS personnel	...	36 875 (14.3)	4447 (11.5)	22 322 (23.0)	10 106 (8.3)	<0.001
Deliver shocks by public-access AED	0	4318 (1.7)	4318 (11.2)	0 (0.0)	0 (0.0)	<0.001
Intravenous fluid	0	77 808 (30.2)	12 900 (33.4)	29 808 (30.8)	35 100 (28.8)	<0.001
Epinephrine	0	40 238 (15.6)	7021 (18.2)	15 850 (16.4)	17 367 (14.3)	<0.001
Advanced airway management	798	111 187 (43.3)	15 383 (39.9)	41 970 (43.4)	53 834 (44.3)	<0.001
EMS response time (call to contact), min	353	8 (6–10)	8 (6–10)	8 (6–10)	8 (7–11)	<0.001
Hospital arrival time (call to hospital), min	741	31 (25–39)	31 (25–38)	31 (25–38)	32 (26–40)	<0.001

Categorical variables were expressed as numbers (%), and continuous variables were expressed as median (25th–75th percentile). AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; PEA, pulseless electric activity; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

\*Denominator is the number of bystanders.



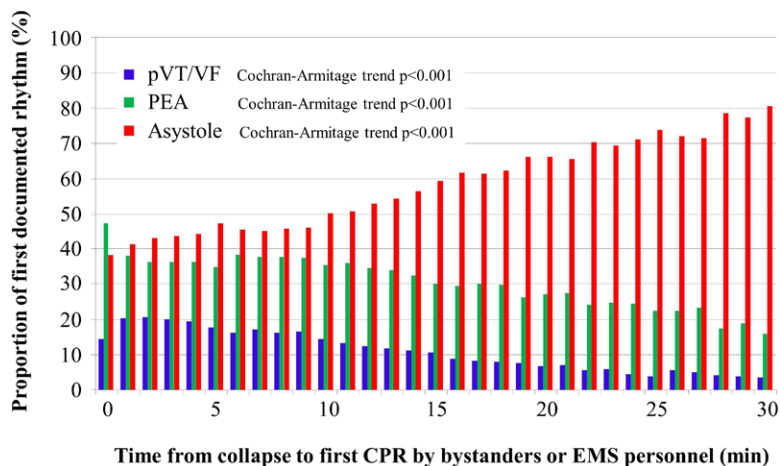
**Figure 2.** Distribution of time to cardiopulmonary resuscitation (CPR). Maximum time 30 minutes indicates  $\geq 30$  minutes in the present study. EMS indicates emergency medical service.

## Results

### Patient Characteristics

As shown in Table 1, median age of the study population was 77 (65–85) years, 60.2% were male sex, and 56.0% of OHCA were cardiac origin. Of all bystander-witnessed OHCA, 47.0% received bystander-CPR and 11.2% of patients with pVT/VF were delivered shocks by a public-access automated external defibrillator. The median EMS response time (time from emergency call to first contact with a patient) was 8 (6–10) minutes and hospital arrival time (time from emergency call to a patient transportation to a hospital) was 31 (25–39) minutes.

The numbers of OHCA patients with pVT/VF, PEA, and asystole were 38 661 (15.0%), 96 906 (37.7%), and 121 787 (47.3%), respectively. There were significant differences in patient demographics among groups. OHCA patients with pVT/VF tended to be younger, more male sex, have more cardiac origin, and received CPR more by bystanders as compared with patients with PEA or asystole. Figure 2 shows the distribution of the time to CPR. The mean value was 6.8 minutes (median, 5 minutes). A total of 53.8% of all witnessed OHCA patients received CPR within 5 minutes after the collapse and 74.7% within 10 minutes. The missing rate of time to CPR among witnessed OHCA patients with first documented rhythm information was 1.2% (3171/260 571). As shown in Figure 3, the proportion of asystole increased as the time from collapse to first CPR delayed, whereas those of pVT/VF and PEA decreased (Cochran–Armitage trend  $P < 0.001$ ).



**Figure 3.** Relationships between time from collapse to first cardiopulmonary resuscitation (CPR) and proportion of first documented rhythms. Maximum time 30 minutes indicates  $\geq 30$  minutes in the present study. EMS indicates emergency medical service; PEA, pulseless electric activity; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

### Relationships Between Time to CPR and Prognoses

Among all study population, 12 551 (32.5%) patients with pVT/VF, 13 137 (13.6%) PEA, and 7310 (6.0%) asystole achieved prehospital ROSC. The proportion of overall 1-month survival of patients with pVT/VF, PEA, and asystole were 30.0%, 7.8%, and 3.0%, respectively, in all study population and 70.5%, 33.8%, and 21.4%, respectively, in patients who achieved prehospital ROSC. The proportion of overall neurologically favorable 1-month survival of patients with pVT/VF, PEA, and asystole were 21.3%, 2.7%, and 0.6%, respectively, in all study population and 55.5%, 15.0%, and 6.3%, respectively, in patients who achieved prehospital ROSC (Table 2).

Estimated probabilities for each end point and the respective 95% confidence bands are shown in Figure 4 with measured values (detailed data are shown in Tables I–VII in the Data Supplement). Prognoses became worse as first CPR delayed irrespective of type of first documented rhythm, but were different by the rhythm both in total population and in patients who achieved prehospital ROSC. OHCA patients with pVT/VF revealed the most favorable prognoses followed by patients with PEA, and patients with asystole demonstrated the worst prognoses. These tendencies were common both in total study population and even in patients who achieved prehospital ROSC (Figure 4). The only exception was a crossing of estimated event proportions of prehospital ROSC between patients with pVT/VF and PEA in the last part of the time course after OHCA (Figure 4A).

In addition, Table 3 showed that the impacts of the time from collapse to first CPR on outcomes were also different among first documented rhythm groups. The adjusted ORs per 1-minute delay on neurologically favorable 1-month survival were 0.91 (0.91–0.92;  $P < 0.001$ ), 0.95 (0.94–0.95;  $P < 0.001$ ), 0.90 (0.88–0.91;  $P < 0.001$ ), and 0.92 (0.92–0.93) in entire OHCA patients with pVT/VF, PEA, asystole, and in total, respectively. The average percentage point decreases in neurologically favorable 1-month survival probability for each incremental minute of CPR delay based on the logistic regression model in the present study were 8.3%, 4.4%, and 6.4% for patients with pVT/VF, PEA, and asystole, respectively. Patients with pVT/VF demonstrated the lowest adjusted OR on prehospital ROSC and 1-month survival followed by asystole and PEA

**Table 2. Overall Outcomes After Out-of-Hospital Cardiac Arrest**

	Total	pVT/VF	PEA	Asystole	P Value
Overall population	n=257 354	n=38 661	n=96 906	n=121 787	
Prehospital ROSC	32 998 (12.8)	12 551 (32.5)	13 137 (13.6)	7 310 (6.0)	<0.001
One-mo survival	22 807 (8.9)	11 617 (30.0)	7 526 (7.8)	3 664 (3.0)	<0.001
Neurologically favorable 1-mo survival	11 535 (4.5)	8 222 (21.3)	2 600 (2.7)	713 (0.6)	<0.001
Patients who achieved prehospital ROSC	n=32 998	n=12 551	n=13 137	n=7 310	
One-mo survival	14 848 (45.0)	8 844 (70.5)	4 442 (33.8)	1 562 (21.4)	<0.001
Neurologically favorable 1-mo survival	9 405 (28.5)	6 965 (55.5)	1 976 (15.0)	464 (6.3)	<0.001

Categorical variables were expressed as numbers (%). PEA indicates pulseless electric activity; pVT, pulseless ventricular tachycardia; ROSC, recovery of spontaneous circulation; and VF, ventricular fibrillation.

in this order, whereas patients with asystole demonstrated the lowest adjusted OR on neurologically favorable 1-month survival (Table 3). The accuracies of prognosis estimation in each first documented rhythm were evaluated with Brier score, and we found that they were acceptable because the scores ranged from 0.006 to 0.239 as shown in Table 3. In addition, we found that the accuracy was the best in patients with asystole, because Bier score in this group was minimal among groups.

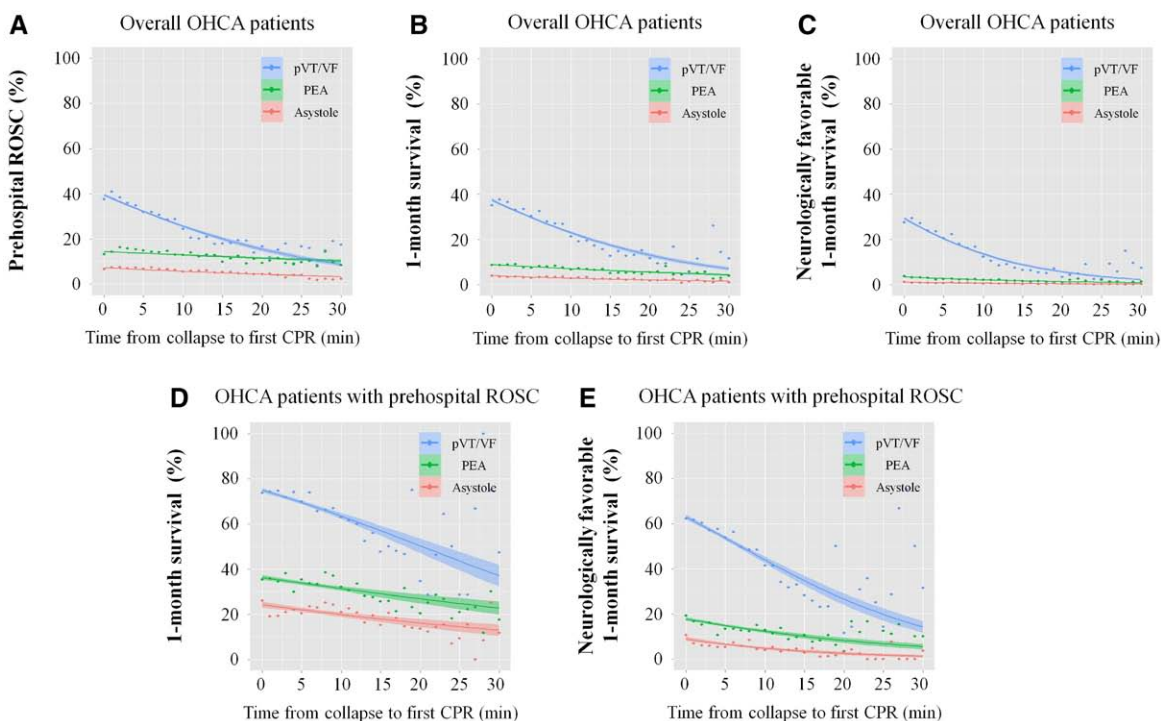
**Discussion**

From the nationwide OHCA registry in Japan, we evaluated and compared the relationships between time to CPR and outcomes after OHCA among adults by the type of first documented rhythm. We demonstrated that prognoses became worse as first CPR delayed irrespective of type of first documented rhythm, but were different among 3 first documented rhythm groups both in total population and in patients who

achieved prehospital ROSC. Our study was large enough to allow evaluation of the differences in outcomes among 3 first documented rhythm groups after OHCA. Therefore, this study will add valuable information for improving resuscitation science.

**Simultaneous Consideration of Both Time to CPR and First Documented Rhythm**

The most noteworthy finding of our study was that we showed different relationships between time to CPR and prognoses after OHCA because of first documented rhythms both in total OHCA population and in patients who achieved ROSC in the same cohort (Figure 4). The simultaneous evaluation of the outcomes after OHCA considering both time to first CPR and the first documented rhythm has been rarely performed previously.<sup>4,5</sup> There are few studies that compared the difference between PEA and asystole after OHCA in the same cohort,



**Figure 4.** Relationships between time from collapse to first cardiopulmonary resuscitation (CPR) and prognoses in overall out-of-hospital cardiac arrest (OHCA) patients (A–C) and OHCA patients with prehospital return of spontaneous circulation (ROSC; D and E). Curves indicate fitted probabilities of prognoses, bands 95% confidence bands, and dots observed rate (detailed data are shown in Tables I–VII in the Data Supplement). PEA indicates pulseless electric activity; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

**Table 3. Parameters for OHCA Outcome Estimation and Fitness of the Formula**

	OR (95% CI)	Adjusted OR (95% CI)*	Brier Score
Overall population			
Prehospital ROSC			
pVT/VF	0.94 (0.93–0.94)	0.94 (0.94–0.95)	0.214
PEA	0.99 (0.98–0.99)	0.98 (0.98–0.99)	0.117
Asystole	0.97 (0.97–0.98)	0.96 (0.96–0.96)	0.056
Total	0.96 (0.96–0.96)	0.97 (0.96–0.97)	...
One-mo survival			
pVT/VF	0.93 (0.93–0.94)	0.94 (0.93–0.94)	0.205
PEA	0.97 (0.97–0.98)	0.97 (0.97–0.98)	0.072
Asystole	0.97 (0.96–0.97)	0.95 (0.94–0.95)	0.029
Total	0.94 (0.94–0.95)	0.96 (0.95–0.96)	...
Neurologically favorable 1-mo survival			
pVT/VF	0.91 (0.90–0.91)	0.91 (0.91–0.92)	0.162
PEA	0.95 (0.94–0.95)	0.95 (0.94–0.95)	0.026
Asystole	0.93 (0.91–0.94)	0.90 (0.88–0.91)	0.006
Total	0.91 (0.91–0.91)	0.92 (0.92–0.93)	...
Patients who achieved prehospital ROSC			
One-mo survival			
pVT/VF	0.95 (0.94–0.96)	0.97 (0.96–0.97)	0.205
PEA	0.98 (0.97–0.98)	0.98 (0.98–0.99)	0.223
Asystole	0.98 (0.97–0.98)	0.97 (0.96–0.98)	0.167
Total	0.95 (0.95–0.95)	0.98 (0.97–0.98)	...
Neurologically favorable 1-month survival			
pVT/VF	0.93 (0.92–0.93)	0.94 (0.94–0.95)	0.239
PEA	0.96 (0.95–0.97)	0.96 (0.95–0.97)	0.127
Asystole	0.93 (0.92–0.95)	0.93 (0.92–0.95)	0.059
Total	0.92 (0.92–0.93)	0.95 (0.94–0.96)	...

All ORs have a  $P < 0.001$ . CI indicates confidence interval; OHCA, out-of-hospital cardiac arrest; OR, odds ratio per 1-min delay; PEA, pulseless electric activity; pVT, pulseless ventricular tachycardia; ROSC, recovery of spontaneous circulation; and VF, ventricular fibrillation.

\*Adjusted for age, sex, cardiac origin, bystander cardiopulmonary resuscitation, intravenous fluid, epinephrine, and advanced airway management as well as first documented rhythm when calculating in total population.

possibly because AHA guidelines included PEA and asystole in the same therapeutic algorithm described as a nonshockable rhythm.<sup>1–3,6,14</sup> In the present study, all estimated probabilities of prognoses after OHCA were better in OHCA patients with PEA than in those with asystole both in total population and in patients who achieved prehospital ROSC (Figure 4). We speculated that this would be partly because PEA sometimes happened because of reversible causes, thus our results indicate that identifying these treatable causes of PEA during CPR is important as described in AHA guidelines.<sup>1</sup> These findings might indicate the need of a rhythm-specific strategy when contacting with OHCA patients with nonshockable rhythms.

### Impact of Achievement of Prehospital ROSC

From our study, we, importantly, reacknowledged that the outcomes among OHCA patients who achieved prehospital ROSC were much better than those in total study population

(Figure 4). For example, overall 1-month survival of entire OHCA patients versus patients with prehospital ROSC with pVT/VF, PEA, and asystole was 70.5% versus 30.0%, 33.8% versus 7.8%, and 21.4% versus 3.0%, respectively (Table 2). The neurologically favorable 1-month survival of patients with pVT/VF, PEA, and asystole was 55.5% versus 21.3%, 15.0% versus 2.7%, and 6.3% versus 0.6%, respectively (Table 2). Because the outcomes among OHCA patients remained poor despite recent advances in treatment strategies, we should investigate more about OHCA to further improve outcomes after OHCA.<sup>10,15</sup> In this regard, achievement of prehospital ROSC could be one of strong surrogate end points in future clinical studies. We need to make much more effort to achieve ROSC after OHCA in prehospital settings.

### Impact of Delay of CPR

The impacts of delay of CPR on the outcomes after OHCA were described as OR per 1-minute delay and its 95% confidence interval in Table 3. In the present study, ORs on outcomes were statistically lower than 1.0 in all initial rhythms, and the adjusted ORs for prehospital ROSC and 1-month survival were lowest in patients with pVT/VF followed by asystole and PEA in this order, whereas that for neurologically favorable 1-month survival was lowest in patients with asystole (Table 3). Relatively low ORs in patients with pVT/VF throughout all end points were also suggested by a steep slope of the probability curve in the first several minutes in patients with pVT/VF. In addition, delay of CPR leads to an increase of proportion of asystole, which showed the worst prognoses among all 3 kinds of first documented rhythms (Figure 3). These findings could remind us the importance of early CPR initiation irrespective of first documented rhythms. However, only 47.0% of bystanders who witnessed OHCA performed CPR in the present study (Table 1), thus there would be still plenty room for improvement.<sup>16</sup> Much efforts should be made for public campaigns to promote the delivery of earlier and high-quality bystander CPR including chest compression-only CPR, which will contribute to improve the chain of survival after OHCA.<sup>1,3,17,18</sup>

### Clinical Perspective

In the present study, we introduced a mathematical model for the estimation of outcomes after OHCA. We consider that it is important to evaluate the prognoses accurately with this kind of mathematical model using population-based database, because it may give medical professionals insights into OHCA treatments and could contribute to the progress of resuscitation science. From our results, we reconfirmed that earlier detection of OHCA, which results in increase in proportion of more treatable first documented rhythm, earlier CPR initiation, and achievement of prehospital ROSC, is crucial for improving the survival after OHCA. Recent attempts such as wearable monitoring devices to detect loss of pulse among high-risk patients for SCA, CPR training application to promote the delivery of earlier and higher quality bystander CPR, and prehospital induction of therapeutic hypothermia may help us to achieve these goals.<sup>19–21</sup> Further comprehensive studies are needed to improve outcomes after OHCA.

## Study Limitations

This study has some limitations that warrant mention. First, the time of collapse and initiation of bystander CPR were obtained by EMS interview with the bystander, although it would be difficult to pinpoint an exact event time like cardiac arrest and CPR initiation. In addition, we did not obtain data on the exact timing of the first rhythm evaluation and how long CPR was performed before the evaluation of the rhythms in this registry. Second, we did not take into account a lot kind of in-hospital cares such as hemodynamic support, induced hypothermia, and coronary interventional therapies in the analyses. Third, this observational study lacks data on the quality of CPR by bystanders or EMS personnel. Fourth, unmeasured confounding factors might have influenced the results. Fifth, we only evaluated short-term outcomes although the evaluation of long-term neurological outcomes would be more important to discuss the health problem after OHCA. Finally, marked regional or racial differences in the incidence and outcome of SCA have been reported and it is unclear whether our results could be applied to other communities.<sup>22,23</sup> However, we think that the use of largest scale uniform data based on Utstein-style guidelines outweigh these potential limitations.

## Conclusions

The OHCA outcome differed by time to first CPR and first documented rhythm. Shortening of time to first CPR is crucial for improving the OHCA outcome.

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## Disclosures

None.

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## Different Impacts of Time From Collapse to First Cardiopulmonary Resuscitation on Outcomes After Witnessed Out-of-Hospital Cardiac Arrest in Adults

Masahiko Hara, Kenichi Hayashi, Shungo Hikoso, Yasushi Sakata and Tetsuhisa Kitamura

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