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Clinical paper

Cardiopulmonary resuscitation performed by off-duty medical professionals versus laypersons and survival from out-of-hospital cardiac arrest among adult patients

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Abstract

Background: Cardiopulmonary resuscitation (CPR) performed by bystanders is a key factor for out-of-hospital cardiac arrest (OHCA) survival. This study aimed to evaluate the relationship between CPR performed by off-duty medical professionals vs. laypersons and one-month survival with favorable neurological outcome after OHCA.

Methods: Using a population-based database of OHCA patients in Osaka City, Japan, from 2013 through 2015, we enrolled adult OHCA patients with resuscitation attempts performed by bystanders before the arrival of emergency-medical-service personnel. Multivariable logistic regression analysis was performed to assess the association between CPR performed by off-duty medical professionals vs. laypersons and the OHCA outcome after adjusting for potential confounding factors. The primary outcome measure was one-month survival with favorable neurological outcome, defined as cerebral performance category of 1 or 2.

Results: A total of 2326 subjects were eligible for our study. Among these, 365 (15.7%) patients received CPR by off-duty medical professionals and 1,961 (84.3%) received CPR by laypersons. In the multivariable analysis, there was no difference in favorable neurological outcome between off-duty medical professionals (6.3% [23/365]) and laypersons (5.1% [100/1,961]) among eligible patients (adjusted odds ratio 0.83, 95% confidence interval [0.37–2.06]). This finding was also confirmed in propensity score-matched patients.

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Conclusions: In Japan where the CPR training or bystander CPR has been widely disseminating, CPR by laypersons had similar effects compared to that by off-duty medical professionals. As this study could not assess the quality of bystander CPR, further studies are essential to verify the effects of the bystander CPR type on OHCA patients.
Keywords: Out-of-hospital cardiac arrest, Cardiopulmonary resuscitation, Bystander, Outcome

Introduction

Out-of-hospital cardiac arrest (OHCA) of cardiac origin is an important public health problem in the industrialized world,[1] and approximately 70,000 events occur every year in Japan.[2] In recent years, the dissemination of the public-access defibrillation program, as well as bystander-initiated cardiopulmonary resuscitation (CPR) has been increasing in many areas, including Japan,[3-7] but the number of survivors with favorable neurologic outcome after an OHCA remains low.

Previous studies suggested that the OHCA outcomes are affected by the types of persons implementing bystander CPR. A Korean study reported that CPR performed by trained responders was associated with improved survival with favorable neurological outcome among bystander-witnessed OHCA patients.[8] A Swedish study also reported that CPR initiated by medically educated bystanders was associated with an increased 30-day survival compared to CPR performed by laypersons among bystander-witnessed OHCA patients.[9] Thus, there might be differences in the CPR training, experience, or skill by the type of bystanders performing CPR. In Japan, the CPR training and bystander CPR has been widely disseminating and the OHCA outcomes has subsequently improved in recent years.[2,4] However, Japanese preceding studies could not assess the OHCA outcomes by the type of bystanders,[3,4] and it is important to reveal the characteristics among OHCA patients by the type of bystanders and to assess the OHCA outcomes between off-duty medical professionals and laypersons.

The Osaka Municipal Fire Department has been conducting a prospective population-based OHCA registry in Osaka City, Japan comprising approximately 2.7 million residents.[10,11] During the 3 years between 2013 and 2015, there were approximately 2400 patients with emergency medical service (EMS)-resuscitated OHCAs of cardiac origin who received CPR by bystanders before the arrival of EMS personnel. Using this database, we aimed to evaluate the association between CPR performed by off-duty medical professionals vs. laypersons and one-month survival with favorable neurological outcome after an OHCA.

Methods

Study design, setting, and population

The Utstein registry in Osaka City, Japan, is a prospective, population-based OHCA database using Utstein-style guidelines.[12] Details of this registry were described in previous publications.[10,11] In this study, we included adult patients aged $>=18$ years with OHCA of presumed cardiac origin who were resuscitated before the arrival of EMS personnel, who received CPR by off-duty medical professionals or laypersons, and who were then transported to emergency hospitals between January 1, 2013 and December 31, 2015. We excluded patients without resuscitation attempts, those witnessed by EMS personnel, those with a non-cardiac origin, those without bystander-initiated CPR, and those with unknown information on the type of bystander performing CPR from our analyses.

Osaka is the third largest city in Japan with a population of 2.69 million residents (2015) in an area of 222 km^2 (population density approximately 12,000 residents/km^2). The research protocol was approved by the institutional review boards of Osaka and Kyoto Universities. The requirement of obtaining individual informed consent for the review of patient outcomes was waived by the Personal Information Protection Law and the national research ethics guidelines of Japan.

Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.[12] The arrest was presumed to be of cardiac origin unless it was caused by trauma, drowning, drug overdose, asphyxia, exsanguination, or any other non-cardiac cause. These diagnoses were made clinically by the physician in charge in collaboration with the EMS rescuers. In this study, we focused on patients with OHCA of cardiac origin because these patients needed be resuscitated in prehospital settings based on the Utstein-style guidelines[12] and excluded those with OHCA of non-cardiac origin because their outcomes was very poor in order to assess the effectiveness of bystander CPR.[13]

EMS systems and systemic CPR training

Details of the EMS system in Japan have also been previously described.[14] The EMS system is operated by local fire stations and the free telephone emergency number 119, is used to call for an ambulance from anywhere in Japan. There are 25 fire stations and a single emergency dispatch center in Osaka City with life support provided 24 h a day. When called, an ambulance is dispatched from the nearest fire station. Each fire ambulance has three EMS personnel with at least one emergency life-saving technician who has been highly trained for providing prehospital emergency care. They are allowed to insert an intravenous line, an adjunct airway, and to use an automated external defibrillator (AED) for OHCA patients. Specially trained ELSTs are permitted to insert tracheal tubes and administer intravenous adrenaline. The use of AED by citizens was legally approved in July 2004. All EMS providers perform CPR according to the Japanese CPR guidelines.[15] In the Utstein registry form in Osaka City, information on the type of bystanders performing CPR (either off-duty medical professionals such as medical doctors, dentists, nurses, and paramedics or other laypersons) were routinely obtained by the EMS interview with the bystander before leaving the scene.

In Japan, CPR training programs have been conducted mainly by local fire departments, and the program has been recommended by the Fire and Disaster Management Agency of Japan and the Ministry of Health, Labor and Welfare on the basis of the Japanese CPR guidelines.[15] Local fire departments trained citizens in conventional 3-h CPR training programs consisting of chest compressions, mouth-to-mouth ventilation, and AED use.[2] The Japanese Red Cross, other organizations such as local nonprofit organizations, and driver's training schools have also provided CPR training. The 45-min chest compression-only CPR training was recommended beginning since

2013. In total, it is estimated that approximately 4% of inhabitants are trained in CPR annually in Osaka.[2]

Data collection and quality control

Data were prospectively collected using a form that included all core data recommended in the Utstein-style reporting guidelines for cardiac arrests.[12] These data included age, sex, witness status, first documented cardiac rhythm, location of cardiac arrest, activity of daily living (ADL) before cardiac arrest, time course of resuscitation, dispatcher instruction, public-access AED pad application and shocks, type of CPR, type of bystanders who performed CPR, as well as outcomes including prehospital return of spontaneous circulation (ROSC), hospital admission, one-month survival, and neurological status one month after the event. EMS-related time courses, such as call receipt, contact with patients, and hospital arrival, were recorded at the dispatch center. The first documented rhythm was diagnosed by EMS personnel with AEDs at the scene, and was regarded as ventricular fibrillation (VF) when bystanders provided shocks using public-access AEDs.[4]

The data form was filled out by EMS personnel in cooperation with the physicians in charge of the patient. They were then transferred to the Osaka Municipal Fire Department Information Center. 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 to one month after the event by the EMS personnel in charge. Neurological outcome was determined by the physician responsible for the care of the patient 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.[12]

Outcome measures

The primary outcome measure was one-month survival with a favorable neurological outcome. Neurologically favorable outcome was defined as having a CPC scale 1 or 2.[4,12] Secondary outcome measures included prehospital ROSC, hospital admission, and one-month survival.

Statistical analysis

In this study, the types of bystanders who performed CPR were defined as follows: off-duty medical professionals (the MP group); and laypersons (the LP group). Characteristics and outcomes were evaluated between the MP group and the LP group. Multivariable logistic regression analysis was used to assess and compare the contribution of the type of bystander who performed CPR to the OHCA outcomes for OHCAs of presumed cardiac origin using odds ratios (ORs) and their 95% confidence intervals (CIs). Factors that were biologically essential and considered to be associated with clinical outcomes were considered potential confounders in the multivariable analysis.[11,14,16] These variables were: age (one year increments); gender (men, women); ADL before cardiac arrest (good, other); witness status (bystander, none); location of cardiac arrest (home, public place, nursing home, others); dispatcher instruction (yes, no); first documented rhythm (VF, non-VF); public-access AED pad application (yes, no); type of CPR (chest compression-only CPR, conventional CPR with rescue breathing); EMS response time (minute increments); and contact-hospital time (minute increments). To further reduce potential confounding effects while comparing the two groups, we estimated a propensity score (PS) by fitting a logistic regression model that was adjusted for the above-listed 11 variables before CPR was performed by bystanders. One-to-one pair matching between the MP group and the LP group was performed by nearest-neighbor matching without replacement, using a caliper width of 0.05 of the standard deviation of the logit of the PS. Covariate balances before and after matching were checked by comparing standardized mean differences. A standardized difference of less than 10% was considered to indicate negligible balancing. A subgroup analysis by witness status (witnessed, not witnessed), location (public, others), first documented rhythm (VF, non-VF), and type of CPR (chest compression-only CPR, conventional CPR with rescue breathing), was also conducted. All statistical analyses were

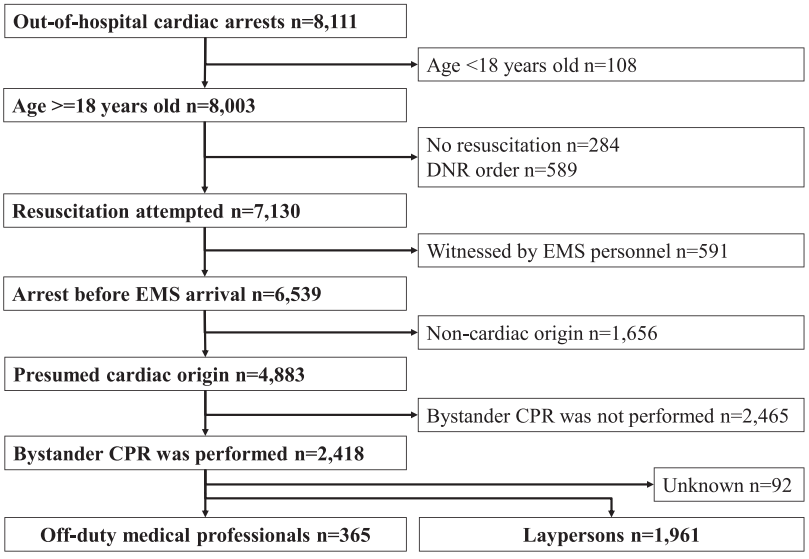

Fig. 1 – Overview of EMS-treated cardiac arrests with an abridged Utstein template from January 1, 2013 to December 31, 2015.
EMS, emergency medical service; DNR, do-not-resuscitate; CPR, cardiopulmonary resuscitation.

performed using an SPSS version 24.0 J statistical package, (IBM Corp.) and R, version 3.2.0 (The R Foundation for Statistical Computing). All tests were 2-tailed, and a p value of < 0.05 was considered statistically significant.

Results

Fig. 1 shows an overview of the patients based on the Utstein template. A total of 8003 adult patients with OHCA were documented during the study period with resuscitation attempts occurring in 7130 patients. Excluding 591 victims witnessed by EMS personnel, 1656 with a non-cardiac origin, 2465 without bystander-initiated CPR, and 92 with unknown information on the type of bystander who performed CPR, a total of 2326 were eligible for our study. Among these patients, 365 (15.7%) victims received CPR by off-duty medical professionals (the MP group) and 1961 (84.3%) received CPR performed by laypersons (the LP group).

Characteristics of eligible patients with the types of bystanders who performed CPR are shown in Table 1. Before PS matching, the LP group was more likely to have an occurrence at home and receive dispatcher instruction with chest compression-only CPR, but were less likely to be witnessed by bystanders and receive public-access AED pad application. The time interval from patient contact to hospital arrival was longer in the LP group than in the MP group. After PS matching, 321 patients from each group were selected and the area under the PS receiver operating characteristic curve was 0.844, and the covariate balance between groups in the matched patients was well improved.

Table 2 shows the outcomes after OHCAs were categorized by the type of bystander who performed CPR. In the multivariable analysis, there was no difference in favorable neurological outcome between the LP group (5.1% [100/1961]) and the MP group (6.3% [23/365]) among all patients (adjusted OR 0.83, 95% CI [0.37–2.06]). There was also no difference in secondary outcomes between the two groups. For the propensity-matched patients, no significant difference was observed in favorable neurological outcome after OHCAs between the two groups: LP group (6.5% [21/321]) vs. the MP group (5.9% [19/321]), adjusted OR 0.88, 95% CI [0.37–2.06]). As for secondary outcomes such as prehospital ROSC, crude and adjusted ORs were reverse; i.e., the MP group had better outcomes than the LP group in univariable analysis, but the MP group had worse outcomes than the LP group in multivariable analysis.

Table 3 shows the results of subgroup analyses. Among non-witnessed patients, the proportion of favorable neurological outcome was higher in the MP group (3.9% [7/180]) than in the LP group (1.4% [18/1,268]) (crude OR 2.81, 95% CI; 1.16–6.83). However, among witnessed patients, the proportion of favorable neurological outcome was lower in the MP group (8.6% [16/185]) than in the LP group (11.8% [82/693]) (crude OR 0.71, 95% CI 0.40–1.24) with an interaction p value of 0.012. With the first documented rhythm, the MP group had a more favorable neurological outcome compared to the LP group among non-VF patients (crude OR 2.42, 95% CI; 0.99–5.89), but not among first documented VF patients (crude OR 0.57, 95% CI; 0.31–1.06) with an interaction p value of 0.012.

Discussion

Using the large-scale population-based OHCA registry in Osaka City, we demonstrated that there were no OHCA outcome differences

Table 1 – Demographic and clinical characteristics of patients with out-of-hospital cardiac arrests by the type of bystander.

	All patients			Propensity score matched patients		
	Laypersons N = 1961	Off-duty medical professionals N = 365	SMD	Laypersons N = 321	Off-duty medical professionals N = 321	SMD
Age, years, medean (IQR)	78 (66–85)	81 (72–88)	0.28	81 (67–88)	81 (71–88)	0.07
Male, n (%)	1140 (58.1%)	185 (50.7%)	0.15	176 (54.8%)	170 (53.0%)	0.04
Good ADL, n (%)	1626 (82.9%)	258 (70.7%)	0.29	226 (70.4%)	226 (70.4%)	<0.01
Witnessed by bystander, n (%)	693 (35.3%)	185 (50.7%)	0.31	152 (47.4%)	155 (48.3%)	0.02
Location, n (%)						
Home	1273 (64.9%)	65 (17.8%)	1.09	61 (19.0%)	65 (20.2%)	0.03
Public	283 (14.4%)	47 (12.9%)	0.05	59 (18.4%)	47 (14.6%)	0.1
Nursing home	331 (16.9%)	195 (53.4%)	0.83	165 (51.4%)	166 (51.7%)	0.01
Others	74 (3.8%)	58 (15.9%)	0.42	36 (11.2%)	43 (13.4%)	0.07
Dispatcher instruction, n (%)	1503 (76.6%)	125 (34.2%)	0.94	124 (38.6%)	125 (38.9%)	0.01
First documented shockable rhythm, n (%)	234 (11.9%)	67 (18.4%)	0.18	57 (17.8%)	57 (17.8%)	<0.01
Pad application of a public-access automated external defibrillator, n (%)	259 (13.2%)	133 (36.4%)	0.56	119 (37.1%)	107 (33.3%)	0.08
Shock by a public-access automated external defibrillator, n (%)	48 (2.4%)	30 (8.2%)	0.26	18 (5.6%)	25 (7.8%)	0.09
Type of CPR, n (%)						
Chest compression-only CPR	1701 (86.7%)	227 (62.2%)	0.59	230 (71.7%)	225 (70.1%)	0.03
Conventional CPR with rescue breathing	260 (13.3%)	138 (37.8%)	0.59	91 (28.3%)	96 (29.9%)	0.03
EMS response time (call to contact with a patient), min, medean (IQR)	8 (6–9)	8 (7–9)	0.06	8 (7–10)	8 (6–9)	0.05
Contact to hospital time, min, median (IQR)	22 (18–26)	20 (17–25)	0.19	22 (17–26)	21 (17–25)	0.09

ADL, activity of daily living; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; IQR, interqurtile; SMD, standard mean difference.

Table 2 – Outcomes of patients with out-of-hospital cardiac arrests by the type of bystander.

	Laypersons	Off-duty medical professionals	OR			
			Crude	(95% CI)	Adjusted	(95% CI)
All patients	N = 1961	N = 365				
Prehospital ROSC, n (%)	176 (9.0%)	53 (14.5%)	1.72	(1.24–2.40)	0.64	(0.41–0.99)
Hospital admission, n (%)	442 (22.5%)	118 (32.3%)	1.64	(1.29–2.10)	0.75	(0.55–1.02)
One-month survival, n (%)	146 (7.4%)	31 (8.5%)	1.15	(0.77–1.73)	1.06	(0.60–1.88)
CPC 1 or 2, n (%)	100 (5.1%)	23 (6.3%)	1.25	(0.78–2.00)	0.83	(0.42–1.64)
Propensity score-matched patients	N = 321	N = 321				
CPC 1 or 2, n (%)	21 (6.5%)	19 (5.9%)	0.9	(0.47–1.71)	0.88	(0.37–2.06)

ROSC, return of spontaneous circulation; CPC, cerebral performance category; OR, odds ratio; CI, confidence interval.
Adjusuted for age, sex, ADL, witness status, location, EMS response time, contact-hospital time, dispatcher instruction, initial rhythm, pad application of a public-access automated external defibrillator, and type of CPR.
ORs were calculated for off-duty medical professionals versus laypersons.

Table 3 – Subgroup analyses of neurologically favorable outcome among all eligible patients with out-of-hospital cardiac arrests by the type of bystander.

	Laypersons % (n/N)	Off-duty medical professionals % (n/N)	Crude OR (95% CI)	P value for interaction
Witness status				0.012
Not witnessed	1.4 (18/1268)	3.9 (7/180)	2.81 (1.16–6.83)	
Witnessed by bystander	11.8 (82/693)	8.6 (16/185)	0.71 (0.40–1.24)	
Location				0.117
Public	17.0 (48/283)	23.4 (11/47)	1.50 (0.71–3.15)	
Others	3.1 (52/1678)	3.8 (12/318)	1.23 (0.65–2.32)	
First documented rhythm				0.012
Non-VF/pulseless VT	1.0 (17/1727)	2.3 (7/298)	2.42 (0.99–5.89)	
VF/pulseless VT	35.5 (83/234)	23.9 (16/67)	0.57 (0.31–1.06)	
Type of CPR				0.133
Chest compression-only CPR	4.8 (81/1701)	7.0 (16/227)	1.52 (0.87–2.64)	
Conventional CPR with rescue breathing	7.3 (19/260)	5.1 (7/138)	0.68 (0.28–1.65)	

F, ventricular fibrillation; VT, ventricular tachycardia; CPR, cardiopulmonary resuscitation; OR, odds ratio; CI, confidence interval.
ORs were calculated for off-duty medical professionals versus laypersons.

between the LP and MP groups before the arrival of EMS personnel. The matched cohort results after PS matching were almost identical to the ones obtained from the all patient cohort results before PS matching, which reinforced the robustness of our results. Our findings provide important insights for prehospital resuscitation strategies in real world settings.

This study underscored the similarities in favorable neurological outcome between the MP and LP groups. CPR quality is a key factor between bystander CPR and OHCA outcome, and previous studies reported that high-quality CPR by bystanders was associated with improved hospital discharge and survival after an OHCA.[17,18] In Japan, Takei et al. demonstrated that the proportion of one-year survival with favorable neurological outcome for OHCA patients who received good quality bystander CPR was higher than for those receiving poor quality bystander CPR (4.2% versus 0.0%).[19] On the other hand, Cheng et al. in Canada, reported that even healthcare providers can overestimate CPR depth and rate.[20] Our study did not, unfortunately, obtain information on the quality of bystander CPR, and we did not have definite reasons for no difference in the OHCA outcomes between the LP and MP groups. However, since the CPR training and bystander CPR have been widely disseminating and the OHCA outcomes has subsequently improved in recent Japan,[2–4] our results might suggest that the dissemination of the CPR training also led to improving the quality of CPR performed by the general public in prehospital settings.

Importantly, our findings were different from ones in the preceding researches showing the effectiveness of CPR performed by off-duty medical professionals, but there are reasons which could partially explain these findings. In the study by Nord et al.,[9] AED pad application was not considered in their analyses. In our study, the proportion of AED pad applications was considerably higher in the MP group than the LP group. Thus, the MP group frequently used public-access AEDs for OHCA victims in prehospital settings, which might affect the OHCA outcome as an unadjusted factor in the Nord et al. study. In addition, Park et al., defined off-duty medical staff as the LP group,[8] but our study defined the MP group as doctors, dentists, nurses, and paramedics who could engage in resuscitation practices, which is an important difference.

Subgroup analyses suggested that the MP group had a better outcome after an OHCA among non-witnessed or non-VF patients in this study. Generally, the OHCA outcomes among these patients were very poor regardless of prehospital resuscitation efforts.[21,22] Thus, any prehospital intervention by medical professionals might be effective for more severe OHCA patients (e.g., non-witness or non-VF

in this study). For example, Nishi et al. in Japan, showed that the presence of multiple rescuers was an independent factor that was associated with one-year survival.[23] As recommended in the CPR guidelines,[24] a bystander should call for help after he/she finds a victim who is unresponsive. Therefore, medical professionals who are familiar with resuscitation practices could perform CPR and use an AED, which might lead to a subsequent better outcome especially for severe OHCA patients.

In this study, the proportion of bystander CPR and AED pad application was only 50% and 17%, respectively. In 2014, the Japan AED Project was launched in an effort to promote bystander CPR and public-access AED use. Using mass media and various medical associations across Japan, this project encourages laypersons to learn how to administer CPR and use an AED for OHCA patients.[25] Some reports have demonstrated that a system to notify laypersons[26] via a mobile-phone text message alert system[27] can contribute to increasing the potential number of people with the ability to provide CPR or initiate early defibrillation. These efforts could lead to an increased implementation of CPR and AED use by bystanders, resulting in an increase in the number of OHCA survivors with favorable neurological outcomes.

Limitations

This study has some inherent limitations. Firstly, this registry did not obtain information on the quality of bystander CPR. Secondly, this study did not obtain information regarding background factors including past medical histories, medications, and life-styles[28] as well as in-hospital treatments such as percutaneous coronary interventions, extracorporeal CPRs, and target temperature management[29] that would affect OHCA outcomes. Thirdly, there might be unmeasured confounding factors that could have influenced the association between the type of bystanders who performed CPR and the OHCA outcome. Finally, as with all epidemiologic studies, the integrity and validity of the data, as well as ascertainment bias, are potential limitations of this study. However, the use of uniform data collection methods based on Utstein-style guidelines for reporting cardiac arrest, a large sample size, and a population-based design should minimize these potential sources of bias.

Conclusions

In this population, there was no difference in one-month survival with favorable neurological outcome among OHCA patients receiving CPR performed by the MP group or the LP group prior to the arrival of EMS personnel. Further observational studies are also essential to verify the effects of the bystander-initiated CPR type on OHCA patients.

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Conflict of interest statement

The authors declare that they have no conflicts of interest.

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REFERENCES

1. Hazinski MF, Nolan JP, Aickin R, et al. Part 1: executive Summary: 2015 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation 2015;132(Suppl 1):S2–S39.
2. Ambulance service planning office of fire and disaster management agency of Japan. Effect of first aid for cardiopulmonary arrest. http://www.fdma.go.jp/neuter/topics/fieldList9_3.html. (Accessed 11 September 2018) (in Japanese).
3. Iwami T, Kitamura T, Kiyohara K, Kawamura T. Dissemination of chest compression-only cardiopulmonary resuscitation and survival after out-of-hospital cardiac arrest. Circulation 2015;132:415–22.
4. Kitamura T, Kiyohara K, Sakai T, et al. Public-access defibrillation and out-of-hospital cardiac arrest in Japan. N Engl J Med 2016;375:1649–59.
5. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2307–15.
6. Malta Hansen C, Kragholm K, Pearson DA, et al. Association of bystander and first-responder intervention with survival after out-of hospital cardiac arrest in North Carolina, 2010–2013. JAMA 2015;314:255–64.
7. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377–84.
8. Park YM, Shin SD, Lee YJ, Song KJ, Ro YS, Ahn KO. Cardiopulmonary resuscitation by trained responders versus lay persons and outcomes of out-of-hospital cardiac arrest: a community observational study. Resuscitation 2017;118:55–62.
9. Nord A, Svensson L, Karlsson T, Claesson A, Herlitz J, Nilsson L. Increased survival from out-of-hospital cardiac arrest when off duty medically educated personnel perform CPR compared with laymen. Resuscitation 2017;120:88–94.
10. Nishiyama C, Iwami T, Kawamura T, et al. Prodromal symptoms of out-of-hospital cardiac arrests: a report from a large-scale population-based cohort study. Resuscitation 2013;84:558–63.
11. Kobayashi D, Kitamura T, Kiyohara K, et al. High-rise buildings and neurologically favorable outcome after out-of-hospital cardiac arrest. Int J Cardiol 2016;224:178–82.
12. Jacobs I, Nadkarni V, Bahr J, et al. 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, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). Circulation 2004;110:3385–97.
13. Kitamura T, Kiyohara K, Sakai T, et al. Epidemiology and outcome of adult out-of-hospital cardiac arrest with non-cardiac origin in Osaka: a population-based study. BMJ Open 2014;4:e006462.
14. Kitamura T, Iwami T, Kawamura T, et al. Nationwide improvements in survival from out-of-hospital cardiac arrests in Japan. Circulation 2012;126:2834–43.
15. Japan Resuscitation Council. Japanese guidelines for emergency care and cardiopulmonary resuscitation. Tokyo, Japan: Igakushoin; 2015.

16. Iwami T, Nichol G, Hiraide A, et al. Continuous improvements in "chain of survival" increased survival after out-of-hospital cardiac arrests: a large-scale population-based study. Circulation 2009;119:728–34.
17. Wik L, Steen PA, Bircher NG. Quality of bystander cardiopulmonary resuscitation influences outcome after prehospital cardiac arrest. Resuscitation 1994;28:195–203.
18. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. JAMA 1995;274:1922–5.
19. Takei Y, Nishi T, Matsubara H, Hashimoto M, Inaba H. Factors associated with quality of bystander CPR: the presence of multiple rescuers and bystander-initiated CPR without instruction. Resuscitation 2014;85:492–8.
20. Cheng A, Overly F, Kessler D, et al. Perception of CPR quality: influence of CPR feedback, Just-in-Time CPR training and provider role. Resuscitation 2015;87:44–50.
21. Iwami T, Kawamura T, Hiraide A, et al. Effectiveness of bystander-initiated cardiac-only resuscitation for patients with out-of-hospital cardiac arrest. Circulation 2007;116:2900–7.
22. SOS-KANTO study group. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an observational study. Lancet 2007;369:920–6.
23. Nishi T, Maeda T, Takase K, Kamikura T, Tanaka Y, Inaba H. Does the number of rescuers affect the survival rate from out-of-hospital cardiac arrests? Two or more rescuers are not always better than one. Resuscitation 2013;84:154–61.
24. Monsieurs KG, Nolan JP, Bossaert LL, et al. European resuscitation council guidelines for resuscitation 2015: section 1. Executive summary. Resuscitation 2015;95:1–80.
25. Japan AED Project. Japan AED Project (in Japanese). Available at: (Accessed 11 September 2018) http://aed-project.jp/.
26. Ringh M, Rosenqvist M, Hollenberg J, et al. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2316–25.
27. Zijlstra JA, Stieglis R, Riedijk F, Smeekes M, van der Worp WE, Koster RW. Local lay rescuers with AEDs, alerted by text messages, contribute to early defibrillation in a Dutch out-of-hospital cardiac arrest dispatch system. Resuscitation 2014;85:1444–9.
28. Thorgeirsson G, Thorgeirsson G, Sigvaldason H, Witteman J. Risk factors for out-of-hospital cardiac arrest: the Reykjavik Study. Eur Heart J 2005;26:1499–505.
29. Neumar RW, Nolan JP, Adrie C, et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A scientific statement from the International Liaison Committee on Resuscitation; the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; the Council on Stroke. Circulation 2008;118:2452–8.