Association of Dispatcher-assisted, Chest Compression-only Resuscitation With Annual Increases in Survival From Unwitnessed Out-of-hospital Cardiac Arrests

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Abstract

Background: Many out-of-hospital cardiac arrest cases are unwitnessed. For both unwitnessed and witnessed cases, recent guidelines endorse the dispatcher's instruction of compression-only cardiopulmonary resuscitation to lay rescuers without previous resuscitation training. This study aimed to investigate the changes in the composition of bystander resuscitation based on the combination of rescue breathing and dispatcher-assisted resuscitation, and the association of the changes in bystander resuscitation content with annual outcome improvement in unwitnessed out-of-hospital cardiac arrest cases.

Method: Retrospective analysis of prospective national cohort study in a population-based setting. Out-of-hospital cardiac arrest cases in 2009–2016 (986,760 cases) were reviewed to provide a complete dataset for analyses (941,858 cases). Main outcome was neurologically favorable survival at 1 month.

Results: Of the 941,858 cases, the rates of neurologically favorable survival adjusted for prehospital confounders continuously increased annually. When classified into 5 groups according to the contents of resuscitation, the proportions of the dispatcher-assisted compression-only resuscitation group increased annually, whereas the proportions of the other groups decreased. That is, the shift from standard (defined as the combination of chest compressions and rescue breathings) to compression-only bystander resuscitation were observed for both unwitnessed and bystander-witnessed cases. In unwitnessed cases, the survival rate of the dispatcher-assisted compression-only resuscitation group was always lower than that of the no-resuscitation group during the study period. On the other hand, the survival rate of dispatcher-assisted standard resuscitation group exceeded that of the no-resuscitation group at the end of the study period (adjusted odds ratio; 95% confidence intervals (CI), 1.41; 1.02–1.93), and the increase in survival rate was prominent compared to that of the dispatcher-assisted compression-only resuscitation group (adjusted unit odds ratio/year; 95% CI, 1.15; 1.08–1.24 vs. 1.04; 1.00–1.07).

Conclusions: The proportions of dispatcher-assisted compression-only resuscitation group increased annually, but its survival rate of the neurologically favorable 1-month did not exceed compared to that of the no-resuscitation group in unwitnessed cases. The dispatcher-assisted compression-only resuscitation did not appear to be an ideal management for unwitnessed out-of-hospital cardiac arrest cases.

Background

Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) is effective to increase the rate of bystander CPR (BCPR), and the content of CPR guidance has changed. Before the 2000 American Heart Association guidelines upon the detection of cardiac arrest dispatchers were recommended to instruct standard CPR, defined as the combination of chest compressions and rescue breathings. In 2000, the guidelines recommended the dispatcher's instruction of compression-only CPR to lay rescuers who are unwilling to provide rescue breathings or to those without previous CPR training. After that, the recommendation level was gradually increased, and in 2010, the level of dispatcher-assisted compression-only CPR changed from class II (weak) to class I (strong).

In Japan, the Japanese Resuscitation Council (JRC) Guidelines released at the end of 2011 recommended the instruction of compression-only CPR to bystander without previous basic life support (BLS) training or experience and the education of dispatchers for proper detection of cardiac arrest. In response to these recommendations, in 2014 the Fire and Disaster Management Agency of Japan (FDMA) released a standard for DA-CPR and an educational program for proper recognition of agonal breathings and cardiac arrest. The 2015 JRC Guidelines re-emphasized the role of dispatchers to detect cardiac arrest during the communication with callers. Therefore, the shift from standard CPR to compression-only CPR was accompanied by quality improvement program of DA-CPR.

Using trend analysis, previous investigations from the United States, Japan, and Sweden reported that the rates of bystander cardiopulmonary resuscitation (BCPR) and survival in bystander-witnessed out-of-hospital cardiac arrest (OHCA) continued to increase after the guidelines for recommending dispatcher-assisted compression-only CPR. However, in these investigations, it is unclear how the composition—the combination of rescue breathings and DA-CPR attempts—of BCPR in unwitnessed OHCA was altered or how the outcomes of unwitnessed OHCA cases were affected by the change in guidelines to compression-only CPR.

This study aimed to investigate the changes in the composition of BCPR based on combination of rescue breathing and DA-CPR and the association of the changes in BCPR content with annual outcome improvement in unwitnessed OHCA cases in Japan.

Methods

Study design and ethics

Consent was obtained from the FDMA to analyze their OHCA data collected prospectively from January 2009 to December 2016. This study was conducted after receiving approval by the review board of Ishikawa Medical Control Council. Because the database analyzed in this study is anonymous and secondary, the requirement for written informed consent was waived.

Population and setting

In 2015, Japan had a population of 127 million individuals age ≥ 65 years (26.6% of the population). The FDMA data show 6184 ambulances operating in 750 fire departments throughout the country. The FDMA has released a document for standard DA-CPR instruction in 2014. The document recommends that the dispatcher instruct compression-only CPR, but the content of the instruction is left to the discretion of the dispatcher. For this reason, the current situation is that the compression-only CPR and standard CPR are mixed in the contents of resuscitation guidance provided by the dispatcher. Unless an OHCA patient is obviously dead (such as decapitation) or presents with post-mortem changes, all emergency medical service (EMS) personnel must continue
resuscitation at the scene. No termination of resuscitation rule was provided for a prehospital setting during the study period. Paramedics may use airway adjuncts and may start a peripheral venous infusion of Ringer's lactate. However, only authorized and specially trained paramedics are permitted to insert tracheal tubes and administer intravenous epinephrine, and these paramedics are not allowed to administer drugs other than epinephrine. Since 2014, they have also been allowed to perform fluid resuscitation in patients with shock and for those with suspected crush syndrome.

**Data selection**

The FDMA database includes the Utstein-style information, such as presence or absence of witnessed, the composition of bystander CPR, contents of dispatcher instructions, recorded time of CPR initiation, emergency call, EMS vehicle arrival, EMS contacted, EMS CPR initiation, and survival at 1 month, among others. The physicians clinically judged whether OHCA was presumed to be cardiac etiology or not in collaboration with the EMS technicians. Fire departments obtained information on 1-month survival from hospitals with cerebral performance categories (CPC).

From 986,760 OHCA cases recorded in 2009–2016, 33,887 were excluded because of incomplete records or illogical data for fundamental patient or case characteristics and time points. An additional 3141 cases were excluded because of the return of spontaneous circulation (ROSC) before EMS contact. After excluding another 7586 cases with uncertain or unknown witness status and 288 cases of patients age < 8 years (for whom advanced life support was not indicated), 941,858 cases with an indication for advanced life support remained. These 941,858 cases were divided into three groups depending on witnessed or unwitnessed status as follows: 558,210 unwitnessed, 310,853 bystander-witnessed, and 72,795 EMS-witnessed cases (Supplemental Figure).

**Outcome measures**

The primary outcome was the neurologically favorable 1-month survival, defined as 1 or 2 on the CPC scale. The secondary outcomes were rates of BCPR, DA-CPR, prehospital ROSC, and 1-month survival.

**Classification of BCPR**

The main focus of this study was dispatcher-assisted compression-only CPR after a DA-CPR attempt. Therefore, all cases except those witnessed by EMS were classified into the following 5 groups according to the contents of BCPR. 1) No-BCPR, no bystander resuscitation; 2) DA-COCPR, dispatcher-assisted compression-only resuscitation; 3) DA-SCPR, dispatcher-assisted standard resuscitation; 4) VI-COCPR, voluntary-initiated (without a DA-CPR attempt or other dispatcher assistance) compression-only resuscitation; 5) VI-SCPR, voluntary-initiated standard resuscitation.

**Calculation of two indices related to DA-CPR**

Each index was calculated as reported previously:

- **DA-CPR sensitivity** = (number of cases with DA-CPR attempt) / ([number of all cases] − [number of cases receiving VI-BCPR])
- Bystander's compliance to DA-CPR = (number of cases receiving dispatcher-assisted BCPR) / (number of cases with DA-CPR attempt)

**Statistical Analysis**

The trend in outcome was assessed by the Cochrane-Armitage test as a univariate test and multivariable logistic regression analyses including year (as a continuous variable) and the following factors that are well known to be associated with survival:

- Patient sex and age
- Etiology of OHCA, either presumed cardiac or non-cardiac
- Traumatic or non-traumatic OHCA
- Initial electrocardiogram rhythm—shockable or non-shockable
- BCPR classification
- Night-time (22:00 ~ 5:59) emergency call
- Prehospital advanced airway management
- Epinephrine administration
- Prehospital involvement of physician: advanced life support by physician and/or physician in ambulance
- Prehospital critical time intervals: call-to-EMS contact with patients, either EMS contact with patients-to-arrival at hospital or call-to-first CPR

Multivariable analysis for comparisons of outcomes among the BCPR groups included the same prehospital confounders. For analysis of trends in each BCPR group, multivariable analyses included patient sex and age, etiology of OHCA, traumatic OHCA, and night-time OHCA. Adjusted odds ratios (ORs) and 95% CIs were calculated. Differences for nominal variables were assessed using the chi-square or Fisher exact probability test and for continuous variables using the Kruskal–Wallis test. The generalized $R^2$ of the final model was computed to measure the fit of the regression model. All data were analyzed using JMP Pro version 15 (SAS Institute, Cary, NC, USA). In each analysis, the null hypothesis was evaluated at a 2-sided significant level of $p < 0.05$; with 95% CIs calculated using the profile likelihood.

**Results**

**Changes in characteristics of OHCA during 8 years**
During the study period of 8 years, relatively considerable increases were noted in the cases of presumed cardiac etiology and with prehospital epinephrine administration and advanced airway management, whereas remarkable decreases were observed in cases with exogenous causes, shockable initial rhythm, and prehospital physician involvement in both unwitnessed and bystander-witnessed OHCA. The call-to-first CPR (CPR performed by bystander or EMT, whichever started earlier) was shortened after 2014, reflecting the increased BCPR rate, and the rate of prehospital ROSC markedly increased in both unwitnessed and bystander-witnessed cases (Supplemental Tables 1 and 2).

**Trends in neurologically favorable survival**

When all cases were classified into 3 groups according to the witness situation and the rates of neurologically favorable survival at 1-month of each group was analyzed, the survival rates in bystander- and EMS-witnessed OHCA cases increased annually (p < 0.01) whereas that for unwitnessed cases did not significantly increase on univariate analysis (p = 0.33) (Fig. 1). However, multivariable analyses revealed that rates of neurologically favorable survival significantly increased in all groups although the adjusted unit OR per year differed among the groups: 1.04 (1.03–1.06) in unwitnessed cases, 1.07 (1.06–1.08) in bystander-witnessed cases, and 1.05 (1.04–1.06) in EMS-witnessed cases.

**Trend in BCPR**

Similar changes in BCPR groups in unwitnessed and bystander-witnessed cases were observed (Table 1). When BCPR was divided into DA-COCPR and other BCPR groups, the proportions of DA-COCPR increased annually, whereas the proportions of No-BCPR and other BCPR decreased in both groups. When BCPR was divided into dispatcher-assisted and voluntary-initiated BCPR groups, an obvious change was observed from standard BCPR to compression-only BCPR in both groups.
### Table 1
Trends in BCPR of unwitnessed and bystander-witnessed OHCA cases

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Adjusted unit OR/year | P for trend |
|------|------|------|------|------|------|------|------|------|-----------------------|------------|
| Unwitnessed cases | | | | | | | | | | |
| Total number of cases | 65,667 | 69,634 | 72,075 | 71,772 | 69,082 | 71,560 | 69,511 | 68,909 | | |
| BCPR classification, % (N) | | | | | | | | | | |
| No BCPR | 57.5% (37,783) | 56.6% (39,380) | 56.1% (40,405) | 55.1% (39,570) | 53.1% (36,675) | 51.6% (26,931) | 50.8% (35,302) | 49.7% (34,219) | 0.96 (0.95–0.96) | < 0.001 |
| Dispatcher-assisted, compression-only BCPR | 26.0% (17,045) | 27.5% (19,146) | 29.8% (21,499) | 31.4% (22,563) | 34.2% (23,648) | 35.5% (25,406) | 36.9% (25,634) | 38.4% (26,456) | 1.08 (1.08–1.09) | |
| Other BCPR | 16.5% (10,839) | 16.0% (11,108) | 14.1% (10,171) | 13.4% (9,639) | 13.4% (9,639) | 12.7% (9,223) | 12.3% (8,757) | 12.0% (8,234) | 0.94 (0.94–0.95) | |
| Dispatcher-assisted, standard BCPR | 6.7% (4,387) | 5.8% (4,005) | 5.2% (3,771) | 4.5% (3,201) | 3.9% (2,798) | 3.7% (2,557) | 3.6% (2,234) | 0.91 (0.90–0.91) | |
| Voluntary-initiated, compression-only BCPR | 6.1% (3,995) | 7.0% (4,897) | 6.3% (4,567) | 6.7% (4,779) | 6.9% (4,777) | 7.2% (5,139) | 7.0% (4,897) | 6.8% (4,716) | 1.01 (1.01–1.02) | |
| Voluntary-initiated, standard BCPR | 3.7% (2,457) | 3.2% (2,224) | 2.6% (1,836) | 2.3% (1,659) | 1.8% (1,286) | 1.6% (1,121) | 1.5% (1,011) | 0.86 (0.86–0.87) | |
| Bystander-witnessed cases | | | | | | | | | | |
| Total number of cases | 36,298 | 38,954 | 39,764 | 40,081 | 38,421 | 39,214 | 38,650 | 39,471 | | |
| BCPR classification, % (N) | | | | | | | | | | |
| No BCPR | 52.8% (19,146) | 53.7% (20,899) | 53.5% (21,286) | 51.9% (20,811) | 49.9% (19,176) | 48.1% (18,867) | 46.8% (18,339) | 46.5% (18,339) | 0.96 (0.96–0.97) | < 0.001 |
| Dispatcher-assisted, compression-only BCPR | 22.0% (7,997) | 23.0% (8,966) | 24.9% (9,881) | 27.0% (10,813) | 30.2% (11,599) | 31.4% (12,320) | 33.7% (13,035) | 34.7% (13,707) | 1.09 (1.09–1.10) | |
| Other BCPR | 25.2% (9,155) | 23.3% (9,089) | 21.6% (8,597) | 21.1% (8,457) | 19.9% (7,646) | 20.5% (8,027) | 19.5% (7,542) | 18.8% (7,425) | 0.94 (0.94–0.95) | |
| Dispatcher-assisted, standard BCPR | 7.2% (2,606) | 6.3% (2,448) | 5.6% (2,230) | 5.1% (2,045) | 4.4% (1,886) | 4.7% (1,856) | 4.5% (1,729) | 4.4% (1,723) | 0.92 (0.91–0.93) | |
| Voluntary-initiated, compression-only BCPR | 10.7% (3,880) | 10.9% (4,250) | 10.7% (4,264) | 11.2% (4,501) | 12.1% (4,642) | 11.8% (4,613) | 11.5% (4,459) | 11.4% (4,505) | 1.01 (1.01–1.02) | |
| Voluntary-initiated, standard BCPR | 7.4% (2,669) | 6.1% (2,391) | 5.3% (2,103) | 4.8% (1,911) | 3.4% (1,318) | 4.0% (1,558) | 3.5% (1,354) | 3.0% (1,197) | 0.87 (0.86–0.88) | |

a) Adjusted by age, sex and night-time OHCA (emergency call during night-time, 22:00 – 5:59).

b) Cochrane-Armitage trend test

BCPR, bystander cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest

### Trends in indices for DA-CPR

Similar alterations in DA-CPR indices occurred in unwitnessed and bystander-witnessed cases. A large increase in sensitivity and small increase in bystander's compliance with DA-CPR were observed (Table 2).
Table 2
Trends in indices for DA-CPR in unwitnessed and bystander-witnessed OHCA cases

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|------|------|------|------|
| Unwitnessed cases | | | | | | | | |
| Total number of cases | 65,667 | 69,634 | 72,075 | 71,772 | 69,082 | 71,560 | 69,511 | 68,909 |
| DA-CPR-attempted, % (N) | 51.7% (33,947) | 52.6% (36,628) | 56.4% (40,667) | 57.7% (41,380) | 60.2% (41,594) | 61.0% (43,663) | 62.4% (43,392) | 63.9% (44,051) |
| Sensitivity, % (N) | 57.3% (33,947) | 58.6% (36,628) | 61.9% (40,667) | 63.3% (41,380) | 66.0% (41,594) | 67.0% (43,663) | 68.3% (43,392) | 69.7% (44,051) |
| Bystander's compliance with DA-CPR, % (N) | 63.2% (21,445) | 63.2% (23,151) | 62.1% (25,764) | 62.3% (25,764) | 63.4% (26,356) | 64.6% (28,206) | 65.0% (28,191) | 65.8% (28,963) |

Bystander-witnessed cases

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|------|------|------|------|
| Total number of cases | 36,298 | 38,954 | 39,764 | 40,081 | 38,421 | 39,214 | 38,650 | 39,471 |
| DA-CPR, % (N) | 42.4% (15,406) | 43.1% (16,772) | 45.3% (18,028) | 46.8% (18,754) | 49.6% (19,037) | 50.4% (19,761) | 52.5% (20,273) | 53.7% (21,180) |
| Sensitivity, % (N) | 51.8% (15,406) | 51.9% (16,772) | 54.0% (18,028) | 55.7% (18,754) | 58.7% (19,037) | 59.8% (19,761) | 61.7% (20,273) | 62.7% (21,180) |
| Bystander's compliance with DA-CPR, % (N) | 68.9% (10609) | 68.1% (11,414) | 67.2% (12,111) | 68.6% (12,528) | 69.8% (13,285) | 71.7% (14,176) | 72.8% (14,765) | 53.7% (15,431) |

a) Adjusted by age, sex, etiology, and night-time OHCA (emergency call during night-time, 22:00 – 5:59).

b) Cochrane-Armitage trend test

Sensitivity = DA-CPR-attempted cases/ (Total cases – Cases with voluntary-initiated BCPR)

Compliance with DA-CPR = DA-CPR-receiving cases/ DA-CPR-attempted cases

DA-CPR, dispatcher-assisted cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest

2-yearly trends in neurologically favorable survival of BCPR groups and comparisons of survival rate among groups

When the annual increases in survival rate were assessed by multivariable analysis (Table 3, second column from right), wide variations were evident for the improvement among the BCPR groups in both unwitnessed and bystander-witnessed cases (interaction test in multivariable logistic regression, \( p = 0.01 \) and \( p = 0.03 \), respectively). The survival rates in all BCPR groups including the No-BCPR group considerably increased in bystander-witnessed cases, whereas survival rates for other groups significantly increased in unwitnessed cases, except for the No-BCPR group. Judging from the calculated unit OR, the increase in survival rate was prominent in DA-SCPR in both unwitnessed (unit OR; 95% CI, 1.15; 1.08–1.24) and bystander-witnessed (1.11; 1.07–1.15) cases.
### Analyses of 2-year changes in neurologically favorable 1-M survival in BCPR subgroups

| BCPR categories | Comparisons of survival rate among BCPR subgroups during each 2-year term | Whole study period | Adjusted unit OR for trend (per year) | Adjusted OR of 2015/2016 with 2009/2010 as referer |
|----------------|--------------------------------------------------------------------------------|-------------------|--------------------------------------|-----------------------------------------------|
|                | 2009–2010 | 2011–2012 | 2013–2014 | 2015–2016 | Rate, % (N/Total) | Adjusted OR (95% CI) | Rate, % (N/Total) | Adjusted OR (95% CI) | Rate, % (N/Total) | Adjusted OR (95% CI) | Rate, % (N/Total) | Adjusted OR (95% CI) | 1.03 | (1.01–1.05) |
| No BCPR        | 0.68 (561/77,163) | 0.68 (540/79,975) | 0.63 (465/73,656) | 0.69 (483/69,521) | 1.03 | (1.00–1.05) |
| Dispatcher-assisted, compression-only BCPR | 0.45 (164/36,191) | 0.47 (207/44,062) | 0.76 (264/49,054) | 0.83 (281/52,090) | 1.04 | (1.00–1.07) |
| Voluntary-initiated, compression-only BCPR | 0.96 (85/8,392) | 0.86 (80/9,343) | 0.77 (91/9,916) | 0.99 (109/9,631) | 1.41 | (1.03–1.83) |
| Volunteer-initiated, Standard BCPR | 0.96 (45/4,681) | 1.13 (49/3,490) | 1.28 (23/2,560) | 1.36 (29/2,132) | 2.00 | (1.27–3.24) |
| Bystander-witnessed OHCA | 3.12 (1,249/40,045) | 3.21 (1,351/42,097) | 3.38 (1,285/38,043) | 3.63 (1,322/36,412) | 1.06 | (1.05–1.07) |
| Dispatcher-assisted, compression-only BCPR | 4.26 (722/16,936) | 1.36 (921/20,694) | 1.37 (1,193/23,919) | 1.45 (1,487/26,742) | 1.53 | (1.07–1.10) |
| Dispatcher-assisted, Standard BCPR | 4.93 (249/5,050) | 1.62 (222/4,275) | 1.60 (228/3,542) | 2.04 (241/3,452) | 1.95 | (1.07–1.15) |
| Volunteer-initiated, compression-only BCPR | 6.17 (502/8,130) | 1.73 (482/8,765) | 1.52 (560/9,255) | 1.59 (539/8,964) | 1.47 | (1.01–1.06) |
| Volunteer-initiated, Standard BCPR | 5.75 (793/13,190) | 1.66 (229/4,014) | 1.55 (165/2,876) | 1.44 (157/2,551) | 1.54 | (1.04–1.11) |

BCPR, bystander cardiopulmonary resuscitation
When the survival rates were compared among the BCPR groups in each 2-year term, wide differences were observed for unwitnessed cases. Furthermore, large changes in the effectiveness of each group, compared with the No-BCPR group, were evident during the study period (Table 3).

In unwitnessed OHCA cases, the survival rate in DA-COCPR remained never higher than that in the No-BCPR group, whereas the survival rate in DA-SCPR was lower than that for the No-BCPR group at the beginning of the study period (adjusted OR; 95% CI, 0.60; 0.43–0.80) but were higher at the end of the study period (adjusted OR; 95% CI, 1.41; 1.02–1.93). The rate in VI-COCPR or VI-SCPR was not significantly higher at the beginning of the study period but higher than that in the No-BCPR group at the end of the study period. As a whole, the rate in VI-SCPR was the highest among the BCPR groups (Table 3, third column from right).

In bystander-witnessed cases, all groups of BCPR provided, either dispatcher-assisted or voluntary-initiated, were associated with higher survival rates, compared with the No-BCPR group. The rate in DA-SCPR was constantly higher than that in DA-COCPR. As a whole, the rate in DA-SCPR was the highest among the BCPR groups.

**Discussion**

This study sought to assess the association of the endorsement of DA-COCPR with the increased rates of BCPR and survival, considering the changes to the DA-CPR indices. In alignment with previous reports, the continuous shift to compression-only BCPR was accompanied by an increase in BCPR rate during the study period. However, the guidelines endorsing the shift to compression-only BCPR also emphasized the role of dispatchers to detect OHCA and to instruct callers and bystanders to perform CPR, and hence the continuous quality program for DA-CPR was activated and dispersed throughout Japan and other countries. Indeed, a prominent increase was observed in DA-CPR sensitivity for OHCA but a small increase in bystander's compliance with DA-CPR was also noted. Therefore, it is likely that the increase in BCPR rate during the study period is mainly attributed to the improved ability of dispatcher to detect OHCA, although the small increase in bystander's compliance with DA-CPR may reflect the preference of some bystanders for compression-only CPR.

This study showed that association of DA-COCPR with 2-year outcome data differed between unwitnessed and bystander-witnessed cases. In unwitnessed cases, DA-COCPR was not significantly associated with a higher rate of neurologically favorable survival than No-BCPR during any 2-year period. Furthermore, the annual increase in the survival rate in this group, assessed by adjusted unit OR, was much smaller than that for the DA-SCPR. In bystander-witnessed cases, DA-COCPR was consistently associated with a higher survival rate than No-BCPR. The annual increase in survival rate in this BCPR group was larger than that for the No-BCPR group but was smaller than the DA-SCPR. Therefore, the association of DA-COCPR with outcome improvement was evident in bystander-witnessed cases but not in unwitnessed cases.

Two reasons for this difference may be assumed. Theoretically, during the first few minutes of OHCA, rescue breaths are less important than chest compressions because blood oxygen levels remain higher than the critical level. It is possible that instruction of standard CPR to untrained bystanders may prolong the time interval to compressions. Thus, instruction compression-only CPR may be more effective than or as effective as standard CPR for a witnessed OHCA, especially in a community with a short interval for EMS response time. The second reason is the increased proportion of untrained bystanders to perform compression-only BCPR in response to dispatcher's instruction, which in turn causes the decrease in overall quality of chest compressions in this group. It is highly possible that high-quality CPR is essential for survival from unwitnessed OHCA.

Because outcome improvement was observed in EMS-witnessed OHCA cases, the improvement was also attributable to the prehospital confounders after EMS contact with patients and in-hospital confounders. In this context, most paramedics were re-trained for high-quality CPR when they were qualified for intravenous access for patients with shock and hypoglycemia. Application of therapeutic hypothermia and extracorporeal circulation as an in-hospital advanced management of OHCA became common in core emergency hospitals. Similarly, these advanced managements of patients with OHCA account for the outcome improvement of bystander-witnessed OHCA cases receiving No-BCPR. Also, it should be noted that the annual increase in survival rate in unwitnessed cases receiving DA-COCPR is similar to that in EMS-witnessed OHCA cases, indicating a small contribution of DA-COCPR to the outcome improvement.

The results of this study suggest that DA-COCPR is not an ideal management for unwitnessed OHCA cases. Presumably, the BCPR performed by well-trained bystanders is ideal. Because this observational study in Japan and other observational studies in other countries did not include the quality of the BCPR as a prehospital confounder, the clinical advantage of standard BCPR over compression-only BCPR should be tested in a large randomized controlled trial, including unwitnessed cases in communities with a first responder system that has recruited well-trained volunteers to arrive at the scene.

What is the best or better strategy for the improvement of unwitnessed OHCA? The shift to compression-only BCPR for the untrained layperson should not be accompanied by an educational shift to compression-only CPR. Education for the standard CPR should be preserved in BLS training. Although the time delay until the start of chest compressions is harmful in bystander-witnessed OHCA, this delay may have little influence on the outcome of unwitnessed OHCA. As another strategy, dispatcher should attempt to instruct callers or bystanders to perform standard CPR as a first trial in unwitnessed cases.

**Limitations**

Factors such as the bystander age, the bystander–patient relationship, bystander training or experience, and the location of the OHCA were not included in the analysis because of lack of these data in unwitnessed cases. Particularly, lack of any data for qualities of BCPR is a potent limitation. A risk of misclassifications for DA-CPR and combination of rescue breaths may have occurred. Also, in other observational studies, validity of data was another potential limitation.
Conclusions

In unwitnessed cases, dispatcher-assisted compression-only BCPR is associated with a lower annual rate of increase in neurologically favorable 1-month survival rate than standard BCPR. Furthermore, the neurologically favorable outcome of dispatcher-assisted compression-only BCPR group never exceeded that of the No-BCPR group. The dispatcher-assisted compression-only BCPR did not appear to be an ideal management strategy for unwitnessed OHCA cases, and education for standard CPR should be preserved in BLS training. A large-scale randomized control study is necessary to clarify whether dispatchers should instruct bystanders to perform standard CPR as a first trial in unwitnessed cases.

List Of Abbreviations

DA-CPR, dispatcher assisted cardiopulmonary resuscitation; BLS, basic life support; JRC, Japan resuscitation council; FDMA, fire and disaster management agency of Japan; BCPR, bystander cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; EMS, emergency medical service; ROSC, return of spontaneous circulation; No-BCPR, no bystander resuscitation; DA-COCPR, dispatcher-assisted compression-only resuscitation; DA-SCPR, dispatcher-assisted standard resuscitation; VI-COCPR, voluntary-initiated compression-only resuscitation; VI-SCPR, voluntary-initiated standard resuscitation.

Declarations

Ethics approval and consent to participate

This study was conducted after receiving approval by the review board of Ishikawa Medical Control Council. The database analyzed in this study is anonymous and secondary. For that reason the requirement for written informed consent was waived.

Availability of data and materials

The datasets used and analyzed during current study are available from the corresponding author on reasonable request.

Competing interests

none

Funding

none

Author Contributions

HM had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: HM and HI

Acquisition of data: all authors

Analysis and interpretation of data: all authors

Drafting of the manuscript: HM and HI

Critical revision of the manuscript for important intellectual content: HM, HI, and YW

Statistical analysis: HM and HI

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Study supervision: HI and YW

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**Figures**
Figure 1

Trends in the proportion of survival and the rate of neurologically favorable 1-month OHCA cases. OHCA, out-of-hospital cardiac arrest

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