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Clinical paper

Effects of dispatcher-initiated telephone cardiopulmonary resuscitation after out-of-hospital cardiac arrest: A nationwide, population-based, cohort study

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Abstract

Aim: This study aimed to investigate the effects of dispatcher-initiated telephone cardiopulmonary resuscitation (TCPR) in Japan using a nationwide population-based registry.

Methods: Adult Japanese patients with out-of-hospital cardiac arrest (OHCA; n = 582,483, age ≥18 years) were selected from a nationwide Utstein-style database (2010–2016) and divided into 3 groups: no bystander CPR (NCPR) before emergency medical service arrival (n = 448,606), bystander-initiated CPR (BCPR) performed without assistance (n = 46,964), and TCPR (n = 86,913). The primary outcome was a favourable neurological outcome 1 month after OHCA.

Results: After adjusting for potential confounders, and relative to the NCPR group, significantly better 1-month neurological outcomes were observed in the BCPR group (odds ratio: 2.25, 95% confidence interval: 2.15–2.36; $P < 0.001$) and in the TCPR group (odds ratio: 1.30, 95% confidence interval: 1.24–1.36; $P < 0.001$). The collapse-to-CPR time was independently associated with the 1-month outcomes, with a rate of <1% for 1-month favourable neurological outcomes if CPR was initiated >5 min after the collapse.

Conclusion: Patients who received TCPR had significantly better outcomes than those who did not receive CPR. However, the TCPR outcomes were less favourable than those in the BCPR group. Better protocol development and enhanced education are needed to improve dispatcher instructions in Japan, which may help lessen the gap between the BCPR and TCPR outcomes and further improve the outcomes after OHCA.

Keywords: Out-of-hospital cardiac arrest, Cardiopulmonary resuscitation, Bystander, Dispatcher-assisted, Neurological outcomes

Introduction

Out-of-hospital cardiac arrest (OHCA) is an important public health problem in developed countries. The overall incidence of OHCA is 80–110 cases per 100,000 population, with annual estimates of 275,000 cases in Europe, 350,000 cases in the US, and 110,000 cases in Japan.[1–3] Successful resuscitation from OHCA requires a coordinated set of rescuer actions, and early bystander-initiated cardiopulmonary resuscitation (BCPR) is a key step in improving the likelihood of survival.[4] However, the rates of BCPR remain low in most communities, as only approximately one-third of patients receive BCPR.[5] Nevertheless, BCPR can increase the likelihood of survival after OHCA by 2–4-fold,[6,7] which highlights the possibility that a dispatcher may also help improve BCPR outcomes by providing instructions via telephone. However, the effects of this telephone guidance on OHCA outcomes remain controversial.[8] For example, some studies have revealed improved survival[9–14] and favourable

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neurological outcomes,[9,11,14–17] while other studies failed to detect a benefit[15,18,19] or even revealed a trend towards decreased survival.[20] Moreover, many previous studies were limited by their historical control design, insufficient adjustment for confounders, or sample size that resulted in underpowered analyses. Therefore, the present study aimed to evaluate the effects of dispatcher-initiated telephone cardiopulmonary resuscitation (TCPR) on OHCA outcomes using a large population-based cohort.

Methods

Study design

This retrospective study evaluated data from an Utstein-style Japanese population-based registry that is prospectively maintained by the Fire and Disaster Management Agency (FDMA). The study included adult patients (age: ≥18 years) who experienced OHCA in Japan between January 1, 2010 and December 31, 2016. We excluded patients who were transported by physician-manned ambulances, whose outcomes were not recorded or invalid, and who did not receive attempted resuscitation. A large sample size was selected to decrease the uncertainty in our estimates. Cardiac arrest was defined as the cessation of cardiac mechanical activities, which was confirmed by the absence of circulation signs. We defined bystander CPR as the steady provision of chest compressions by anyone who had not performed CPR as part of their emergency medical service (EMS) duties.

Eligible patients were classified into 3 groups according to CPR exposure: (1) no CPR (NCPR) before EMS arrival, (2) BCPR that was initiated by a bystander without telephone guidance, and (3) TCPR that was initiated by a bystander after receiving instructions from the dispatcher via telephone. The study's retrospective protocol was approved by the institutional review board of the Tokyo Metropolitan Bokutoh Hospital (31-009). The requirement for informed consent was waived because all data were de-identified prior to the analysis in order to protect the patients' personal information.

The EMS system in Japan

Japan has an area of 378,000 km^2 and had a population of approximately 127 million residents between 2010 and 2016. The Japanese EMS system has been described in previous reports[1,21] and is supervised by the FDMA, with individual EMS systems being operated by municipal governments. An ambulance EMS crew generally includes three individuals, with at least one technician who is trained to operate a semiautomated external defibrillator, insert an intravenous line, and place advanced airways. These technicians are authorized to perform endotracheal intubation and to administer adrenaline (epinephrine) intravenously under remote medical supervision. The permitted dosage of adrenaline is 1 mg per attempt and repeated doses may be administered under supervision.

All EMS providers performed and taught CPR according to the Japanese CPR guidelines, which are based on the International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations.[22] Because EMS personnel in Japan are legally prohibited from terminating resuscitation in the field, most OHCA patients undergo EMS-provided CPR and are transported to hospitals, except in cases where death is certain. The guidelines for dispatcher instructions regarding CPR were provided by the FDMA in 1999 and were subsequently revised based on the Japanese CPR guidelines. The dispatcher instructions are based on algorithms that help the bystander identify patients who should receive CPR and help guide the bystander in performing CPR before EMS arrival.[23]

Data collection and quality control

The prospectively maintained FDMA database uses a form that is based on the Utstein-style guidelines for reporting OHCA. The relevant parameters include sex, age, aetiology of arrest, presence of dispatcher instructions regarding CPR, witnessed status, the bystander's relationship to the OHCA patient (family member, friend, colleague, passer-by, EMS personnel, or other), initial cardiac rhythm, bystander CPR performance and manoeuvres, time of collapse recognition, time of CPR initiation, time of emergency call, time of EMS arrival at the scene, time of hospital arrival, time of pre-hospital return of spontaneous circulation (ROSC), 1-month survival outcome, and 1-month neurological outcome. Physicians in charge determined the aetiology of arrest, which was presumed to be cardiac unless evidence suggested a non-cardiac aetiology. The type of bystander CPR, and the presence or absence of chest compressions and rescue breathing, were determined by EMS observation and interviewing the bystander at the scene. Outcomes were clinically determined by the attending physician 1 month after the cardiac arrest using the cerebral performance category (CPC) scale,[24] which classifies the outcomes as 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). Data forms are completed by the EMS personnel in cooperation with the attending physician before being uploaded to the FDMA database server, and undergo automated computerized verification and review by a working group. Incomplete data forms are returned to the responsible station for completion. Permission was obtained from the FDMA to analyse the anonymised patient records.

The initial cardiac rhythm was dichotomized as shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia) or unshockable rhythm. The collapse-to-CPR time was calculated from the time of collapse recognition to the time of CPR initiation. The call-to-response time was calculated from the emergency call to the time of EMS arrival at the scene. The call-to-hospital time was calculated from the time of emergency call to the time of vehicle arrival at the hospital. The year of hospital admittance was arbitrarily dichotomized as early (2010–2012) or late (2013–2016).

Outcomes

The primary outcome was defined as a favourable neurological outcome (CPC 1–2) 1 month after the cardiac arrest. The secondary outcome was defined as survival to 1 month after the cardiac arrest and pre-hospital ROSC.

Statistical analysis

Continuous variables were presented as median and interquartile range (IQR), and were compared using the Kruskal–Wallis test or the Mann–Whitney U test, as appropriate. Categorical variables were presented as number (percentage) and compared using the chi-squared test. We used a multivariate logistic regression model to determine the association of the 3 categories of CPR exposure with the outcomes. To minimize the risk of falsely identifying significant results, a set of covariates for the regression models was chosen *a priori* based on

biological plausibility and previous reports.[11,15,19,20,25,26] The selected covariates were age, sex, period of hospital admittance, call-to-response time, call-to-hospital time, witnessed status, presumed cardiac aetiology, and initial shockable rhythm. We further compared the outcomes between the BCPR and TCPR groups using a multivariate logistic regression model with the previously selected covariates as well as bystander-patient relationship, automated external defibrillator use by the bystander, and collapse-to-CPR time. Variance inflation factors (VIFs) were used to check for multicollinearity. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to determine the likelihoods of the various outcomes.

We also investigated the association between the collapse-to-CPR time and 1-month favourable neurological outcomes in the TCPR group by calculating the dynamic proportion of favourable neurological outcomes as a function of the collapse-to-CPR time. Patients with a collapse-to-CPR time of >60 min were excluded from this analysis based on their extremely low expected rate of survival.[27] The dynamic proportion for each outcome was calculated using the following formula:Dynamic proportion (%) = ([{all patients who had the outcome} – Nx] × 100)/(number of patients).

In this formula, Nx was the number of patients who had the outcome and received TCPR between 0 and x min.

All statistical tests were two-tailed and P-values of <0.05 were considered significant. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R software (The R Foundation for Statistical Computing, Vienna, Austria).[28]

Results

During the study period, the database included 876,120 OHCA cases. Fig. 1 shows the study flowchart. Based on the inclusion and exclusion criteria, the present study included 582,483 patients (NCPR group: 448,606 patients, BCPR group: 46,964 patients, and TCPR group: 86,913 patients).

Demographic characteristics

Table 1 shows the characteristics and clinical outcomes in the NCPR, BCPR, and TCPR groups. The overall median age was 78 years (IQR: 67–86 years) and 58.3% of the patients were men. Dispatcher instructions were provided in 45.1% of cases. The cardiac arrest was witnessed in 43.2% of cases. The presumed aetiology was a cardiac cause in 58.3% of cases. The other presumed aetiologies were respiratory disease (7%), malignancy, (4%), stroke (4%), unspecified extrinsic causes (12%), drowning (2%), injury during a traffic accident, (1%), intoxication (<1%), hypothermia (<1%), anaphylaxis (<1%), and other causes (11%). The median call-to-response time was 7 min (IQR: 5–9 min) and the median call-to-hospital time was 32 min (IQR: 26–40 min). The rates were 2.9% for 1-month favourable neurological outcomes, 5.4% for 1-month survival, and 8.7% for pre-hospital ROSC. Significant differences in the patient characteristics were observed when we compared the three CPR-based groups (P < 0.001 for each comparison).

Outcome analyses

The BCPR group had the highest rates of 1-month favourable neurological outcomes (5.7%), 1-month survival (8.7%), and prehospital ROSC (13.6%). The TCPR group had intermediate results (3.1%, 5.6%, and 9.2%, respectively), while the NCPR group had the poorest results (2.6%, 5.0%, and 8.1%, respectively).

Table 2 summarizes the results of the multivariate logistic regression analyses based on 582,044 of the 582,483 patients. We excluded 439 patients (0.1%) because of one or more missing values.

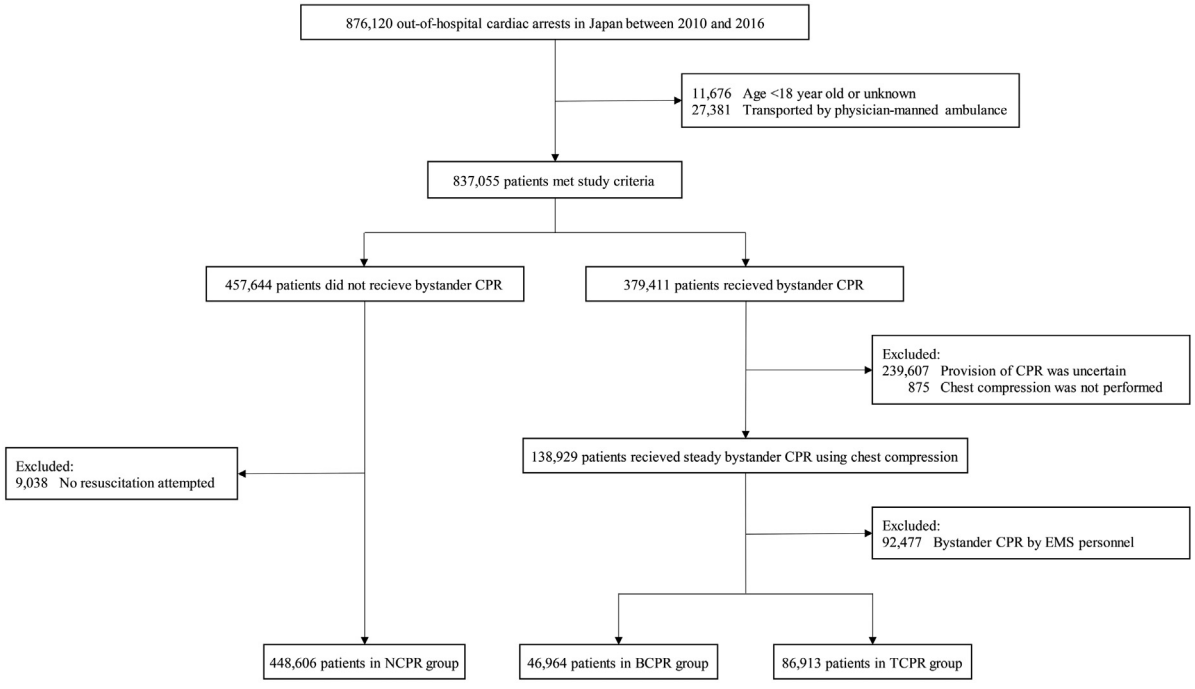

Fig. 1 – Study flowchart.
BCPR: bystander-initiated cardiopulmonary resuscitation, TCPR: dispatcher-initiated telephone cardiopulmonary resuscitation, NCPR: no bystander cardiopulmonary resuscitation before EMS arrival.

Table 1 – Baseline patient characteristics.

Variables	Overall	Group			P-value
		NCPR	BCPR	TCPR	
No. of patients	582,483	448,606	46,964	86,913	
Period of hospital admittance					<0.001
Early (2010–2012)	264,664 (45)	203,323 (45)	23,509 (50)	37,832 (44)	
Late (2013–2016)	317,819 (55)	245,283 (55)	23,455 (50)	49,081 (57)	
Patient age, years	78 [67–86]	78 [66–85]	82 [72–89]	80 [69–87]	<0.001
Male sex	339,500 (58)	269,228 (60)	23,326 (50)	46,946 (54)	<0.001
Witnessed arrest	251,840 (43)	195,155 (44)	24,491 (52)	32,194 (37)	<0.001
Dispatcher assistance provided (%)	249,235 (45)	143,944 (34)	18,378 (39)	86,913 (100)	<0.001
Initial shockable cardiac rhythm (VF/pulseless VT)	38,657 (7)	28,232 (6)	3748 (8)	6677 (8)	<0.001
Presumed cardiac aetiology	339,531 (58)	258,523 (58)	28,273 (60)	52,735 (61)	<0.001
Call-to-response time, min	7 [5–9]	7 [5–9]	7 [6–9]	7 [6–9]	<0.001
Call-to-hospital time, min	32 [26–40]	32 [26–40]	31 [25–38]	30 [25–37]	<0.001
One-month favourable neurological outcomes (CPC 1–2)	17,029 (3)	11,660 (3)	2682 (6)	2687 (3)	<0.001
One-month survival	31,386 (5)	22,450 (5)	4102 (9)	4834 (6)	<0.001
Pre-hospital ROSC	50,832 (9)	36,423 (8)	6392 (14)	8017 (9)	<0.001

Data are presented as number (percentage) or median [interquartile range].
NCPR: no bystander cardiopulmonary resuscitation, BCPR: bystander-initiated cardiopulmonary resuscitation, TCPR: dispatcher-initiated telephone cardiopulmonary resuscitation, VF: ventricular fibrillation, VT: ventricular tachycardia, ROSC: return of spontaneous circulation, CPC: cerebral performance category.

Table 2 – Likelihood of various outcomes following out-of-hospital cardiac arrest according to risk factors.

Variables	One-month favourable outcome		One-month survival		Pre-hospital ROSC	
	aOR (95% CI)	*P*-value	aOR (95% CI)	*P*-value	aOR (95% CI)	*P*-value
CPR status						
NCPR	Reference		Reference		Reference	
BCPR	2.25 (2.15–2.36)	<0.001	1.76 (1.69–1.82)	<0.001	1.76 (1.71–1.81)	<0.001
TCPR	1.30 (1.24–1.36)	<0.001	1.24 (1.19–1.28)	<0.001	1.34 (1.31–1.38)	<0.001
Period of hospital admittance						
Early (2010–2012)	Reference		Reference		Reference	
Late (2013–2016)	1.18 (1.14–1.21)	<0.001	1.11 (1.08–1.13)	<0.001	1.18 (1.16–1.20)	<0.001
Patient age, years	0.97 (0.97–0.98)	<0.001	0.98 (0.98–0.98)	<0.001	0.99 (0.99–0.99)	<0.001
Male sex	1.10 (1.07–1.14)	<0.001	1.01 (0.99–1.04)	0.31	1.05 (1.03–1.07)	<0.001
Witnessed arrest	6.13 (5.86–6.41)	<0.001	5.04 (4.89–5.19)	<0.001	4.37 (4.28–4.47)	<0.001
Initial shockable cardiac rhythm (VF/pulseless VT)	5.40 (5.21–5.61)	<0.001	5.25 (5.09–5.41)	<0.001	3.63 (3.54–3.73)	<0.001
Presumed cardiac aetiology	1.76 (1.69–1.83)	<0.001	1.09 (1.06–1.12)	<0.001	0.82 (0.80–0.83)	<0.001
Call-to-response time, minute	0.94 (0.93–0.95)	<0.001	0.94 (0.94–0.95)	<0.001	0.94 (0.94–0.94)	<0.001
Call-to-hospital time, minute	1.00 (1.00–1.00)	<0.001	1.00 (1.00–1.00)	0.21	1.02 (1.02–1.02)	<0.001

ROSC: return of spontaneous circulation, aOR: adjusted odds ratio, CI: confidence interval, CPR: cardiopulmonary resuscitation, NCPR: no bystander cardiopulmonary resuscitation, BCPR: bystander-initiated cardiopulmonary resuscitation, TCPR: dispatcher-initiated telephone cardiopulmonary resuscitation, VF: ventricular fibrillation; VT: ventricular tachycardia.

The VIFs for multicollinearity were <1.20 for all predetermined explanatory variables, which indicated a lack of collinearity. After adjusting for potential confounders, and relative to the NCPR group, significantly better 1-month favourable neurological outcomes were observed in the BCPR group (aOR: 2.25, 95% CI: 2.15–2.36; $P < 0.001$) and in the TCPR group (adjusted OR [aOR]: 1.30, 95% CI: 1.24–1.36; $P < 0.001$). In addition, relative to the NCPR group, significantly better 1-month survival rates were observed in the BCPR group (aOR: 1.76, 95% CI: 1.69–1.82; $P < 0.001$) and in the TCPR group (aOR: 1.24, 95% CI: 1.19–1.28; $P < 0.001$). Furthermore, significantly better 1-month ROSC rates were observed in the BCPR group (aOR: 1.76, 95% CI: 1.71–1.81; $P < 0.001$) and in the TCPR group (aOR: 1.34, 95% CI: 1.31–1.38; $P < 0.001$).

Table 3 summarizes the results of the univariate comparisons of witnessed OHCAs between the BCPR group (n = 24,491) and the TCPR group (n = 32,194). Bystander-patient relationship was unspecified in 61% of the BCPR cases, while the relationship was a family member in 66% of the TCPR cases. The rate of prehospital bystander automated external defibrillator use was significantly higher in the BCPR group (6.9% vs. 2.5%, $P < 0.001$). The collapse-to-CPR time was also significantly shorter in the BCPR group (0 min [IQR: 0–2 min] vs. 3 min [IQR: 1–5 min], $P < 0.001$). The call-to-CPR time in the TCPR group was 1 min [IQR: 0–3 min]. The BCPR group had significantly higher rates of 1-month favourable neurological outcomes (9.4% vs. 7.1%, $P < 0.001$), 1-month survival (13.9% vs. 12.1%, $P < 0.001$), and prehospital ROSC (20.9% vs. 18.7%, $P < 0.001$).

Table 3 – Comparison of the characteristics of patients who received BCPR or TCPR for witnessed out-of-hospital cardiac arrest.

Variables	BCPR	TCPR	P-value
No. of patients	24,491	32,194	
Period of hospital admittance			<0.001
Early (2010–2012)	11,991 (49)	13,414 (42)	
Late (2013–2016)	12,500 (51)	18,780 (58)	
Patient age, years	82 [71–89]	80 [69–87]	<0.001
Male sex	12,797 (52)	18,688 (58)	<0.001
Bystander-patient relationship			<0.001
Family members	6913 (28)	21,346 (66)	
Friends	826 (3)	950 (3)	
Colleagues	850 (4)	890 (3)	
Passers-by	985 (4)	729 (2)	
Others	14,917 (61)	8279 (26)	
Dispatcher-assistance provided (%)	8582 (35)	32,194 (100)	<0.001
Initial shockable cardiac rhythm (VF/pulseless VT)	2969 (12)	4861 (15)	<0.001
Prehospital AED use by a bystander	1695 (7)	802 (3)	<0.001
Presumed cardiac aetiology	14,328 (59)	18,721 (58)	0.4
Call-to-response time, min	7 [6–9]	8 [6–10]	<0.001
Call-to-hospital time, min	31 [25–39]	31 [26–39]	<0.001
Collapse-to-CPR time, min	0 [0–2]	3 [1–5]	<0.001
Call-to-CPR time, min	NA	1 [0–3]	
One-month favourable neurological outcomes (CPC 1–2)	23 (9)	2297 (7)	<0.001
One-month survival	34 (14)	3882 (12)	<0.001
Pre-hospital ROSC	5108 (21)	6023 (19)	<0.001

Data are presented as number (percentage) or median [interquartile range].
BCPR: bystander-initiated cardiopulmonary resuscitation, TCPR: dispatcher-initiated telephone cardiopulmonary resuscitation, VF: ventricular fibrillation, VT: ventricular tachycardia, AED: automated external defibrillator, CPC: cerebral performance category, ROSC: return of spontaneous circulation.

Table 4 summarizes the results of the multivariate logistic regression analyses based on 56,617 of the 56,685 patients with witnessed OHCA. We excluded 68 patients (0.1%) because of one or more missing values. The VIFs for multicollinearity were <1.52 for all predetermined explanatory variables. After adjusting for potential confounders, and relative to the BCPR group, the TCPR group had significantly poorer 1-month favourable neurological outcomes (aOR: 0.83, 95% CI: 0.77–0.89; P < 0.001) and 1-month survival (aOR: 0.92, 95% CI: 0.87–0.97; P = 0.0047). There was no significant difference between the groups' pre-hospital ROSC outcomes ($P = 0.13$). The collapse-to-CPR time was independently associated with the various outcomes, with a decreasing likelihood of 1-month favourable neurological outcome for each additional minute of delay in initiating CPR (aOR: 0.98, 95% CI: 0.98–0.99; P < 0.001).

Dynamic proportion analyses

Fig. 2 shows the dynamic proportion analyses of study outcomes according to the collapse-to-CPR time in TCPR patients. The rate of 1-month favourable neurological outcomes decreased to <1% when the bystander CPR was initiated >5 min after the collapse. No patients had 1-month favourable neurological outcomes when the collapse-to-CPR time was ≥25 min. The 1-month survival rate decreased to <1% when the bystander CPR was initiated >8 min after the collapse.

Discussion

Our analyses revealed that, relative to NCPR, TCPR was associated with better 1-month neurological and survival outcomes, as well as an increased pre-hospital ROSC rate in Japanese adult patients with OHCA. However, the effects of TCPR were inferior to those of BCPR. The present study also confirmed that the benefit of TCPR is related to the collapse-to-CPR time, with a <1% chance of favourable 1-month neurological outcomes after ≥5 min and a <1% chance of 1-month survival after ≥8 min. These findings are strengthened by the fact that we included nearly all Japanese adult patients with OHCA during the study period, as Japanese EMS personnel are legally obligated to transport these patients to hospital except in cases of obvious mortality. To the best of our knowledge, ours is the largest cohort study to investigate the effects of TCPR on the outcomes of patients with OHCA.

Our finding that the TCPR group had significantly better outcomes than the NCPR group is consistent with the findings of some previous studies.[8,11,14,15] However, our results regarding the better outcomes of the BCPR group relative to the TCPR group conflict with the results of the previous studies,[11,14,15] which indicated that BCPR and TCPR provided approximately equal benefits in terms of neurological outcomes and survival. Given that individuals who perform BCPR are more likely to have received CPR training[29] or to have greater physical capability than individuals who perform TCPR, we believe that it is plausible that the BCPR group would experience better outcomes than the TCPR group. Wu et al. have also compared the outcomes of BCPR and TCPR,[11] and suggested that any difference between the BCPR and TCPR groups might be minimized using dispatcher assistance to initiate and maintain appropriate CPR. We also observed that the collapse-to-CPR time was >3 min for approximately one-half of the TCPR cases, and this duration is considered suboptimal.[30] Given that the collapse-to-CPR time and the likelihood of effective TCPR depend on local dispatch training,[30–32] some of the differences between our findings and previously reported findings may be related to those factors.

Table 4 – Likelihood of various outcomes after witnessed out-of-hospital cardiac arrest according to risk factors.

Variables	One-month favourable outcome		One-month survival		Pre-hospital ROSC	
	aOR (95% CI)	*P*-value	aOR (95% CI)	*P*-value	aOR (95% CI)	*P*-value
CPR status						
BCPR	Reference		Reference		Reference	
TCPR	0.83 (0.77–0.89)	<0.001	0.92 (0.87–0.97)	0.0047	0.96 (0.92–1.01)	0.13
Period of hospital admittance						
Early (2010–2012)	Reference		Reference		Reference	
Late (2013–2016)	1.24 (1.16–1.32)	<0.001	1.17 (1.11–1.24)	<0.001	1.20 (1.14–1.25)	<0.001
Patient age, years	0.97 (0.97–0.97)	<0.001	0.98 (0.97–0.98)	<0.001	0.99 (0.99–0.99)	<0.001
Male sex	1.19 (1.11–1.29)	<0.001	1.07 (1.01–1.13)	0.026	1.02 (0.98–1.07)	0.32
Bystander-patient relationship						
Family members	Reference		Reference		Reference	
Friends	1.67 (1.46–1.93)	<0.001	1.57 (1.39–1.78)	<0.001	1.37 (1.23–1.54)	<0.001
Colleagues	1.60 (1.41–1.83)	<0.001	1.53 (1.35–1.72)	<0.001	1.40 (1.25–1.57)	<0.001
Passers-by	1.81 (1.56–2.09)	<0.001	1.54 (1.36–1.75)	<0.001	1.49 (1.32–1.67)	<0.001
Others	1.06 (0.97–1.15)	0.19	1.08 (1.01–1.15)	0.03	1.11 (1.05–1.17)	<0.001
Pre-hospital AED use by a bystander	4.62 (4.16–5.13)	<0.001	4.11 (3.73–4.52)	<0.001	4.37 (4.28–4.47)	<0.001
Initial shockable cardiac rhythm (VF/pulseless VT)	3.94 (3.64–4.25)	<0.001	4.16 (3.89–4.45)	<0.001	3.31 (3.03–3.62)	<0.001
Presumed cardiac aetiology	1.21 (1.11–1.31)	<0.001	0.80 (0.76–0.85)	<0.001	0.65 (0.62–0.69)	<0.001
Collapse-to-CPR time, min	0.97 (0.96–0.97)	<0.001	0.98 (0.98–0.99)	<0.001	0.99 (0.98–0.99)	<0.001
Call-to-response time, min	0.93 (0.92–0.94)	<0.001	0.93 (0.92–0.94)	<0.001	0.92 (0.92–0.93)	<0.001
Call-to-hospital time, min	1.00 (1.00–1.01)	<0.001	1.00 (1.00–1.01)	<0.001	1.02 (1.02–1.02)	<0.001

ROSC: return of spontaneous circulation, aOR: adjusted odds ratio, CI: confidence interval, CPR: cardiopulmonary resuscitation, NCPR: no bystander cardiopulmonary resuscitation, BCPR: bystander-initiated cardiopulmonary resuscitation, TCPR: dispatcher-initiated telephone cardiopulmonary resuscitation, VF: ventricular fibrillation; VT: ventricular tachycardia.

Our findings that both the BCPR and TCPR groups had higher proportions of initial shockable cardiac rhythm (vs. the NCPR group) are consistent with the results of previous studies.[8] Previous research has also indicated that CPR can postpone the transition from shockable cardiac rhythms to asystole, and the better outcomes after bystander CPR may be partially explained by the sustained shockable cardiac rhythm until the first cardiac rhythm analysis.[33] In the analysis of witnessed cardiac arrests, we found that the TCPR group had a higher proportion of initial shockable rhythm, relative to the BCPR group. However, given that an initial shockable cardiac rhythm is associated with better outcomes after OHCA, it is incompatible with the better outcomes

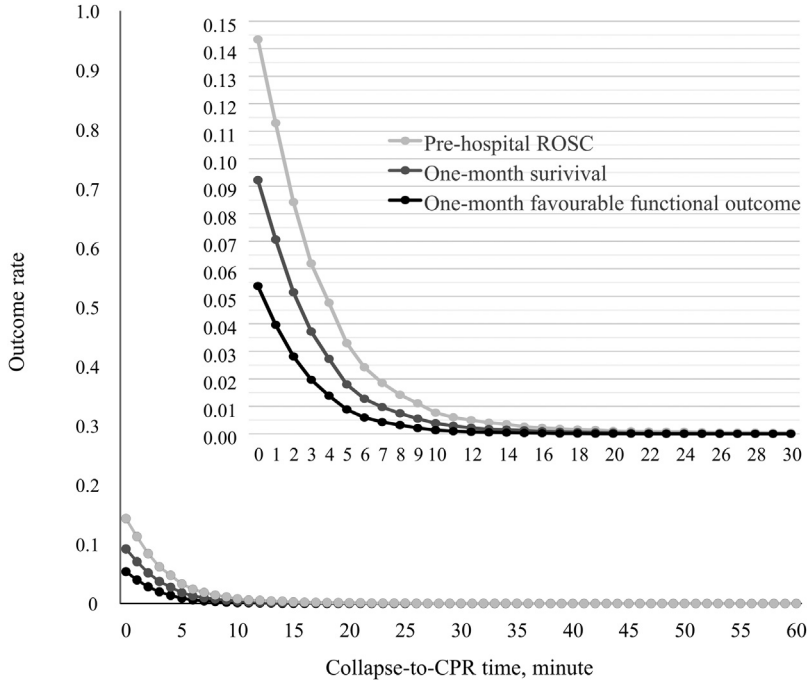

Fig. 2 – Changes in outcomes according to the time until CPR.
CPR: cardiopulmonary resuscitation, ROSC: return of spontaneous circulation.

that we observed in the BCPR group. Unfortunately, given the study design, we cannot definitively comment on the reasons behind this finding, and further studies are needed to address this point. Nevertheless, it is important to note that TCPR could modify the cardiac rhythm to an extent that was at least similar to that of BCPR.

Dispatcher management of the call is a key factor for successful TCPR. One systematic review has indicated that, in most EMS systems, the dispatcher has ≤70% sensitivity for recognizing cardiac arrest, and the most modifiable factor for increasing this sensitivity was the failure to recognize agonal respirations.[30] Although up to one-half of patients with cardiac arrest exhibit agonal respirations, it is often difficult for callers to accurately describe breathing, especially in stressful situations. Therefore, dispatchers need to approach these calls with a high index of suspicion and begin providing CPR instructions when cardiac arrest is potentially identified. In this process, delayed chest compressions may be caused by the dispatcher asking superfluous questions regarding the incident and medical history.[34] It has also been reported that changes focused on the dispatcher's breathing assessment may help shorten this interval.[35] Thus, it is recommended that dispatchers use a systematic and streamlined set of questions that is designed to identify cardiac arrest as close to the start of the call as possible.[34]

Once CPR has been identified, minimizing the time-to-CPR initiation is a key target for achieving better outcomes after OHCA. As our findings indicated, each minute after the collapse is associated with decreasing effectiveness of TCPR. Our results also support the previous recommendations that the time to recognition of a cardiac arrest should be <1 min and the time to the first compression should be <2 min.[30] Based on our dynamic proportion analyses, shortening the collapse-to-CPR time in the TCPR group from the median value (3 min) to 2 min would be expected to increase the 1-month favourable neurological outcome rate from 2.0% to 2.8% and the 1-month survival rate from 3.7% to 5.1%. Furthermore, dispatchers should give instructions regarding CPR using only chest compressions for adults, as a meta-analysis of three randomized controlled trials revealed a significantly improved likelihood of survival after chest-compression-only TCPR, relative to conventional TCPR.[36] A randomized controlled manikin trial also revealed that CPR quality was better during chest-compression-only TCPR, relative to conventional TCPR, based on superior compression frequency and a reduced no-flow time.[37] Moreover, chest-compression-only CPR is easier to teach and perform, and could theoretically be associated with increased CPR rates. In addition to the early initiation of BCPR, the dispatcher's continuous coaching is key to maintaining the quality of a bystander's CPR efforts, as even 50–75-year old bystanders can perform adequate CPR when appropriate dispatcher instructions were provided.[11]

Even if cardiac arrest has been identified and the dispatcher has suggested performing CPR, some bystanders may hesitate to perform CPR, which can be related to emotional distress, fear of being incapable, fear of causing harm, and medicolegal concerns.[38] In these cases, dispatcher instructions can play a key role in engaging hesitant bystanders, especially given that a major predictor of bystander action is their belief that they can successfully perform lifesaving techniques. Thus, the dispatcher should use a communication strategy that aims to help the bystander overcome any reservations and be willing to start TCPR.[34] Therefore, the EMS system should also include provisions to protect bystanders from a legal perspective, as this approach might help increase the rate of successful TCRP.

Although we cannot determine why TCPR was less effective than BCPR in the present study, it is possible that better dispatcher instructions might help lessen the gap between these two groups. Therefore, our findings highlight the importance of a national education campaign targeting dispatchers and the quality of the assistance they provide to bystanders who are performing CPR for OHCA. Careful review of TCPR calls may help improve our understanding of the local barriers to bystander CPR. This type of review would also allow the standardization of dispatcher instructions, which is known to help improve OHCA identification, TCPR quality, and OHCA outcomes.[10,39] We believe that our findings may also help guide protocol developments that might improve OHCA care and outcomes.

Limitations

The present study has several limitations. First, the retrospective design is prone to various biases. Although we used a mathematical model to adjust for confounding factors, it is possible that unmeasured factors biased our findings. Second, the dataset that we used did not include information regarding the quality of prehospital CPR and in-hospital interventions, although we assume that patients received standard basic and advanced life support based on the existing guidelines. Third, the integrity and validity of the data could not be evaluated, although we aimed to minimize any bias by using nationally representative data that were collected based on the Utstein-style guidelines for reporting cardiac arrest. Finally, eligible patients from the present study were older than patients in previous studies.[8,11,14,15] Thus, given that outcomes after OHCA are related to both patient demographics and EMS services, our results require external validation in other populations with different demographic characteristics and emergency care protocols.

Conclusion

The present study revealed that, relative to NCPR, TCPR provided better outcomes for Japanese adult patients who experienced OHCA. However, the outcomes after TCPR were less favourable than those after BCPR. Protocol development and further education regarding dispatchers' instructions may help lessen the gap between the BCPR and TCPR groups, and may help improve outcomes after OHCA.

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Conflict of interest

None.

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