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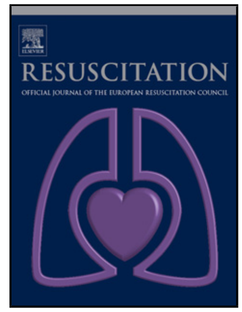

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Impact of prehospital physician-led cardiopulmonary resuscitation on neurologically intact survival after out-of-hospital cardiac arrest: a nationwide population-based observational study

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Abstract

Aim: The impact of prehospital physician care for out-of-hospital cardiac arrest (OHCA) on long-term neurological outcome is unclear. We aimed to determine the association between emergency medical services (EMS) physician-led cardiopulmonary resuscitation (CPR) versus paramedic-led CPR and neurologically intact survival after OHCA.

Methods: We assessed 613,251 patients using All-Japan Utstein Registry data from 2011 to 2015 retrospectively. The main outcome measure was 1-month neurologically intact survival after OHCA, defined as Cerebral Performance Category 1 or 2 (CPC 1–2).

Results: Before propensity score matching, the 1-month CPC 1–2 rate was significantly higher in EMS physician-led CPR than in paramedic-led CPR [5.7% (1114/19,551) vs. 2.5% (14,859/593,700), P<0.001; adjusted odds ratio (aOR), 1.50; 95% confidence interval (CI), 1.40–1.61]. After propensity score matching, EMS physician-led CPR showed more favourable neurological outcomes than paramedic-led CPR [6.0% (996/16,612) vs. 4.6% (766/16,612), P<0.001; aOR, 1.44; 95% CI, 1.29–1.60]. In most subgroup analyses after matching, physician-led CPR had higher 1-month CPC 1–2 rates than paramedic-led CPR did; however, 1-month CPC 1–2 rates were similar between the two CPR configurations for patients aged <18 years (5.6% vs. 8.2%, P=0.10; aOR, 0.82; 95% CI, 0.46–1.47) and those who received bystander defibrillation (26.3% vs. 21.5%; P=0.10; aOR, 1.07; 95% CI, 0.74–1.53).

Conclusion: Within the limitations of this retrospective observational research, EMS physician-led CPR for OHCA was associated with improved 1-month neurologically intact survival compared with paramedic-led CPR. However, neurologically intact survival was similar for patients aged <18 years and those receiving bystander defibrillation.

Keywords: Out-of-hospital cardiac arrest; Emergency medical services; Cardiopulmonary resuscitation, Epiemiology

Introduction

Early activation of the emergency medical services (EMS) system is a key element in the chain of survival after out-of-hospital cardiac arrest (OHCA) [1–3]. Establishment of an optimal EMS system configuration of prehospital care for OHCA is an important step for improving outcomes [4,5]. However, EMS systems for OHCA vary in their configurations worldwide [6–17]. In many European countries, an EMS physician on board the ambulance is dispatched as a member of the prehospital critical care team and performs advanced life support (ALS) in the field [6–11]. In other countries, such as the United States and most parts of Japan, a paramedic EMS team with no physician delivers prehospital advanced care for OHCA [12–17]. Until now, there is only limited evidence that EMS physician-led cardiopulmonary resuscitation (CPR) has positive influences on survival and neurologically intact survival after OHCA because no randomized controlled trials are available. Previous studies have suggested that EMS physician-led CPR for OHCA is associated with improved survival outcomes compared with non-physician-led (i.e., paramedic-led) CPR [18–21]. However, some studies have demonstrated conflicting results, finding no differences in patient-centred outcomes after OHCA between the two different EMS systems [6,10,11,22]. Thus, the effect of physician-staffed EMS systems on long-term neurologically intact survival is unclear. We hypothesized that prehospital physician care produces neurologically intact survival that is superior to paramedic-led CPR for patients with OHCA.

Using propensity score matching analyses, we investigated a large cohort of patients with OHCA to assess differences in post-OHCA outcomes between EMS physician-led CPR and paramedic-led CPR.

Methods

Study design

This was a nationwide, population-based, observational study of all patients who received resuscitation performed by EMS personnel after OHCA and were transported to the hospitals in Japan between 1 January 2011 and 31 December 2015. This study was conducted with the approval of the ethics committee of Kanazawa University.

Study setting

Japan has nearly 127 million residents in an area of 378,000 km^2. The Fire and Disaster Management Agency (FDMA) of Japan supervises the nationwide EMS system, whereas local fire stations operate the local EMS systems. Most local governments use a one-tiered system, with a crew of three EMS personnel including at least one emergency lifesaving technician. Emergency lifesaving technicians are permitted to use several resuscitative methods, including automated external defibrillators, insertion of an airway adjunct or a peripheral intravenous line, and administration of Ringers lactate solution. However, only specifically emergency lifesaving technicians are permitted to insert a tracheal tube and administer intravenous adrenaline (epinephrine) in the field while receiving physician instruction on the phone. Namely, EMS personnel in Japan are required to call the physician in charge and obtain their permission to perform ALS [12–14,18,21]. All EMS providers perform CPR according to Japanese CPR guidelines [23]. Importantly, since the Japanese law prohibits EMS personnel from terminating resuscitation in the field, most patients with OHCA who receive CPR by EMS providers are transported to hospitals, except in cases where fatality is certain. Since 2006, emergency telephone dispatchers in Japan are required to provide CPR instructions for compression-only CPR if it is difficult for bystanders to administer rescue breathing [24]. As emergency lifesaving technicians have very few opportunities to perform ALS procedures, several municipalities have their own two-tiered system that includes a paramedic-staffed ambulance and physician-staffed ambulance (with or without a nurse) to improve patient’s outcomes after OHCA [13,14,25]. Prehospital physician care includes following ALS and the following medical procedures, dependent on the physician’s skill and equipment: endotracheal intubation, intravenous catheter insertion, blood transfusion, drug administration (i.e., antiarrhythmic drugs, catecholamine, anaesthetic drugs, and thrombolytic agents), extracorporeal CPR, temporal pacing, and any necessary surgical interventions (i.e., tracheostomy, thoracotomy, thoracic drainage, and so on) [18,21]. Moreover, EMS physicians in Japan are specialized in emergency and critical care medicine [4,10,21,25].

Data collection and quality control

Since 2005, the FDMA in Japan has conducted an ongoing, prospective, population-based, observational study involving all patients with OHCA transported to the hospitals by EMS personnel [23]. Specifically, EMS personnel at each treatment centre record patient data using an Utstein-style template, in cooperation with the physician in charge. The recorded data are then transferred to individual local fire stations and subsequently integrated into the data registry system of the FDMA database. Ultimately, all data are stored in the nationwide database developed by the FDMA for public use. With permission from the FDMA, we analysed de-identified patient data contained within this database for this study. Neurological outcomes were stratified using the Cerebral Performance Category (CPC) 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) [26]. For all patients, the CPC score was determined by the attending physician.

Study endpoints

The primary endpoint included 1-month neurologically intact survival, defined as a CPC of 1 or 2 (CPC 1–2). Secondary endpoints included prehospital return of spontaneous circulation (ROSC) and 1-month survival.

Statistical analysis

We compared outcomes after OHCA between groups according to whether CPR was led by an EMS physician or a paramedic. We defined EMS physician-led CPR as prehospital CPR guided by a physician on board the ambulance, regardless of whether ALS was performed. Paramedic-led CPR was defined as prehospital CPR led by EMS personnel, with no attending physician present.

To perform rigorous adjustment for differences in the baseline characteristics of patients, we utilized both logistic regression analyses as well as propensity-score matching analyses to adjust for selection bias when comparing outcomes between the two groups.

In the analyses of unmatched and matched patients, both univariate and multivariate logistic regression analyses were performed to estimate the association between patient outcome and the type of EMS CPR configuration. In propensity score matching analyses, we estimated two propensity scores by fitting a logistic regression model that included 16 variables, as described in Table 1. We performed one-to-one nearest neighbour matching between patients with EMS physician-led and paramedic-led CPR without replacement, using a calliper width equal to 0.20 of the standard deviation of the logit of the propensity score [27]. Before analysing outcomes, we assessed the success of the propensity matching procedure by comparing the distribution of patient characteristics in the matched sample, by calculating an absolute standardized difference [28]. An absolute standardized difference ≥0.1 was considered indicative of a significant difference between the two cohorts [29]. To compare the outcomes between the two EMS CPR configurations, we utilized either chi-square or Fisher's exact tests in the pre-propensity-matched patients, and McNemar's test in the post-propensity-matched patients. We further analysed subgroups according to 10 variables, as described in **Tables 2 and 3.**

Continuous variables are expressed as mean (standard deviation), and categorical variables are expressed as percentages. As an estimate of the effect size and variability, we reported odds ratios (ORs) with 95% confidence intervals (CIs). All statistical analyses were performed using the JMP statistical package, version 14-Pro (SAS Institute Inc., Cary, NC, USA). All reported tests were two-tailed with a P value <0.05 considered statistically significant.

Results

Over 5 years, data of 629,471 patients were compiled in the database. Of these patients, 97.4% (n=613,251) were eligible for study enrolment (**Fig. 1**). We divided patients with OHCA into two groups according to whether a physician was on board the ambulance or not: physician-led CPR (n=19,551, 3.2%) and paramedic-led CPR groups (n=593,700, 96.8%). Patient matching was achieved for 16,612 of 19,551 patients with physician-led CPR (85.0%) and 16,612 of 593,700 patients with paramedic-led CPR (2.8%). Absolute standardized differences in matched cohorts were considerably improved (**Table 1**).

The results of outcome comparisons between the two groups before propensity score matching are shown in **Fig. 2A and 2B**. The crude (unadjusted) rates of prehospital ROSC, 1-month survival, and 1-month CPC 1–2 were significantly higher in the physician-led CPR group than in the paramedic-led

CPR group (Fig. 2A). In the multivariate logistic regression model, physician-led CPR was associated with increased odds of favourable outcomes compared with paramedic-led CPR (Fig. 2B).

The results of outcome comparisons between the two groups following propensity score matching are shown in Fig. 3A and 3B. The crude (unadjusted) rates of prehospital ROSC, 1-month survival, and 1-month CPC 1–2 were significantly higher after physician-led CPR than after paramedic-led CPR (Fig. 3A). After analysis with the multivariate logistic regression model, physician-led CPR was again found to be associated with increased odds of favourable outcomes compared with paramedic-led CPR (Fig. 3B).

The results of post-matched subgroup analyses of 1-month survival and 1-month CPC 1–2 are shown in Table 2. The rates of survival and CPC 1–2 after OHCA were significantly higher after physician-led CPR than after paramedic-led CPR in most subgroups. However, there were no significant differences between the two groups in the 1-month survival and 1-month CPC 1–2 rates for patients aged <18 years and for patients with bystander defibrillation. Moreover, there were no significant differences in the 1-month CPC 1–2 rate for patients in urban area and for patients witnessed by a family member or by physician or EMS personnel.

Table 3 shows aORs of physician-led CPR for 1-month outcomes in the post-matched subgroups compared with paramedic-led CPR. In 8 of 10 subgroup analyses, physician-led CPR was associated with increased ORs for 1-month survival and CPC 1–2. However, in patients aged <18 years and those who received bystander defibrillation, physician-led CPR was associated with favourable outcomes that were similar to those for paramedic-led CPR.

Discussion

In this 5-year nationwide population-based observational study, we analysed the data of 613,251 patients with OHCA of any cause from the All-Japan Utstein Registry. We demonstrated that compared with paramedic-led CPR, EMS physician-led CPR was associated with a 15.5% absolute increase and 194% relative increase in prehospital ROSC, a 3.7% absolute increase and 68% relative increase in 1-month survival, and a 1.4% absolute increase and 44% relative increase in 1-month neurologically intact survival **(Fig. 3)**. Unlike an earlier study that was underpowered to identify this clinically important association [6,10,22], the present study was sufficiently large to demonstrate the positive association between the EMS physician-led CPR configuration and neurologically intact survival after cardiac arrest. However, in patients aged <18 years and those who received bystander defibrillation, EMS physician-led CPR was not associated with improved outcomes compared with paramedic-led CPR.

Several potential reasons can be considered as to why physician-led CPR has greater benefits over paramedic-led CPR. First, EMS physicians in Japan deliver high-quality interventions more frequently than paramedics, similar to other countries [4,10,21,25,30]. Second, paramedic-led CPR may be required considerable time delay for performing ALS following physicians instructions conveyed over phone. Previous studies from Japan showed that earlier ALS (i.e., adrenaline administration [12] and advanced airway management [31]) was associated with good 1-month outcomes. However, we did not have sufficient data to demonstrate this time delay. Third, EMS physicians on board the ambulance can provide patients with prehospital critical care after achievement of prehospital ROSC; this is limited without a physician. ALS that can potentially be performed by a physician but not by paramedics in Japan includes the following: intraosseous access; central venous catheterization; injection of catecholamine except adrenaline; administration of antiarrhythmic, anaesthetic, and/or fibrinolytic drugs; and surgical procedures such as chest drain, pericardial drain, thoracotomy, and tracheotomy [24]. Unfortunately, we could not obtain information on such interventions due to a lack of All-Japan Utstein Registry data. Fourth, EMS physicians may transport patients to the most suitable tertiary hospital, according to level of experience with therapeutic hypothermia and percutaneous coronary interventions (PCI). Moreover, EMS physicians can determine the need for PCI or extracorporeal membrane oxygenation (ECMO) and can alert the hospital to prepare for PCI or ECMO prior their arrival at the hospital [25].

The results of the present study are consistent with those of some previous studies [18–21] but not those of other studies [6,9,10,22]. Yasunaga et al. [18] evaluated patients with bystander-witnessed OHCA between 2005 and 2007 from a Japanese database. Those authors showed that ALS by a physician was associated with increased 1-month survival regardless of preceding bystander CPR. However, physician-administered ALS without preceding bystander CPR was associated with a significantly increased number of patients with unfavourable neurological outcomes. In the present study, we demonstrated that physician-led CPR was associated with improved neurologically intact survival, regardless of bystander CPR and administration of ALS. We analysed patients with OHCA using propensity score matching; Yasunaga et al. did not use such a method to exclude confounding factors. Moreover, the differences between the study by Yasunaga et al. (data from 2005 to 2007) and the present study (data from 2011 to 2015) may be explained by quality improvement in the strategy for OHCA after the update of the 2010 international CPR guidelines.

Another study from Japan [21] showed that having an EMS physician on board the ambulance was independently associated with increased short- and long-term survival in adult patients (aged ≥18 years) with OHCA from 2005 to 2010 using propensity score matching. Those results are consistent with the present findings. Unlike a study by Hagihara et al. [21], we also included children (aged <18 years) with OHCA in the analysis and found that there were no differences between the two EMS CPR configurations.

Limitations

This observational study had several potential limitations. First, physician-led CPR is only available in limited areas around specific emergency medical centres in Japan [14,18,21,22,25]. Patients with OHCA are usually transported to the specific hospital with which the physician on board is affiliated. Those circumstances may influence the positive effect on the outcomes in physician-led CPR, although we included Japanese geographic regions as a confounding variable for analysis, and equality in personal health-care access and quality is widespread in Japan [32]. Furthermore, there is a possibility that some medically futile patients with OHCA were not transported to the hospital in the physician-led CPR group. Because physicians are allowed to pronounce death at the site, some EMS physicians might refrain from resuscitation or might terminate resuscitation after CPR efforts for medically futile patients in the field; however, we did not have precise data regarding this issue. Taken together, we cannot exclude the possibility of a selection bias. Second, although the duration of bystander CPR prior to EMS arrival may have influenced the patient outcomes [33], our analysis could not account for this issue. Third, the data lacked sufficient detail to allow us to perform further risk adjustment for the outcomes (e.g., comorbid diseases, CPR quality, location of arrest and in-hospital medication). Fourth, as we excluded most patients from an original cohort of paramedic-led CPR (97.2%; 577,088/593,700) to compare outcomes by propensity score matching, an adequately powered randomized controlled trial will be required to determine the role of physician-led CPR for patients with OHCA. Fifth, we did not analyse cost-effectiveness and cost–utility due to a lack of data. Dispatching physician-led CPR teams would substantially increase costs and would limit resources. Additional prospective studies are required to clarify this issue. Finally, caution must be exercised in generalizing these results to additional EMS configurations, as we observed relatively infrequent deployment of EMS physician-led CPR (3%), administration of adrenaline (~20%), and defibrillation (~10%) in the present study, as compared with much more frequent physician deployment, use of adrenaline, and defibrillation in many European countries [7–11,19,34].

Conclusions

Within the limitations of this retrospective observational research, EMS physician-led CPR for OHCA was associated with improved neurologically intact survival compared with paramedic-led CPR. However, 1-month neurologically intact survival with EMS physician-led CPR was similar to that with paramedic-led CPR for patients aged <18 years and those who received bystander defibrillation.

Funding Sources

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Conflicts of Interest

None.

Acknowledgement

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Legends to figures

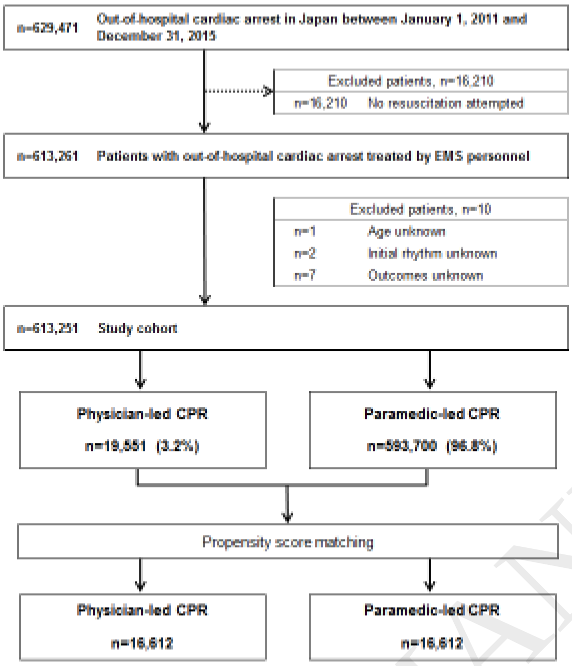


Figure 1. Flowchart of Patient Inclusion Criteria

CPR, cardiopulmonary resuscitation; EMS, emergency medical services.

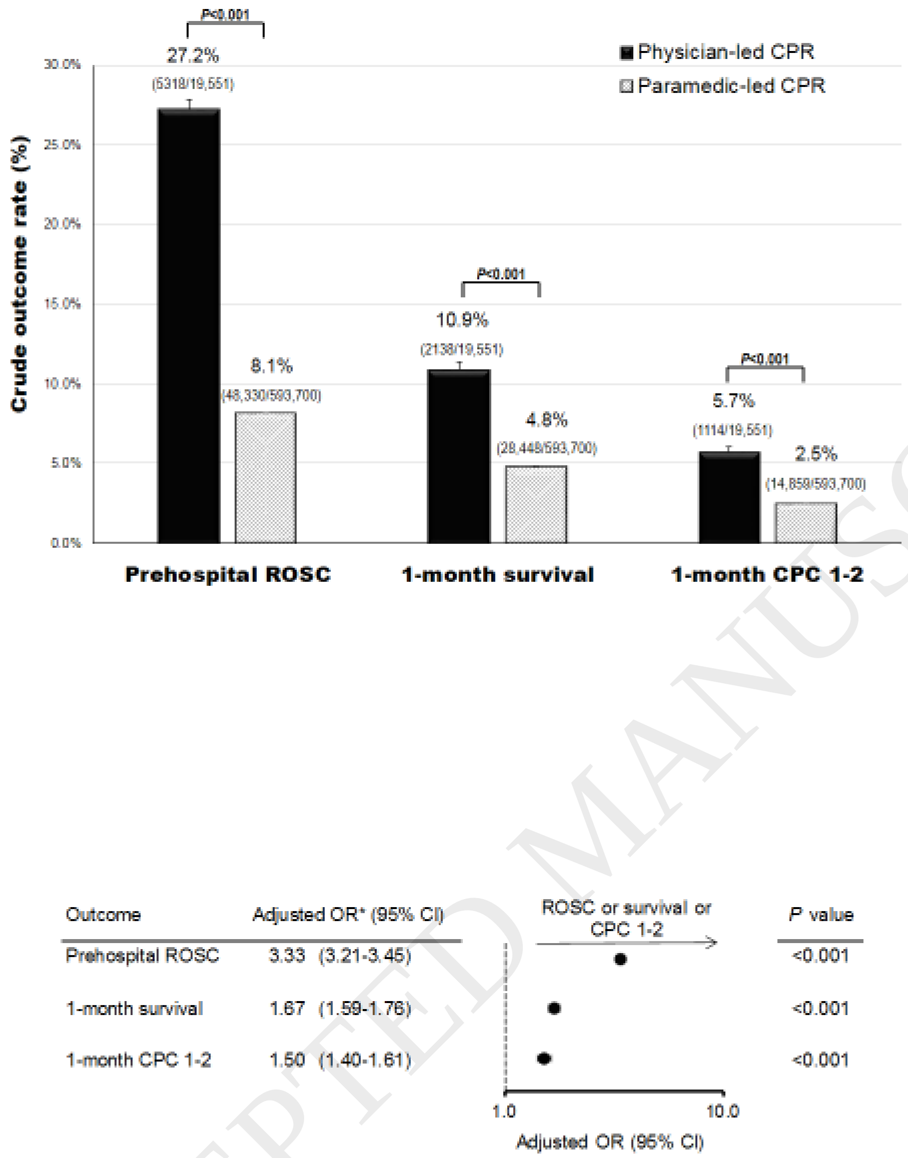
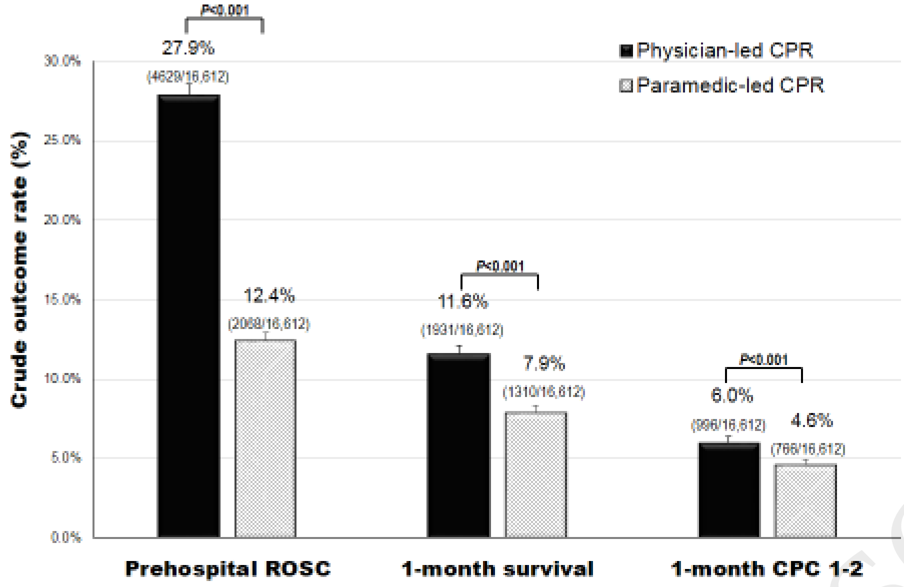
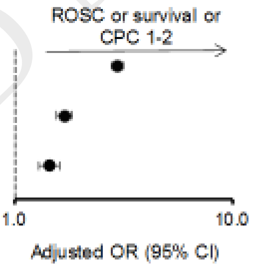


Figure 2. Comparison of Outcomes in the 613,251 Unmatched Patients

A. Crude (unadjusted) outcomes of the two groups. **B**. Adjusted odds ratios of physician-led CPR for each outcome compared with paramedic-led CPR. CI, confidence interval; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; OR, odds ratio;

ROSC, return of spontaneous circulation. *Adjusted ORs were calculated using a predefined set of 12 potential confounders: year, rural area, age, sex, cardiac cause, initial shockable rhythm, witnessed arrest, bystander CPR, bystander defibrillation, use of advanced airway management, adrenaline administration, and call-to-response time.





Outcome	Adjusted OR* (95% CI)	*P* value
Prehospital ROSC	2.94 (2.77-3.12)	<0.001
1-month survival	1.68 (1.55-1.82)	<0.001
1-month CPC 1-2	1.44 (1.29-1.60)	<0.001

Figure 3. Comparison of Outcomes in the 33,224 Matched Patients

A. Crude (unadjusted) outcomes of the two groups. **B**. Adjusted odds ratios of physician-led CPR for each outcome compared with paramedic-led CPR. CI, confidence interval; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; OR, odds ratio; ROSC, return of spontaneous circulation. *Adjusted ORs were calculated using a predefined set of 12 potential confounders: year, rural area, age, sex, cardiac cause, initial shockable rhythm, witnessed arrest, bystander CPR, bystander defibrillation, use of advanced airway management, adrenaline administration, and call-to-response time.

Table 1. Baseline characteristics of unmatched and matched patients

Characteristic	Pre-propensity-matched patients						Post-propensity-matched patients				
	Physician-led CPR (n=19,551)		Paramedic-led CPR (n=593,700)		ASD*		Physician-led CPR (n=16,612)		Paramedic-led CPR (n=16,612)		ASD*
Year											
2011	3740	(19.1)	121,179	(20.4)	0.03		3740	(22.5)	3679	(22.2)	<0.01
2012	3790	(19.4)	121,200	(20.4)	0.03		3775	(22.7)	3788	(22.8)	<0.01
2013	3992	(20.4)	115,677	(19.5)	0.02		2928	(17.6)	2929	(17.6)	<0.01
2014	4061	(20.8)	119,178	(20.1)	0.02		3084	(18.6)	3046	(18.3)	<0.01
2015	3968	(20.3)	116,466	(19.6)	0.02		3085	(18.6)	3170	(19.1)	0.01
Geographic Japanese regions											
Rural area†	7177	(36.7)	141,543	(23.8)	0.28		6235	(37.5)	6216	(37.4)	<0.01
Age, y, mean (SD)	68.8	(20.7)	68.7	(20.1)	<0.01		68.7	(20.1)	68.8	(20.7)	<0.01
Male sex	12,244	(62.6)	336,962	(56.8)	0.12		10,370	(62.4)	10,397	(62.6)	<0.01
Etiology of cardiac arrest											
Presumed cardiac origin	10,249	(52.4)	351,223	(59.2)	0.14		8908	(53.6)	9101	(54.8)	0.02
Initial cardiac rhythm											
Shockable	2217	(11.3)	40,888	(6.7)	0.16		2059	(12.4)	2048	(12.3)	<0.01
Bystander witness status											
No witness	8243	(42.2)	351,904	(59.3)	0.35		6876	(41.4)	6862	(41.3)	<0.01
Witnessed by family member	4349	(22.2)	118,589	(20.0)	0.06		3780	(22.8)	3745	(22.5)	<0.01
Witnessed by nonfamily member	4687	(24.0)	75,631	(12.7)	0.29		4039	(24.3)	4099	(24.7)	<0.01
Witnessed by physician or EMS personnel	2272	(11.6)	47,576	(8.0)	0.12		1917	(11.5)	1906	(11.5)	<0.01
Dispatcher CPR instruction											
Offered	8948	(49.4)	309,455	(55.0)	0.13		7556	(45.5)	7517	(45.3)	<0.01

Bystander intervention											
Bystander defibrillation	502	(2.6)	6152	(1.0)	0.12		452	(2.7)	451	(2.7)	<0.01
Bystander conventional CPR	2250	(11.5)	40,309	(6.8)	0.16		1964	(11.8)	1982	(11.9)	<0.01
Bystander compression-only CPR	6962	(35.6)	226,290	(38.1)	0.05		5907	(35.6)	6022	(36.3)	0.01
Bystander rescue breathing-only CPR	88	(0.45)	1618	(0.27)	0.03		79	(0.48)	82	(0.49)	<0.01
No bystander intervention	10,251	(52.4)	325,483	(54.8)	0.05		8662	(52.1)	8526	(51.3)	0.02
Defibrillation by physician or EMS personnel	3,206	(19.0)	56,836	(11.0)	0.20		3001	(18.1)	3028	(18.2)	<0.01
Use of advanced airway management	6764	(34.6)	235,555	(39.7)	0.11		5746	(34.6)	5621	(33.8)	0.02
Insertion of intravenous line	6557	(33.5)	187,239	(31.5)	0.04		5618	(33.8)	6052	(36.4)	0.06
Adrenaline administration	4601	(23.5)	91,642	(15.4)	0.21		4002	(24.1)	3947	(23.8)	<0.01
Call-to-response time, min, mean (SD)	8.29	(4.60)	7.84	(3.71)	0.11		8.21	(4.47)	8.21	(4.16)	<0.01
Call-to-hospital arrival time, min, mean (SD)	33.0	(12.9)	31.5	(10.4)	0.12		33.1	(13.0)	33.0	(10.9)	<0.01

Values are reported as n (%) unless indicated otherwise. ASD, absolute standardized difference; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; SD, standard deviation.

*An ASD of equal or more than 0.1 was considered to indicate a substantial imbalance between the two groups.

†The rural area is constituted 19 prefectures with population of less than 200 inhabitants per km^2.

Table 2. Subgroup analyses for 1-month outcomes in matched cohorts

	1-month survival					1-month CPC 1-2				
	Physician-led CPR (n=16,612)		Paramedic-led CPR (n=16,612)		*P* value	Physician-led CPR (n=16,612)		Paramedic-led CPR (n=16,612)		*P* value
Age										
<18 year, n=991	70/518	(13.5)	75/473	(15.9)	0.32	29/518	(5.6)	39/473	(8.2)	0.10
18-74 years, n=16,123	1279/8132	(15.7)	911/7991	(11.4)	<0.001	776/8132	(9.5)	593/7991	(7.4)	<0.001
≥75 year, n=16,110	582/7962	(7.3)	324/8148	(4.0)	<0.001	191/7962	(2.4)	134/8148	(1.6)	<0.001
Geographic Japanese regions										
Rural area, n=12,451	873/6235	(14.0)	438/6216	(7.0)	<0.001	429/6235	(6.9)	255/6216	(4.1)	<0.001
Urban area, n=20,773	1058/10,377	(10.2)	872/10,396	(8.4)	<0.001	567/10,377	(5.5)	511/10,396	(4.9)	0.08
Etiology										
Cardiac origin, n=18,009	1284/8908	(14.4)	917/9101	(10.1)	<0.001	808/8908	(9.1)	627/9101	(6.9)	<0.001
Noncardiac origin, n=15,215	647/7704	(8.4)	393/7511	(5.2)	<0.001	188/7704	(2.4)	139/7511	(1.9)	0.01
Initial rhythm										
Shockable, n=4107	807/2059	(39.2)	606/2048	(29.6)	<0.001	552/2059	(26.8)	439/2048	(21.4)	<0.001
Nonshockable, n=29,117	1124/14,553	(7.7)	704/14,564	(4.8)	<0.001	444/14,553	(3.1)	327/14,564	(2.2)	<0.001
Witnessed status										
No witness, n=13,738	334/6876	(4.9)	154/6862	(2.2)	<0.001	136/6876	(2.0)	56/6862	(0.8)	<0.001
Witnessed by family member, n=7525	582/3780	(15.4)	396/3745	(10.6)	<0.001	253/3780	(6.7)	217/3745	(5.8)	0.12
Witnessed by nonfamily member, n=8138	665/4039	(16.5)	480/4099	(11.7)	<0.001	384/4039	(9.5)	298/4099	(7.3)	<0.001
Witnessed by physician or EMS personnel, n=3823	350/1917	(18.3)	280/1906	(14.7)	<0.001	223/1917	(11.6)	195/1906	(10.2)	0.18
Bystander defibrillation										

Yes, n=903	144/452	(31.9)	125/451	(27.7)	0.19		119/452	(26.3)	97/451	(21.5)	0.10
No, n=32,321	1787/16,160	(11.1)	1185/16,161	(7.3)	<0.001		877/16,160	(5.4)	669/16,161	(4.1)	<0.001
Bystander any interventions											
Yes, n=16,036	941/7950	(11.8)	688/8086	(8.5)	<0.001		519/7950	(6.5)	409/8086	(5.1)	<0.001
No, n=17,188	990/8662	(11.4)	622/8526	(7.3)	<0.001		477/8662	(5.5)	357/8526	(4.2)	<0.001
Defibrillation by physician or EMS personnel											
Yes, n=6029	915/3001	(30.5)	719/3028	(23.7)	<0.001		612/3001	(20.4)	514/3028	(17.0)	<0.001
No, n=27,195	1016/13,611	(7.5)	591/13,584	(4.4)	<0.001		384/13,611	(2.8)	252/13,584	(1.9)	<0.001
Use of advanced airway management											
Yes, n=11,367	603/5746	(10.5)	271/5621	(4.8)	<0.001		227/5746	(4.0)	108/5621	(1.9)	<0.001
No, n=21,857	1328/10,866	(12.2)	1039/10,991	(9.5)	<0.001		769/10,866	(7.1)	658/10,991	(6.0)	0.001
Adrenaline administration											
Yes, n=7949	376/4002	(9.4)	236/3947	(6.0)	<0.001		123/4002	(3.1)	89/3947	(2.3)	0.03
No, n=25,275	1555/12,610	(12.3)	1074/12,665	(8.5)	<0.001		873/12,610	(6.9)	677/12,665	(5.3)	<0.001

Values are reported as no./total no. (%) unless indicated otherwise. CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; EMS, emergency medical services.

Table 3. Adjusted odds ratios of physician-led CPR for 1-month outcomes in post-matched subgroups

Subgroup	1-month survival			1-month CPC 1-2	
	Adjusted OR*	(95% CI)		Adjusted OR*	(95% CI)
Age					
<18 years, n=991	1.06	(0.72-1.56)		0.82	(0.46-1.47)
18-74 years, n=16,123	1.62	(1.46-1.79)		1.48	(1.30-1.68)
≥75 year, n=16,110	1.85	(1.60-2.13)		1.37	(1.09-1.73)
Geographic Japanese regions					
Rural area, n=12,451	2.17	(1.90-2.48)		1.86	(1.55-2.22)
Urban area, n=20,773	1.38	(1.24-1.53)		1.22	(1.07-1.40)
Etiology					
Cardiac origin, n=18,009	1.63	(1.47-1.81)		1.44	(1.27-1.63)
Noncardiac origin, n=15,215	1.72	(1.50-1.96)		1.43	(1.14-1.79)
Initial rhythm					
Shockable, n=4107	1.62	(1.40-1.86)		1.44	(1.23-1.69)
Nonshockable, n=29,117	1.68	(1.52-1.86)		1.42	(1.22-1.65)
Witnessed status					
No witness, n=13,738	2.06	(1.69-2.53)		2.11	(1.51-2.93)
Witnessed by family member, n=7525	1.75	(1.50-2.03)		1.37	(1.11-1.70)
Witnessed by nonfamily member, n=8138	1.60	(1.39-1.84)		1.41	(1.17-1.69)
Witnessed by physician or EMS personnel, n=3823	1.45	(1.21-1.74)		1.34	(1.07-1.67)
Bystander defibrillation					
Yes, n=903	1.02	(0.74-1.42)		1.07	(0.74-1.53)
No, n=32,321	1.73	(1.59-1.88)		1.48	(1.32-1.66)

Bystander any interventions					
Yes, n=16,036	1.56	(1.39-1.75)		1.41	(1.21-1.64)
No, n=17,188	1.78	(1.59-1.99)		1.49	(1.28-1.73)
Defibrillation by physician or EMS personnel					
Yes, n=6029	1.55	(1.36-1.76)		1.39	(1.20-1.61)
No, n=27,195	1.77	(1.59-1.97)		1.51	(1.28-1.78)
Use of advanced airway management					
Yes, n=11,367	2.17	(1.85-2.55)		1.98	(1.53-2.56)
No, n=21,857	1.50	(1.36-1.65)		1.32	(1.17-1.49)
Adrenaline administration					
Yes, n=7949	1.78	(1.49-2.14)		1.62	(1.20-2.18)
No, n=25,275	1.63	(1.49-1.78)		1.40	(1.24-1.57)

CI, confidence interval; CPC, Cerebral Performance Category; EMS, emergency medical services; OR, odds ratio. *Adjusted ORs were calculated using a predefined set of 12 potential confounders: year, rural area, age, sex, cardiac cause, initial shockable rhythm, witnessed status, bystander CPR, bystander defibrillation, use of advanced airway management, adrenaline administration, and call-to-response time.