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Association of Dispatcher-Assisted Compression-Only Resuscitation with Survival Rate in Unwitnessed Out-of-Hospital Cardiac Arrest: A Temporal Trend and Analyses of 8-Years Trend

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Abstract: Background: Recent guidelines recommend that dispatchers instruct untrained bystanders to perform compression-only cardiopulmonary resuscitation. However, how bystander cardiopulmonary resuscitation (BCPR) composition and survival change in unwitnessed out-of-hospital cardiac arrest (OHCA) cases remains unclear. The aim of this study was to investigate (1) the changes in BCPR based on combined rescue breathing and dispatcher-assisted resuscitation; and (2) the association between changes in BCPR content and annual outcome improvement in unwitnessed OHCA cases compared to bystander-witnessed OHCA cases.
Method: This study involved the retrospective analysis of data for OHCA cases that were prospectively collected nationwide and population-based. OHCA cases from 2009 to 2016 were evaluated to provide a complete dataset for the analysis. The primary outcome was neurologically favorable 1-month survival.
Results: The rate of dispatcher-assisted compression-only resuscitation increased annually. Further, there was a shift from standard resuscitation to compression-only bystander resuscitation and an increased rate of dispatcher attempts of instructions in both unwitnessed and bystander-witnessed arrest cases. In a multivariable logistic regression model for cases with dispatcher attempts, the neurologically favorable 1-month survival rate of patients who experienced unwitnessed arrest in the dispatcher-assisted standard BCPR group was higher than that in the dispatcher-assisted compression-only BCPR group (adjusted odds ratio 1.23 [95% confidence interval: 95%CI 1.03–1.46]). Further, the outcome improvement for 8 years in the standard BCPR group was more prominent than that in the compression-only BCPR group ($p < 0.01$, interaction test). The neurologically favorable 1-month survival rate of patients with unwitnessed arrest in the voluntarily-initiated standard BCPR group without the dispatcher's attempt of instructions was higher than that in the voluntarily-initiated compression-only BCPR group (adjusted odds ratio 1.21 [95%CI 1.01–1.52]). However, the outcomes improved similarly in both groups. The differences between standard and compression-only resuscitation were less prominent in patients with bystander-witnessed OHCA, particularly in cases without dispatcher instructions.
Conclusions: Compression-only resuscitation may not be the ideal management strategy for unwitnessed OHCA when dispatchers attempt resuscitation instructions.

Key Words: bystander resuscitation, dispatcher-assisted resuscitation, compression-only resuscitation, out-of-hospital cardiac arrest, basic life support

Introduction

Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) is effective in increasing the rate of bystander cardiopulmonary resuscitation (BCPR) (1, 2). Based on previous American Heart Association guidelines (3), upon detecting cardiac arrest, dispatchers provide instructions about standard cardiopulmonary resuscitation (CPR), defined as the combination of chest compressions and rescue breathing. However, these guidelines were modified in 2000. Dispatchers were recommended to instruct rescuers who were unwilling to perform rescue breathing or had no previous CPR training to give

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compression-only CPR (4). In 2010, the level of dispatcher-assisted compression-only CPR changed from class II (weak) to class I (strong) (5, 6).

In Japan, the Japanese Resuscitation Council Guidelines released at the end of 2011 recommended that bystanders without previous basic life support (BLS) training or experience should perform compression-only CPR, and dispatchers should be educated on the accurate detection of cardiac arrest (7). In response to these recommendations, in 2014, the Fire and Disaster Management Agency (FDMA) of Japan released a standard guideline for DA-CPR and an educational program for the proper recognition of agonal breathing and cardiac arrest (8). The 2015 Japanese Resuscitation Council Guidelines reemphasized the role of dispatchers in detecting cardiac arrest during communication with callers (9). Therefore, the shift from standard CPR to compression-only CPR has been accompanied by a quality improvement program for DA-CPR.

Through a trend analysis, previous studies conducted in the United States (10), Japan (11), and Sweden (12) showed that the rates of BCPR and survival in bystander-witnessed out-of-hospital cardiac arrest (OHCA) continually increased after implementing the guidelines for dispatcher-assisted compression-only CPR. However, how BCPR composition and survival change in unwitnessed OHCA cases remains unclear. The aim of this study was to investigate the changes in the composition of BCPR based on combined rescue breathing and DA-CPR. Moreover, we assessed the association between changes in BCPR content and annual outcome improvement in unwitnessed OHCA cases in Japan.

Methods

Study design and ethics

After obtaining consent from the Japanese FDMA, we retrospectively analyzed their OHCA data, which were prospectively collected between 2009 and 2016 using a nationwide, population-based, Japanese registry system. Because the database was anonymized and secondary, requirement for informed consent was waived according to Japanese guidelines (13). This study exclusively used previously de-linked and anonymized existing material and, therefore, did not require ethical review.

Population and setting

In 2015, Japan had a population of 127 million, of which 26.6% individuals were over 65 years old (14). FDMA data showed that 6184 ambulances operated in 750 fire departments (15). FDMA released a document for standard DA-CPR instructions in 2014 (8). These guidelines recommend that dispatchers instruct laypeople to perform compression-only CPR. However, the content of the instructions was based on the discretion of the dispatchers. Currently, instructions regarding compression-only CPR and standard CPR are selected at the discretion of the dispatchers. Unless a patient with OHCA is dead (in instances of decapitation) or displays post-mortem changes, all emergency medical service (EMS) personnel must provide continuous resuscitation at the scene. There were no existing guidelines regarding the termination of resuscitation in the prehospital setting during the study period. Patients with an extremely low chance of survival were resuscitation-attempted and transported to hospitals by EMS. Paramedics may use several resuscitation methods, including semi-automated external defibrillation, suprapharyngeal airway device insertion, and Ringer's lactate solution infusion via the peripheral vein. However, only authorized and specially trained paramedics can insert tracheal tubes and administer epinephrine intravenously. Paramedics in Japan are not allowed to administer drugs other than epinephrine. Since 2014, they have been able to perform fluid resuscitation for patients with shock and suspected crush syndrome.

Data selection

The FDMA database includes Utstein-style information (16), such as the presence or absence of arrest witnesses, composition of BCPR, contents of dispatcher instructions, recorded time of CPR initiation, emergency call, EMS vehicle arrival, time when EMS was contacted, CPR initiation by the EMS, and 1-month (1-M) survival. Physicians and EMS technicians have clinically identified the etiology of OHCA. The fire departments obtained information on 1-M survival from hospitals with cerebral performance categories (17).

Of 986,760 OHCA cases recorded between 2009 and 2016, 33,887 were excluded owing to incomplete records or illogical data on fundamental patient characteristics and time points, 3141 were excluded owing to the return of spontaneous circulation (ROSC) before EMS contact, 7586 were excluded owing to uncertain or unknown witness status, and 288 were excluded owing to age (< 8 years, for whom advanced life support was not indicated). Finally, 941,858 patients with indications for advanced life support were included. After excluding 81,108 patients with a low (overall rate < 0.6%) chance of neurologically favorable 1-month survival (30,805 patients with malignancies, 9,904 patients with traffic accidents, and 40,860 patients with an age ≥ 95 years), we classified the remaining cases into three groups based on witness status as follows: n = 516,321, unwitnessed; n = 279,072, bystander-witnessed; and n = 65,357, EMS-witnessed cases (Figure 1).

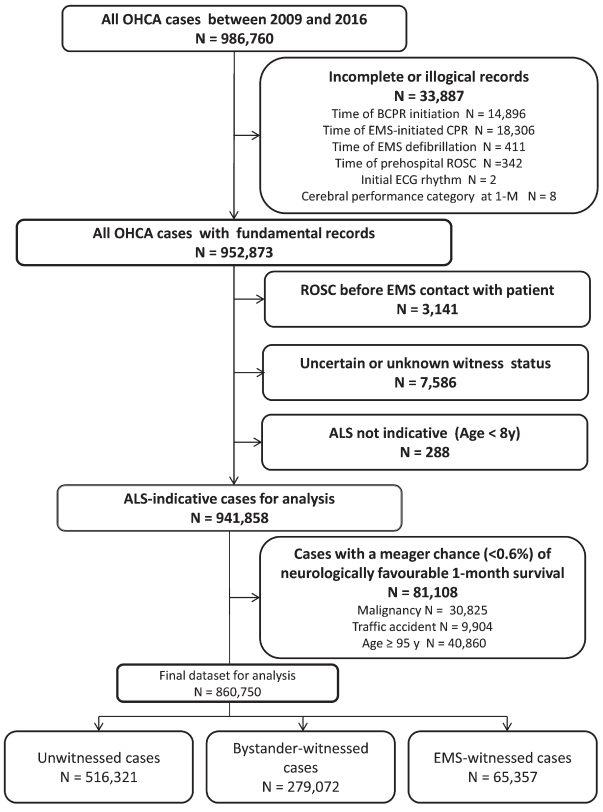

Figure 1. Data selection process.
OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation; EMS, emergency medical service; ALS, advanced life support.

Outcome measures

The primary outcome was neurologically favorable 1-month (1-M) survival, defined as a cerebral performance category scale score of 1 or 2 (17). The secondary outcomes were pre-hospital ROSC and 1-M survival. The secondary outcomes are presented in Tables 1 and 2. Major prehospital confounders in multivariate analysis were defined when the following criteria were satisfied (Table 1, 2): P for trend < 0.001 and > 15% changes in nominal variables or median value changes in continuous variables.

Classification of BCPR

This study focused on dispatcher-assisted compression-only CPR after attempted DA-CPR. Therefore, all cases except EMS-witnessed cases were divided into two major groups with and without the DA-CPR attempt, and each major group was classified into three groups according to the BCPR content as follows:

Major group of cases with DA-CPR attempt

1. no bystander resuscitation (No-BCPR) despite DA-CPR attempt
2. dispatcher-assisted compression-only resuscitation (DA-COCPR)
3. dispatcher-assisted standard resuscitation (DA-SCPR)

Major group of cases without DA-CPR attempt or other dispatcher assistance

4. No BCPR without DA-CPR attempt
5. voluntarily-initiated compression-only resuscitation (VI-COCPR)
6. voluntarily-initiated standard resuscitation (VI-SCPR).

Statistical analysis

The trend in outcomes was assessed using the Cochrane-Armitage trend, univariate logistic regression analysis, and least square method. Outcomes that were unadjusted odds ratio (OR) obtained by univariate logistic regression analysis were expressed as values per year and/or for the whole study period. Multivariate logistic regression analysis including an interaction test between year (as a continuous variable) and BCPR groups included the following factors which are well known to be associated with survival:

- Sex and Age
- Etiology of OHCA—cardiac or non-cardiac
- Initial electrocardiogram rhythm—shockable or non-shockable
- Night-time (22:00–5:59) emergency call
- Time interval between emergency call and EMS contact with patients (response time interval) Multivariate logistic regression analysis included comparisons of outcomes and trends among the BCPR groups. Regression models were created for each major group with and without DA-CPR attempts. All data were analyzed using JMP Pro version 16 (SAS Institute, Cary, NC, USA). In each analysis, the null hypothesis was evaluated at a two-sided significance level of $p < 0.05$, and 95% confidence intervals (CIs) were calculated using profile likelihood.

Results

Changes in the characteristics of OHCA cases within the whole study period

As shown in Table 1 and 2, the proportion of cases with presumed cardiac etiology slightly increased during the whole study period (unadjusted OR) for the whole study period in unwitnessed OHCA cases 1.34 [95%CI 1.31–1.36], in bystander-witnessed OHCA cases 1.39 [95%CI 1.16–1.63]), and the ratios of prehospital epinephrine administration (unadjusted OR for the whole study period in unwitnessed OHCA cases 2.11 [95%CI 2.05–2.17], in bystander-witnessed OHCA cases 2.26 [95%CI 2.20–2.32]) and DA-CPR (unadjusted OR for the whole study period in unwitnessed OHCA cases 2.27 [95%CI 2.27–2.31], in bystander-witnessed OHCA cases 2.21

Table 1. Trends in major prehospital confounders and secondary outcomes of unwitnessed OHCA cases

	Year								Unadjusted OR for the whole study period [a]	P [b]
	2009	2010	2011	2012	2013	2014	2015	2016		
N	61,318	64,856	67,007	66,380	63,491	65,980	63,820	63,459		
Age, median (IQR)	76(63–84)	77(64–84)	78(65–85)	78(66–85)	78(66–85)	78(66–85)	79(67–86)	79(67–86)	Undetermined	<0.001
Male patient, % (N)	56.7% (37,250)	56.1% (39,063)	55.0% (39,613)	55.4% (39,725)	55.4% (38,302)	55.3% (39,539)	55.4% (38,523)	55.5% (38,219)	0.97 (0.95–0.98)	<0.001
Night-time (22:00–5:59) OHCA	20.8% (13,686)	21.1% (14,671)	20.9% (15,067)	21.2% (15,230)	21.4% (14,784)	21.6% (15,444)	21.5% (14,928)	21.9% (15,058)	1.05 (1.03–1.07)	<0.001
Dispatcher-assisted CPR, attempted, % (N)	51.7% (61,313)	52.5% (34,016)	56.3% (37,701)	57.7% (38,300)	66.2% (38,506)	66.0% (40,569)	67.4% (40,111)	68.6% (40,759)	2.27 (2.27–2.31)	<0.001
Presumed cardiac, % (N)	57.2% (37,573)	56.1% (39,046)	57.3% (41,311)	58.4% (41,885)	61.5% (42,513)	61.4% (43,940)	60.7% (42,182)	62.1% (42,800)	1.34 (1.31–1.36)	<0.001
Exogenous causes, % (N)	19.1% (12,510)	19.7% (13,682)	18.9% (13,627)	17.6% (12,659)	15.9% (11,002)	15.6% (11,151)	15.0% (10,425)	14.2% (9,811)	0.61 (0.60–0.62)	<0.001
Shockable initial rhythm, % (N)	3.5% (2,317)	3.4% (2,338)	3.0% (2,185)	3.2% (2,219)	5.6% (3,843)	3.1% (2,102)	3.0% (2,048)	2.9% (2,023)	0.92 (0.88–0.96)	<0.001
Prehospital epinephrine, % (N)	7.0% (4,609)	8.0% (5,572)	9.4% (6,764)	10.5% (7,514)	11.5% (7,953)	12.3% (8,783)	13.0% (9,048)	14.1% (9,691)	2.11 (2.05–2.17)	<0.001
Advanced airway management, % (N)	57.7% (37,916)	59.0% (41,093)	59.2% (42,642)	59.1% (42,406)	60.3% (41,684)	61.2% (43,808)	61.7% (42,909)	60.9% (41,987)	1.15 (1.13–1.17)	<0.001
Prehospital involvement of physician, % (N)	15.1% (9,911)	14.1% (9,782)	4.0% (2,861)	7.2% (5,153)	8.4% (5,828)	9.4% (6,737)	8.8% (6,142)	8.2% (5,618)	0.58 (0.56–0.59)	<0.001
Time factors, median (IQR), min										
Call-to-first CPR	8 (7–11)	9 (7–11)	9 (7–11)	9 (7–11)	9 (7–11)	5 (1–9)	5 (1–9)	5 (1–9)	Undetermined	<0.001
Call-to-EMS contact to patient	8 (6–10)	8 (6–10)	8 (7–10)	8 (7–10)	8 (7–11)	8 (7–11)	9 (7–11)	9 (7–11)	Undetermined	<0.001
EMS contact to patient-to-EMS arrival at hospital	21 (16–28)	22 (17–28)	22 (17–28)	22 (17–29)	22 (17–29)	22 (17–29)	22 (17–29)	22 (17–30)	Undetermined	<0.001
Outcomes										
Prehospital ROSC, % (N)	2.9% (1,906)	3.0% (2,113)	3.3% (2,381)	3.5% (2,480)	3.7% (2,531)	3.8% (2,743)	3.9% (2,683)	3.9% (2,687)	1.37 (1.31–1.43)	<0.001
1-M survival	2.0% (1,308)	2.1% (1,439)	1.8% (1,308)	1.9% (1,382)	1.8% (1,283)	1.8% (1,315)	1.8% (1,315)	1.9% (1,301)	0.93 (0.87–0.98)	0.012

a) Determined by a simple logit test.
b) Determined by Cochran-Armitage trend test for nominal variables and by least square method for continuous variables.

[95%CI 2.16–2.26]) also increased. Meanwhile, the proportion of cases with shockable initial rhythm slightly decreased (unadjusted OR for the whole study period in unwitnessed OHCA cases 0.92 [95%CI 0.88–0.96], in bystander-witnessed OHCA cases 0.95 [95%CI 0.92–0.98]) and the proportions of exogenous causes (unadjusted OR for the whole study period in unwitnessed OHCA cases 0.61 [95%CI 0.60–0.62], in bystander-witnessed OHCA cases 0.16 [95%CI 0.15–0.16]) and prehospital physician involvement in both unwitnessed (unadjusted OR for the whole study period 0.58 [95%CI 0.56–0.59]) and bystander-witnessed (unadjusted OR for the whole study period 0.66 [95%CI 0.64–0.68]) OHCA remarkably reduced. The call-to-first CPR (performed by bystanders or the EMS team, whichever started earlier) was shortened after 2014, reflecting an increased BCPR rate. Moreover, the rate of prehospital ROSC increased in both unwitnessed (unadjusted OR for the whole study period 1.37 [95%CI 1.31–1.43]) and bystander-witnessed cases (unadjusted OR for the whole study period 1.47 [95%CI 1.43–1.52]).

Trends of neurologically favorable 1-M survival

The neurologically favorable 1-M survival rates of

Table 2. Trends in major prehospital confounders and secondary outcomes of bystander-witnessed OHCA cases

	Year								Unadjusted OR for the whole study period [a]	P [b]
	2009	2010	2011	2012	2013	2014	2015	2016		
N	33,381	35,582	36,199	36,293	33.883	34,795	34,042	34,897		
Age, median (IQR)	77(64–84)	77(65–85)	77(65–85)	78(66–85)	78(67–86)	78(67–86)	79(67–86)	79(68–86)	Undetermined	<0.001
Male patient, % (N)	60.4% (21,914)	60.0% (23,375)	59.8% (23,760)	59.1% (23,670)	59.2% (22,727)	59.8% (23,435)	59.4% (22,944)	59.2% (23,363)	0.96 (0.94–0.99)	0.001
Night-time (22:00–5:59) OHCA	19.3% (6,986)	19.0% (7,384)	19.1% (7,575)	18.5% (7,411)	18.8% (7,208)	18.7% (7,326)	18.7% (7,224)	18.6% (7,329)	0.95 (0.92–0.98)	<0.001
Dispatcher-assisted CPR, attempted, % (N)	42.3% (14,129)	42.7% (15,191)	44.9% (16,257)	46.7% (16,953)	56.1% (17,060)	55.6% (17.733)	58.1% (18,111)	59.0% (18,980)	2.21(2.16–2.26)	<0.001
Presumed cardiac, % (N)	56.0% (20,323)	54.9% (21,379)	55.5% (22,085)	55.9% (22,411)	60.1% (23,100)	60.0% (23,530)	58.6% (22,656)	59.6% (23,515)	1.39 (1.16-1.63)	<0.001
Exogenous causes	18.2% (6,618)	18.3% (7,135)	17.4% (6,905)	16.1% (6,471)	9.1% (3,479)	7.8% (3,113)	7.8% (3,017)	7.8% (3,090)	0.16 (0.15–0.16)	<0.001
Shockable initial rhythm, % (N)	14.4% (5,240)	13.9% (5,419)	12.9% (5,145)	12.9% (5,153)	14.0% (5,382)	13.0% (5,080)	12.8% (4,937)	13.1% (5,154)	0.95 (0.92–0.98)	0.003
Prehospital epinephrine, % (N)	15.2% (5,520)	17.8% (6,949)	21.0% (8,366)	22.6% (9,062)	24.6% (9,454)	26.1% (10,214)	27.6% (10,655)	29.4% (11,601)	2.26 (2.20–2.32)	<0.001
Advanced airway management, % (N)	53.7% (19,500)	55.9% (21,765)	56.0% (22,257)	56.6% (22,689)	57.1% (21,944)	57.9% (22,694)	58.3% (22,532)	57.2% (22,587)	1.12 (1.09–1.14)	<0.001
Prehospital in volvement of physician, % (N)	17.4% (6,296)	16.5% (6,424)	6.9% (2,751)	10.2% (4,095)	11.2% (4,296)	12.1% (4,757)	11.6% (4,483)	10.9% (4,285)	0.66 (0.64–0.68)	<0.001
Time factors, median (IQR), min										
Call-to-first CPR	8 (7–11)	9 (7–11)	9 (7–11)	9 (7–11)	9 (7–11)	5 (1–9)	5 (1–9)	5 (1–9)	Undetermined	<0.001
Call-to-EMS contact to patient	8 (6–10)	8 (6–10)	8 (7–10)	8 (7–11)	8 (7–11)	9 (7–11)	9 (7–11)	9 (7–11)	Undetermined	<0.001
EMS contact to patient-to-EMS arrival at hospital	22 (17–29)	23 (17–30)	23 (18–30)	23 (18–30)	23 (18–31)	23 (18–31)	23 (18–30)	24 (18–31)	Undetermined	<0.001
Outcomes										
Prehospital ROSC, % (N)	12.0% (4,366)	12.5% (4,874)	13.3% (5,302)	13.8% (5,537)	15.2% (5,835)	15.5% (6,059)	16.0% (6,181)	15.8% (6,237)	1.47(1.43–1.52)	<0.001
1-M survival	8.3% (3,015)	8.6% (3,329)	8.1% (3,238)	8.4% (3,365)	8.9% (3,423)	8.7% (3,427)	9.1% (3,503)	9.5% (3,758)	1.21 (1.16–1.26)	<0.001

a) Determined by a simple logit test.
b) Determined by Cochran-Armitage trend test for nominal variables and by least square method for continuous variables.

bystander- and EMS-witnessed OHCA increased annually (trend test, $p < 0.01$) (Figure 2). Meanwhile, the neurologically favorable 1-M survival rates of unwitnessed OHCA did not significantly increase based on univariate logistic regression analysis ($p = 0.19$). However, the multivariate logistic regression analyses revealed that the neurologically favorable 1-M survival rates significantly increased in all groups: the adjusted unit OR per year, 1.06 (95%CI 1.04–1.09) in unwitnessed cases, 1.07 (95%CI 1.05–1.10) in bystander-witnessed cases, and 1.05 (95%CI 1.03–1.08) in EMS-witnessed cases.

Trends of BCPR

The changes in unwitnessed and bystander-witnessed cases in the six BCPR groups were similar (Figure 3). After classifying BCPR cases into DA-COCPR and other BCPR groups, the proportion of DA-COCPR cases increased annually both unwitnessed and bystander-witnessed cases (unadjusted OR per year in unwitnessed OHCA cases 1.09, in bystander-witnessed OHCA cases 1.10). Meanwhile, the proportion of No-BCPR and other BCPR decreased in both unwitnessed and witnessed OHCA cases. After classifying BCPR cases into dispatcher-assisted and voluntarily initiated BCPR groups,

there was an evident change from standard BCPR to compression-only BCPR in both groups.

Trends of neurologically favorable survival in the BCPR groups

Actual trends in the neurologically favorable 1-M survival in the six BCPR groups are shown in the four panels of Figure 4 according to witness status and DA-CPR attempts. Interaction tests in the multivariable logistic regression models revealed an evident variation in the improvement of unwitnessed cases with DA-CPR attempts among the BCPR groups (upper part of Table 3, interaction test, $p < 0.01$). The neurologically favorable 1-M survival rate did not improve in the no BCPR group, despite the DA-CPR attempt. The outcome was more significantly improved in the DA-SCPR group (adjusted OR per year 1.16 [95%CI 1.09–1.24]) than in the DA-COCPR group (adjusted OR per year 1.04 [95%CI 1.01–1.07]). Furthermore, the neurologically favorable 1-M survival rate in the DA-SCPR group was higher than that in the DA-COCPR group (adjusted OR 1.23 [95%CI 1.03–1.46]). Similar findings were obtained in bystander-witnessed cases with DA-CPR attempts. However, the variation in improvement among the BCPR groups was not significant (lower part of Table 3, interaction test, $p = 0.16$). The augmentation of neurologically favorable 1-M survival rate by the provision of BCPR (in the DA-COCPR and DA-SCPR groups) was more prominent in bystander-witnessed cases (adjusted OR 1.63 [95%CI 1.52–1.75] for DA-COCPR, 2.11 [95%CI 1.92–2.33] for DA-SCPR) than in unwitnessed cases (adjusted OR 1.25 [95%CI 1.11–1.41] for DA-COCPR, 1.53 [95%CI 1.27–1.85] for DA-SCPR.

In cases without DA-CPR attempts (Table 4), the variations among the BCPR groups in neurologically favorable 1-M survival rate and outcome improvement differed considerably between unwitnessed and bystander-witnessed OHCA. The outcome of no BCPR without DA-CPR attempt group was improved in patients with bystander-witnessed OHCA, but not in patients with

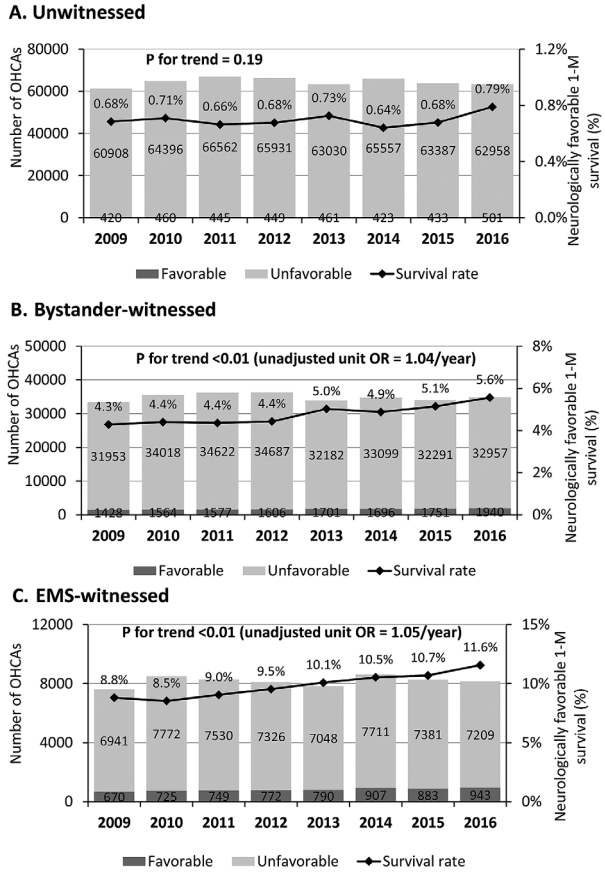

Figure 2. Trends in the number of OHCA and in OHCA prognosis in unwitnessed, bystander-witnessed, and EMS-witnessed.
OHCA, out-of-hospital cardiac arrest; EMS, emergency medical service

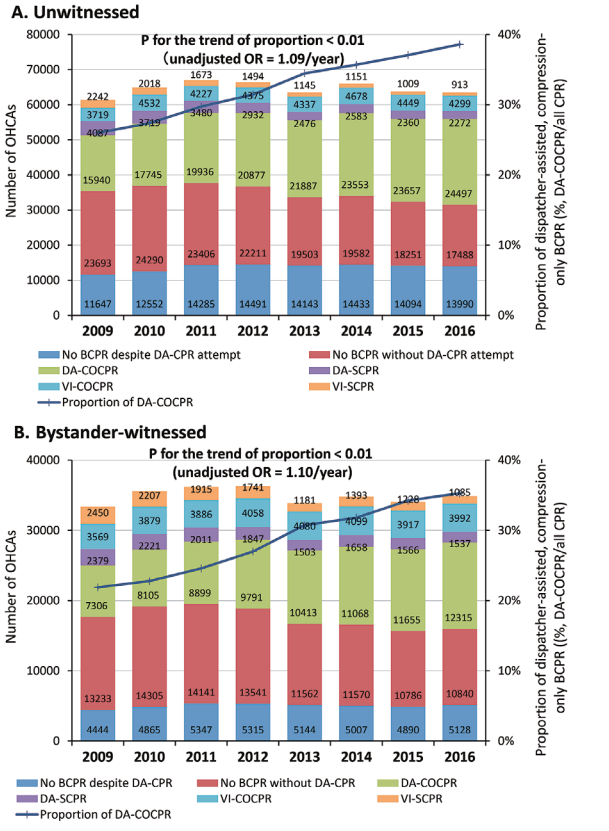

Figure 3. Trends in BCPR classification in unwitnessed and bystander-witnessed OHCA cases.
OHCA, out-of-hospital cardiac arrest; BCPR, bystander cardiopulmonary resuscitation
The proportion of dispatcher-assisted compression-only CPR (DA-COCPR) was also shown.

Figure 4. Actual trends in the neurologically favorable 1-M survival rate of BCPR groups.
BCPR, bystander cardiopulmonary resuscitation

Table 3. Comparisons of neurologically favorable 1-M survival among the BCPR groups in cases with DA-CPR attempt

BCPR categories	N	Outcome comparisons for the whole study period			Analysis for trend		
		Neurologically favorable 1-M survival, % (N)	Adjusted OR (95% CI) for the outcome		Adjusted OR (95% CI)		Difference in trend among the groups (Interaction test)
			No BCPR as reference	Dispatcher-assisted, compression-only BCPR as reference	Adjusted OR per year	Adjusted OR for the whole study period	
Unwitnessed OHCA	301,636	0.49% (1,466)			1.08 (1.05–1.09)	1.69 (1.38–2.07)	
No BCPR despite DA-CPR attempt	109,635	0.36% (392)	Reference	-	1.03 (0.99–1.08)	1.25 (0.91–1.72)	
Dispatcher-assisted, compression-only BCPR	168,092	0.54% (904)	1.25 (1.11–1.41)	Reference	1.04 (1.01–1.07)	1.32 (1.07–1.65)	
Dispatcher-assisted, Standard BCPR	23,909	0.71% (170)	1.53 (1.27–1.85)	1.23 (1.03–1.46)	1.16 (1.09–1.24)	2.85 (1.78–4.57)	P<0.01
Bystander-witnessed OHCA	134,414	3.0% (6,418)			1.08 (1.07–1.10)	1.74 (1.57–1.93)	
No BCPR despite DA-CPR attempt	40,104	3.0% (1,207)	Reference	-	1.07 (1.04–1.10)	1.57 (1.30–1.89)	
Dispatcher-assisted, compression-only BCPR	79,552	5.4% (4,277)	1.63 (1.52–1.75)	Reference	1.08 (1.06–1.09)	1.7 (1.52–1.89)	
Dispatcher-assisted, Standard BCPR	14,722	6.3% (934)	2.11 (1.92–2.33)	1.29 (1.19–2.33)	1.1 (1.07–1.14)	2.01 (1.60–2.51)	P=0.16

unwitnessed OHCA. However, outcomes were similarly enhanced in the VI-COCPR and VI-SCPR groups. The neurologically favorable 1-M survival rate in the VI-SCPR group was higher than that in the VI-COCPR group only in patients with unwitnessed OHCA.

Discussion

The aim of this study was to investigate changes in the composition of BCPR based on a combination of rescue breathing and DA-CPR. Consistent with previous reports (18), the continuous shift to compression-only BCPR was accompanied by an increase in the BCPR rate during the study period, and the increase in the proportion of DA-CPR attempts was particularly remarkable. This is because Japanese society is increasingly accepting guidelines endorsing a shift to compression-only BCPR. They also emphasized the role of dispatchers in detecting OHCA and instructing callers and bystanders in performing CPR. A continuous quality improvement program for DA-CPR was activated and disseminated throughout Japan (19), similarly in other countries (20-23). Furthermore, post-resuscitation care in hospitals has also improved. A regional system that organizes and optimizes transportation to hospitals providing advanced care, including extracorporeal circulation and hypothermia, has been established (24, 25). Therefore, the improvement in OHCA outcomes cannot be solely attributed to the continuous shift to compression-only BCPR.

We performed primary analyses after dividing patients into two major groups: those with and those without a DA-CPR attempt. The significant influence of DA-CPR attempts confirmed the validity of this analytic method for outcomes; the neurologically favorable 1-M survival rate in patients with DA-CPR attempts was consistently lower than that in patients without DA-CPR attempts, regardless of the year, BCPR group, and witness status. The lower neurologically favorable 1-M survival rate of patients with DA-CPR attempts should not indicate a detrimental effect of DA-CPR on outcomes. DA-CPR is initiated after confirming or detecting cardiac arrest via communication between the callers and dispatchers. It is well known that apparent signs of cardiac arrest, including apnea, completely pale skin, and a deathlike face, appear a few minutes after the cease of circulation. The lower neurologically favorable 1-M survival rate observed in patients with DA-CPR attempts is likely to reflect the prolonged time after patient collapse and not-sudden OHCA with gradual progression into cardiac arrest. Indeed, even when BCPR was not performed, the neurologically favorable 1-M survival rate was lower in the DA-CPR attempt group

Table 4. Comparisons of neurologically favorable 1-M survival and its trend among the BCPR groups in cases without DA-CPR attempt

BCPR categories	N	Outcome comparisons for the whole study period			Analysis for trend		
		Neurologically favorable 1-M survival, % (N)	Adjusted OR (95% CI) for the outcome		Adjusted OR (95% CI)		Difference in trend among the groups (Interaction test)
			No BCPR as reference	Voluntary-initiated, compression-only BCPR as reference	Adjusted OR per year	Adjusted OR for the whole study period	
Unwitnessed OHCA	214,685	0.70% (2,126)			1.04 (1.01–1.08)	1.34 (1.09–1.66)	
No BCPR without DA-CPR attempt	168,424	0.96% (1,619)	Reference	-	1.02 (0.99–1.04)	1.14 (0.98–1.34)	
Voluntary-initiated, compression-only BCPR	34,616	1.04% (361)	1.04 (0.92–1.17)	Reference	1.06 (1.01–1.12)	1.54 (1.09–2.18)	
Voluntary-initiated, Standard BCPR	11,645	1.25% (146)	1.29 (1.08–1.54)	1.21 (1.01–1.52)	1.07 (1.00–1.15)	1.6 (1.01–2.73)	P=0.40
Bystander-witnessed OHCA	144,658	6.3% (6,845)			1.05 (1.03–1.06)	1.44 (1.38–1.52)	
No BCPR without DA-CPR attempt	99,978	3.9% (3,937)	Reference	-	1.06 (1.04–1.07)	1.48 (1.34–1.64)	
Voluntary-initiated, compression-only BCPR	31,480	6.6% (2,071)	1.63 (1.53–1.73)	Reference	1.04 (1.01–1.06)	1.22 (1.08–1.40)	
Voluntary-initiated, standard BCPR	13,200	6.3% (837)	1.66 (1.53–1.81)	1.02 (0.93–1.12)	1.05 (1.01–1.09)	1.35 (1.09–1.67)	P=0.28

than in the no-DA-CPR attempt group.

One of the essential findings of this study was that the association between DA-COCPR and outcomes differed between the unwitnessed and bystander-witnessed cases (Figure 4, Table 3). DA-COCPR was significantly associated with an annual increase in the neurologically favorable 1-M survival rate in bystander-witnessed cases compared with unwitnessed cases. Augmentation of neurologically favorable 1-M survival by DA-CPR was more prominent in bystander-witnessed cases. Therefore, outcome improvement by DA-COCPR was fully evident in bystander-witnessed cases.

Another important finding is that the difference in the neurologically favorable 1-M survival rate between compression-only and standard BCPR varied depending on witness status and DA-CPR attempt (Figure 4). When DA-CPR was attempted, the neurologically favorable 1-M survival rate of patients receiving standard BCPR (DA-SCPR group) was higher than that of patients receiving compression-only BCPR (DA-COCPR group) in both unwitnessed and bystander-witnessed cases. However, when DA-CPR was not attempted and BCPR was voluntarily initiated, the neurologically favorable 1-M survival rate of patients receiving standard BCPR (VI-SCPR group) was higher than that of patients receiving compression-only BCPR (VI-COCPR group) only in unwitnessed cases.

These differences can be attributed to two factors. First, during the first few minutes of OHCA, rescue breaths are less important than chest compressions because the blood oxygen levels remain higher than the critical level. Thus, when CPR is voluntarily initiated, compression-only CPR (VI-COCPR) may be more effective than standard CPR (VI-SCPR) for witnessed OHCA, particularly in a community with a short EMS response time (26). Second, a higher proportion of untrained bystanders performed compression-only BCPR following the dispatcher's instructions (DA-COCPR), resulting in chest compressions with overall low quality in the COCPR group. Hence, high-quality CPR may be essential for the neurologically favorable 1-M survival of patients with unwitnessed OHCA, in which oxygen is completely depleted in the whole body.

Outcome improvement was particularly observed in EMS-witnessed OHCA cases, which could be associated with prehospital confounders after EMS contact with patients and in-hospital confounders. In this context, most paramedics were re-trained for high-quality CPR, as they were qualified to establish intravenous access for patients with shock and hypoglycemia. The application of therapeutic hypothermia and extracorporeal circulation for in-hospital advanced management of OHCA has become common in core emergency hospitals (24, 25). Similarly, these advanced management strategies for patients with OHCA may explain the improved outcomes of bystander-witnessed OHCA in patients who did not receive BCPR.

Moreover, DA-COCPR may not the most effective management strategy for unwitnessed OHCA cases. Presumably, BCPR performed by well-trained bystanders would be ideal. This observational study conducted in Japan and other countries did not assess the quality of BCPR as a prehospital confounder. Where possible, the clinical advantage of standard BCPR over compression-only BCPR may be worth evaluating in a large randomized controlled trial including unwitnessed cases in communities with a first responder system that can recruit well-trained volunteers to arrive at the scene.

The best strategy for improving the outcome of unwitnessed OHCA needs to be determined. Compression-only BCPR is attractive to untrained laypersons. Short educational training sessions for compression-only CPR effectively spread knowledge on resuscitation procedures, including automated external defibrillator use. However, education regarding standard CPR should be imparted in the second stage of BLS training. Although the time delay until the start of chest compressions can be disadvantageous in bystander-witnessed OHCA, it may have a minimal influence on the outcome of unwitnessed OHCA. An alternative strategy would be for dispatchers to attempt to instruct callers or bystanders to perform standard CPR in cases of initial arrest and, if unsuccessful, perform chest compression-only CPR. However, the improvement in outcomes in unwitnessed OHCA may exert a minor influence on the outcomes of all patients with OHCA because the outcome of unwitnessed OHCA is much lower than that of witnessed OHCA.

Limitations

Factors such as bystander age, bystander–patient relationship, bystander training or experience, and location of the OHCA were not analyzed due to missing data in cases of unwitnessed arrest. In particular, the lack of data on BCPR quality was a significant limitation of this study. In addition, the risk of misclassification for DA-CPR and its combination with rescue breaths may have occurred. Finally, similarly to other observational studies, data validity was not evaluated.

Conclusions

This study found that compared to standard BCPR, dispatcher-assisted compression-only BCPR showed a weak association with an annual increase in neurologically favorable 1-M survival rates in cases of unwitnessed OHCA. Furthermore, the neurologically favorable outcome of the compression-only BCPR group was lower than that of the standard BCPR group, regardless of DA-CPR attempt. Hence, dispatcher-assisted compression-only BCPR may not be an ideal

management strategy for unwitnessed OHCA. Education regarding standard CPR should be imparted in the second stage of BLS training.

Data availability statement

Some restrictions will apply for data availability. Data cannot be shared publicly because of restriction from Japanese FDMA (Fire and Disaster Management Agency). Data are available from the FDMA for Japanese researchers who meet the criteria.

Author contributions

TU had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: TU, HM and HI.
Acquisition of data: all authors.
Analysis and interpretation of data: all authors.
Drafting of the manuscript: TU, HM and HI.
Critical revision of the manuscript for important intellectual content: TU, HM, HI, and YW.
Statistical analysis: TU, HM and HI.
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Study supervision: HI and YW.

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Conflict of Interest

The authors declare no conflicts of interest associated with this manuscript.

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