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Dispatcher-assisted cardiopulmonary resuscitation improves the neurological outcomes of out-of-hospital cardiac arrest victims: a retrospective analysis of prehospitalisation records in Kumamoto City

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Abstract

***Background*: Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) is an effective tool for improving the outcome of out-of-hospital cardiac arrest (OHCA) by providing dispatcher assistance (DA) to bystander cardiopulmonary resuscitation (BCPR) and public access defibrillators (PAD). However, it is unclear whether DA-CPR improves the neurological outcomes of OHCA. In this study, we assessed the effectiveness of DA-CPR using prehospitalisation records in Kumamoto City (Japan), which has a population of 730,000, an area of 390 km^2, and 25 ambulances. The DA-CPR protocol in Kumamoto City commenced in 2014.**

***Methods*: We retrospectively analysed the prehospitalisation records in Kumamoto City between 2014 and 2016. The cases were divided into two groups according to whether they received DA: DA group and non-DA group. The BCPR and PAD rates were compared between the two groups. The neurological outcomes (Glasgow–Pittsburgh cerebral performance category 1–2) were compared between the two groups by propensity score analysis with inverse probability of treatment weighting.**

***Results*: A total of 1607 prehospitalisation records were identified and divided into the DA (n=1132) and non-DA (n=474) groups. BCPR (72% vs 17%, p<0.001) and PAD (11% vs 5%, p<0.001) rates were greater in the DA group. Propensity score analysis showed that the neurological outcome was significantly better in the DA group (odds ratio 1.718; 95% confidence interval: 1.017-2.902; p=0.0431).**

***Conclusions*: DA-CPR was associated with improved BCPR, PAD, and neurological outcomes of OHCA in this analysis of prehospitalisation cases in Kumamoto City.**

Key words: Dispatcher assistance, out-of-hospital cardiac arrest, return of spontaneous circulation, mortality.

Background

Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) is a method of assisting bystander cardiopulmonary resuscitation (BCPR) and public access defibrillation (PAD) via a telephone call with a dispatcher, and is expected to improve the outcomes of out-of-hospital cardiac arrest (OHCA). Recent reports suggest that DA-CPR can improve hospital survival, but it is unclear whether dispatcher assistance (DA) also improves the neurological outcomes of patients. (1-3) In addition, the DA-CPR protocol is limited by the dispatcher's ability to recognise OHCA from the information provided by the bystander. (4-6) Although the outcomes of patients with unrecognised OHCA are expected to be worse if they do not receive DA-CPR, it is unclear whether DA influences the neurological outcomes of OHCA.

Kumamoto City is located in Kyushu, Japan, with a population of 730,000, an area of 390 km^2, and 25 ambulances. This city implemented a DA-CPR protocol in 2014 and 71% of OHCA patients received DA-CPR in the first 3 years (2014-2016).

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The DA-CPR protocol in Kumamoto City involves the following: (1) DA starts once the emergency centre receives a call regarding an unconscious or abnormally breathing person; (2) in some cases, the dispatcher confirmed abnormal breathing by asking the bystander to place the cell phone close to the patient's mouth; (3) the dispatcher provides advice on performing chest compressions (including position, pace, and depth); (4) if an automatic external defibrillator (AED) is available, the dispatcher provides advice on how to use it; and (5) the dispatcher does not terminate the call until an ambulance reaches the scene. This protocol is used by dispatchers at Kumamoto City Fire Services Bureau.

Here, we performed a retrospective review of prehospitalisation cases in Kumamoto City to investigate whether DA improved the rates of BCPR and PAD, and improved the neurological outcomes following OHCA.

Methods

Subjects

The protocol of this retrospective clinical study was approved by the Institutional Review Board of Kumamoto University Hospital. We retrospectively analysed the prehospitalisation records of OHCA patients treated between 2014 and 2016. We retrieved the following data: age, sex, witness, cardiogenic status, return of spontaneous circulation (ROSC) at ambulance admission, initial rhythm as ventricular fibrillation/ventricular tachycardia (VF/VT), ambulance technician activities (defibrillation, tracheal intubation, supraglottic device, and epinephrine infusion), and Glasgow-Pittsburgh cerebral performance category (CPC).

The patients were divided into two groups according to whether they received DA: DA group and non-DA group. The neurological outcomes and clinical factors were compared between the two groups using univariate and multivariable statistical methods, as well as propensity score analysis.

The neurological outcomes were evaluated in terms of the CPC at hospital discharge. The CPC comprises five categories: CPC1 (good recovery), CPC2 (moderate disability), CPC3 (severe disability), CPC4 (vegetative state), and CPC5 (death). (7) In the present study, we defined favourable neurological outcomes as CPC1-2.

Statistical analyses were performed using SPSS software version 23.0 (IBM, Armonk, NY, USA), except for propensity score analysis. Propensity score analysis was performed using R software version 3.1.2 (GNU general public license). Univariate analyses were performed with the Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables. Multivariable analyses were performed with logistic regression analysis. Propensity score analysis was performed using the inverse probability of treatment weighting (IPTW) method with adjustment for the following variables: age, sex (male), witness, cardiogenic status, ROSC at ambulance admission, initial rhythm as VF/VT, and ambulance technician activities (defibrillation, tracheal intubation, supraglottic device, and adrenaline infusion). The threshold of significance was set at $p<0.05$.

Results

We retrieved the medical records of 1607 patients. The median age was 79 years and 54% were male. Patients were divided into the DA and non-DA groups, and their characteristics are listed in **Table 1**. Univariate analysis showed significant differences in age ($p=0.004$), witness ($p<0.001$), ROSC at ambulance admission ($p<0.001$), initial rhythm as VF/VT ($p=0.017$), defibrillation by an ambulance technician ($p=0.002$), and adrenaline infusion by an ambulance technician ($p=0.005$) between the DA and non-DA groups. Multivariable analysis showed significant differences in witness ($p<0.001$), ROSC at ambulance admission ($p<0.001$), adrenaline infusion by an ambulance technician ($p=0.008$), and CPC1-2 at discharge ($p=0.008$) between the two groups.

Table 2 cross-tabulates the rates of BCPR and PAD in the DA and non-DA groups. The BCPR (72% vs 17%, $p<0.001$) and PAD (11% vs 5%, $p<0.001$) rates were significantly greater in the DA group than in the non-DA group.

Table 3 shows the results of the propensity score analysis with the IPTW method for CPC1-2 at hospital discharge according to receipt of DA. The propensity score analysis showed significantly better neurological outcome in the DA group than in the non-DA group (odds ratio 1.718; 95% confidence interval 1.017-2.902; $p=0.0431$). This analysis was adjusted for age, sex (male), witness, cardiogenic status, ROSC at ambulance admission, initial rhythm as VF/VT, and ambulance technician activities (defibrillation, tracheal intubation, supraglottic device, and adrenaline infusion).

Discussion

DA-CPR has the potential to improve the general outcomes of OHCA, but it was unclear whether DA-CPR improves the neurological outcomes of patients. (1-3) BCPR and PAD are known to improve the neurological outcomes of OHCA patients, and it is thought that earlier initiation of

BCPR and PAD could be more beneficial to the patient. However, it is unknown whether DA-CPR, and hence early initiation of BCPR and PAD, improves the neurological outcomes of patients. A recent study suggested that BCPR initiated before the emergency call and BCPR initiated during the emergency call were associated with similar improvements in patient outcomes. (8) Under these circumstances, our present data suggest that the DA-CPR protocol may improve neurological outcomes compared with patients who received other case, based on the propensity score analysis (**Table 3**).

In the present study, although patients in the non-DA group were treated as unrecognised OHCA cases, 17% of patients in this group underwent BCPR and 5% underwent PAD. Thus, 17% of patients in the non-DA group had apparently undergone BCPR before the emergency call, so DA was not required. This also suggests that 17% of the non-DA group were treated by a knowledgeable bystander and 6% had CPC1-2 at hospital discharge (vs 4% in the DA group). However, the non-DA group was significantly younger (78 years vs 80 years, $p=0.004$), were more frequently witnessed (53% vs 31%, $p<0.001$), and had a higher ROSC rate at ambulance admission (18% vs 4%, $p<0.001$), based on univariate analysis. Although the presence of a knowledgeable bystander improved the neurological outcome of some patients in the non-DA group, the propensity score analysis showed that the neurological outcomes were superior in the DA group than in the non-DA group.

In recent reports, the rate of recognised OHCA ranged from 70%-78%. (4-6) In our study, 71% of patients had recognised OHCA and received DA, based on the emergency telephone call. Among these patients, 72% were given BCPR and 11% were given PAD; these rates were significantly greater than for those in the non-DA group. BCPR was therefore performed four times more often and PAD was given twice as often in the DA group than in the non-DA group. These significant increases in BCPR and PAD possibly contributed to the improved neurological outcomes in the DA group.

The high rate of recognising CA, and the significant increases in BCPR and PAD rates observed in this study suggest that DA-CPR protocol used by Kumamoto City Fire Services Bureau is an effective system. The responders are trained and regularly update their skills in dispatch simulations and group discussions. Although our data demonstrate the effectiveness of the DA-CPR protocol in Kumamoto City, improvements in the DA-CPR protocol in Kumamoto City, improvements in the DA-CPR protocol could be continued. Recent reports have suggested that targeted simulations and education could improve the recognition of OHCA, permitting DA-CPR, and a single dispatch centre might elicit better improvements in patient outcomes than a multiple dispatch centre system. (9,10) As noted above, the DA-CPR system in our region improved BCPR and PAD, although it has not adopted recent recommendations (e.g. target simulation and single dispatch centre). Because we anticipate further improvements in neurological outcomes with the DA-CPR protocol, we will continue to observe its clinical impact.

Our study has some limitations. First, this was a retrospective study at a single city and involved a small number of patients, which may limit the strength of the conclusions. Second, many patients had ROSC at ambulance admission, but their OHCA status was documented by a member of the public. Third, the neurological outcomes were assessed at hospital discharge, but some patients might experience neurological improvements after discharge.

Despite these limitations, the DA-CPR protocol used in Kumamoto City was associated with significant increases in the rates of BCPR and PAD, which contributed to improve neurological outcomes following OHCA. To date, very few reports have investigated the effects of a DA-CPR protocol on neurological outcomes. Therefore, our results support the belief that DA-CPR protocols improve the neurological outcomes following OHCA.

Conclusions

This study showed that DA-CPR was associated with significant increases in the rates of BCPR and PAD compared with the non-DA group. Propensity score analysis with the IPTW method showed that the DA-CPR used in Kumamoto City was also associated with significant improvements in neurological outcomes following OHCA.

Ethics approval and consent to participate

The protocol of this retrospective clinical study was approved by the Institutional Review Board of Kumamoto University Hospital. The participant consent was not necessary as this study involved the use of opt-out form at website: http://www2.kuh.kumamoto-u.ac.jp/kyukyu/research/index.html

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding

author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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Authors' contributions
KN was contributed to collection data. TK, HT, KU, RK, SI, HI, and SK were contributed to make study design. TK wrote manuscript and contributed to statistical analysis. All authors read and approved the final manuscript.

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Table 1. Characteristics of out-of-hospital cardiac arrest cases in Kumamoto city (2014-2016)

Variable	All cases n=1607	DA group n=1132 (71%)	Non-DA group n=474 (29%)	p value [a]	p value [b]	OR (95% CI)
Age (years)	79 (65-87)	80 (66-87)	78 (62-86)	0.004	0.090	1.005 (0.999-1.011)
Male	874 (54%)	600 (53%)	274 (58%)	0.079	0.336	0.891 (0.704-1.127)
Witness	604 (38%)	352 (31%)	252 (53%)	<0.001	<0.001	0.459 (0.362-0.581)
Cardiogenic status	982 (61%)	709 (63%)	273 (58%)	0.064	0.152	1.194 (0.937-1.522)
Ambulance team activity						
ROSC at ambulance admission	131 (8%)	47 (4%)	84 (18%)	<0.001	<0.001	0.217 (0.141-0.332)
Initial rhythm as VF/VT	90 (6%)	53 (5%)	37 (8%)	0.017	0.525	0.763 (0.332-1.754)
Defibrillation	129 (8%)	75 (7%)	54 (11%)	0.002	0.231	0.652 (0.323-1.313)
Tracheal intubation	103 (6%)	78 (7%)	25 (5%)	0.264	0.657	1.120 (0.681-1.841)
Supraglottic device	250 (16%)	178 (16%)	72 (15%)	0.821	0.628	0.924 (0.670-1.274)
Adrenaline infusion	303 (19%)	234 (21%)	69 (15%)	0.005	0.008	1.546 (1.122-2.130)
CPC1-2 at hospital discharge	71 (4%)	43 (4%)	28 (6%)	0.063	0.008	2.273 (1.242-4.160)

Legend: [a]=Univariate analysis; [b]=Multivariable analysis; DA=dispatcher assistance; OR=odds ratio; CI=confidential interval; ROSC=return of spontaneous circulation; VF=ventricular fibrillation; VT=ventricular tachycardia; CPC=Glasgow-Pittsburgh cerebral performance category.
Data are presented as the median (interquartile range) or n (%).

Table 2. Rates of bystander cardiopulmonary resuscitation or public access defibrillation

Variable	DA group n=1132	Non-DA group n=474	p value
BCPR (yes)	817/1132 (72%)	79/472 (17%)	<0.001
PAD (yes)	121/1132 (11%)	25/474 (5%)	<0.001

Legend: DA=dispatcher assistance; BCPR=bystander cardiopulmonary resuscitation; PAD=public access defibrillation.

Table 3. Propensity score analysis with inverse probability of treatment weighting method for favourable neurological outcome at hospital discharge [a]

Variable	OR (95% CI)	p value
DA vs non-DA	1.718 (1.017-2.902)	0.0431

Legend: [a]=favourable neurological outcome was defined as Glasgow-Pittsburgh cerebral performance category 1-2. The analysis was adjusted for: age, sex (male), witness, cardiogenic status, return of spontaneous circulation at ambulance admission, initial rhythm as ventricular fibrillation/ventricular tachycardia, and ambulance technician activities (defibrillation, tracheal intubation, supraglottic device, and adrenaline infusion). OR=odds ratio; CI=confidence interval; DA=dispatcher assistance.

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