Thus, the data regarding 1-month follow-up (1-month survival and neurological status) are collected systematically. Survival at 1 month with minimal neurological impairment was not documented for 52 (<0.3%) patients, 32 in the monophasic group and 20 in the biphasic group. They were excluded for subsequent analyses of the primary outcome measures. Survival at 1 month was documented in all eligible patients.

The times of the emergency call receipt and hospital arrival were recorded according to the times on the clock used by the EMS that responded to the call. Information on witness status and bystander CPR was collected by EMS personnel by interviewing the bystander. The cause of cardiac arrest was determined by the physician in charge[23,24] based on physical, laboratory, and radiological findings, together with scene information obtained from EMS crew. It was presumed to be cardiac in origin unless unequivocal evidence suggested respiratory diseases, cerebrovascular diseases, external causes (trauma, hanging, drowning, drug overdose, asphyxia), or any other noncardiac cause.[21] Data were verified by EMS personnel and anonymized at the local fire stations, then transferred and stored in the database at the FDMA.[25] The data were checked by computer, and if there were any inconsistencies or missing data, the FDMA consulted the corresponding regional fire stations and the data were corrected when necessary.[13,25]

Study Targets and End Points

In the present study, we focused on patients whose first documented rhythms were ventricular fibrillation (VF) or pulseless ventricular tachycardia. The primary outcome measure was survival at 1 month with minimal neurological impairment, which was defined as Glasgow-Pittsburgh cerebral performance category 1 (good cerebral performance) or 2 (moderate cerebral disability),[14,15] as evaluated by the physician in charge at 1 month after the event. The secondary outcome measures were survival at 1 month and return of spontaneous circulation before hospital arrival.

Statistical Analysis

The time from the emergency call to CPR by the EMS was subdivided into the following 3 categories: early response (0–6 minutes), moderate response (7–12 minutes), and late response (13–18 minutes). The cause of the cardiac arrest was categorized into cardiac or noncardiac origin subgroups. Patients received CPR based on 2 American Heart Association CPR guidelines (2000 and 2005 American Heart Association Guidelines). Patient characteristics were evaluated using the unpaired Student *t* test for numerical variables and the χ^2 test for categorical variables. The outcomes were compared between the subgroups using χ^2 tests.

To identify the association between defibrillator type (monophasic or biphasic) and outcomes, we performed multivariate logistic regression analyses with adjustment for age, sex, cause of arrest, the type of bystander CPR performed (no bystander CPR, compression only CPR, or conventional CPR), the type of guideline-based CPR performed (2000 Guideline-based or 2005 Guideline-based), time from emergency call to CPR by EMS (early, moderate, or late response), whether the collapse was witnessed by a bystander, whether an advanced airway device was inserted, whether epinephrine was injected, and calendar year. We assumed that data were structured hierarchically into 2 levels: communities and patients. We accounted for clustering of outcomes within communities using a generalized estimation equation (GEE). This is commonly used in place of a basic regression approach because outcomes of patients in the same community may be correlated, thus violating independence assumptions made by traditional regression procedures.[26] We also performed logistic GEE regression analyses focusing on the following subgroups: (1) early response subgroup (0–6 minutes from the time of the emergency call to CPR by the EMS) (n=7036), (2) cardiac origin subgroup (n=18 173), and (3) 2005 Guideline-based subgroup (n=9024).

We performed additional confirmatory logistic GEE regression analyses for all patients with adjustment for propensity to receive biphasic defibrillation. The propensity score approach addresses selection bias that is inherent in retrospective observational studies, where outcomes can reflect a lack of comparability in treatment groups rather than the effects of treatment.[27] To estimate the propensity score, we fitted a logistic regression model for the receipt of biphasic defibrillation as a function of the reported covariates. The c-statistic for evaluating the goodness of fit was calculated. First, we added the estimated propensity scores to the logic GEE models as a covariate (ie, propensity-score–adjusted analyses). Second, we performed a one-to-one matching between the monophasic and biphasic defibrillation groups on the basis of estimated propensity scores of each patient using a nearest neighbor matching within a caliper. The caliper size was set as a quarter of an SD of the sample estimated propensity scores. The covariate imbalance was checked using the standardized differences in covariates in the matched samples.[27] All statistical analyses were conducted using SAS version 9.2 (SAS, Cary, NC). All tests were 2-tailed, and $P<0.05$ was regarded as significant.

Results

The documented number of OHCA patients ≥18 years of age was 312 322. We excluded patients who had no attempted resuscitation by the EMS (n=4500), whose initial rhythms were not VF nor pulseless ventricular tachycardia (n=284 843), who were not shocked by the EMS (n=1606), and who lacked information on receiving defibrillation shock (n=25). Consequently, the number of VF/pulseless ventricular tachycardia patients who were shocked for defibrillation by the EMS at least once before their arrival at the hospital was 21 348. Patients who underwent defibrillation by a public-access AED by bystanders (n=175) and patients shocked with an unknown type of defibrillator (n=1) were then excluded, leaving 21 172 patients eligible for inclusion in the study. Figure 1 shows a flow diagram of the study. Of the eligible patients, 8224 (39%) patients were shocked with a monophasic defibrillator and 12 948 (61%) patients were shocked with a biphasic defibrillator.

Table 1 presents the demographic and medical characteristics of the included patients. Figure 2 shows the annual changes in the number of patients by defibrillator type. The proportion of patients who were shocked with the monophasic defibrillator decreased each year. Figure 3 shows the cerebral performance category status of survivors by defibrillator type (monophasic/biphasic).

Table 2 shows the outcomes by type of defibrillator of eligible patients and of subgroups of patients. χ^2 tests showed significant differences in survival at 1 month with minimal neurological impairment (11.6% versus 12.8%) and return of spontaneous circulation before hospital arrival (21.2% versus 22.3%) between monophasic and biphasic groups.

Table 3 shows the results of logistic GEE regression analyses. There were no significant differences between the monophasic and biphasic groups in all outcome measures of eligible patients, including return of spontaneous circulation before hospital arrival (odds ratio, 1.03; 95% confidence interval, 0.91–1.16; $P=0.64$), survival at 1 month (odds ratio, 1.02; 95% confidence interval, 0.92–1.14; $P=0.69$), and survival at 1 month with minimal neurological impairment (odds ratio,

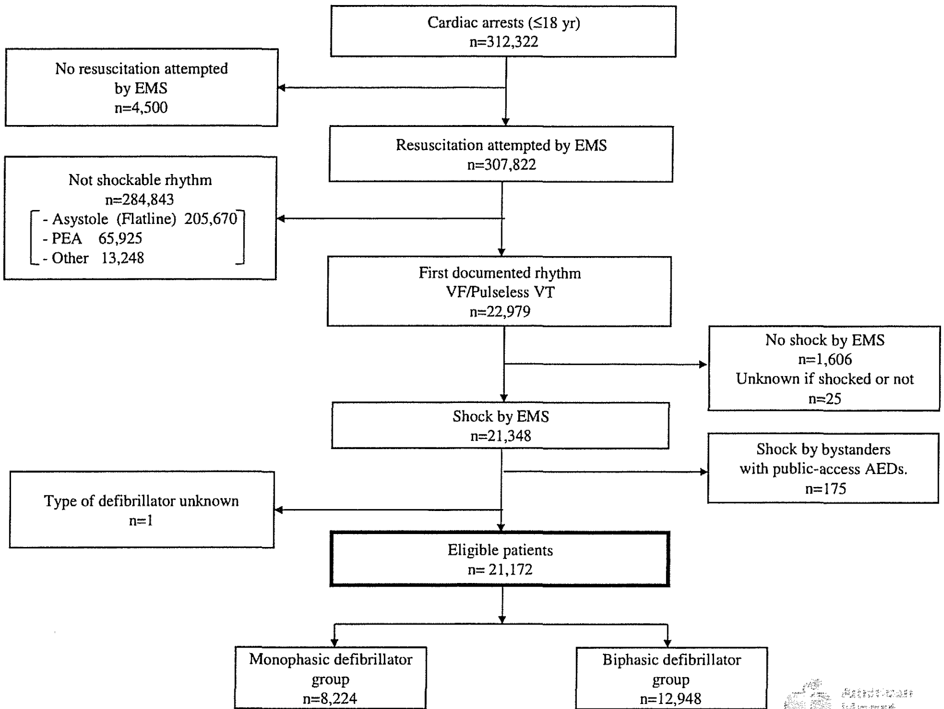

Figure 1. Study flow diagram. During the 3 years of the study, 312 322 out-of-hospital cardiac arrest patients ≥18 years old were documented. AED indicates automated external defibrillator; EMS, emergency medical service; VF, ventricular fibrillation; VT, ventricular tachycardia; and PEA, pulseless ventricular activity.

1.07; 95% confidence interval, 0.91–1.26; P=0.42). No significant association between defibrillator type and outcomes was shown in any of the 3 subgroup analyses (ie, early response subgroup, cardiac origin subgroup, or 2005 Guideline-based subgroup).

Table 3 also shows the results of the propensity-score–adjusted analyses and propensity-score–matched analyses for all patients. The c-statistic for goodness of fit was 0.641 in the propensity score model. By one-to-one propensity-score matching, 7293 pairs of the monophasic and biphasic groups were selected (n=14 586). The standardized differences in covariates in the matched samples were all <0.1. Again, there were no significant differences between the monophasic and biphasic groups in all outcome measures.

Discussion

In our study, no significant difference was observed in multivariate logistic regression analyses between the patients who were shocked with a biphasic defibrillator or with a monophasic defibrillator, either in the primary outcome or in the secondary outcomes. To date, it has been indicated that biphasic waveform shock is superior to monophasic waveform shock with respect to safety and efficacy under controlled laboratory and in-hospital conditions.[3–6] An observational study of subjects with OHCA indicated that biphasic waveform shock afforded a higher probability of terminating VF than monophasic waveform shock.[7–9] With regard to the long-term outcome, no significant difference was observed between the 2 types of waveform for defibrillation in any of the 4 randomized trials.[28–31] These studies focused on differences in the waveforms among defibrillators. However, compared with the monophasic defibrillator, the commercialized biphasic defibrillator not only has a different waveform but also has differences in the amount and duration of defibrillation energy. Furthermore, the equipment is smaller and lighter.[10–12] Sellers of defibrillators seem to consider that biphasic defibrillators are equal to or better than the monophasic defibrillator in improving outcomes of OHCA patients. Purchasers are also assumed to expect improved outcomes of OHCA patients with the biphasic defibrillator, and this may be a factor in replacing the monophasic defibrillator with the biphasic defibrillator. The FDMA of Japan has encouraged fire stations nationwide to replace the monophasic defibrillators with biphasic defibrillators by assisting each fire station with the expense of purchasing new defibrillators. Consequently, a majority of the patients underwent shock by biphasic defibrillator (Figure 2).

Biphasic defibrillators have several advantages compared with monophasic defibrillators, including a lower burden for EMS personnel because of their lower weight and greater portability. However, despite theoretical advantages of biphasic waveforms and some limited evidence about their better surrogate outcomes, the present study showed no significant advantage of biphasic defibrillators over monophasic defibrillators on meaningful clinical outcomes. Although some EMS systems may replace monophasic defibrillators with biphasic ones because of their lighter weight and increased portability, there is no patient-safety, outcome-based reason to do so. There are mainly 2 reasons why no significant association could be confirmed. First, there was no difference in the association with outcome of OHCA

Table 1. Characteristics of the Study Participants

	Total (n=21 172)	Monophasic (n=8224)	Biphasic (n=12948)	*P*
Age, mean (SD)	65.3 (15.2)	64.8 (15.1)	65.6 (15.3)	<0.001
Male, n (%)	16400 (77.5)	6468 (78.6)	9932 (76.7)	0.001
Witnessed by laypersons, n (%)	14962 (70.7)	5862 (71.3)	9100 (70.3)	0.12
Type of bystander-initiated CPR*				
No CPR, n (%)	12599 (60.1)	4974 (60.9)	7625 (59.6)	<0.001
Compression-only CPR, n (%)	4393 (21.0)	1594 (19.5)	2799 (21.9)	
Conventional CPR, n (%)	3963 (18.9)	1599 (19.6)	2364 (18.5)	
Advanced airway management†, n (%)	10616 (50.5)	4209 (51.5)	6407 (49.9)	0.025
Adrenaline‡, n (%)	907 (4.4)	257 (3.2)	650 (5.1)	<0.001
Call to CPR by EMS, min, mean (SD)§	8.8 (5.5)	8.8 (5.5)	8.8 (5.4)	0.68
0–6 min, n (%)	7036 (34.6)	2719 (34.4)	4317 (34.8)	
7–12 min, n (%)	11527 (56.8)	4526 (57.3)	7001 (56.4)	
13–18 min‖, n (%)	1748 (8.6)	654 (8.3)	1094 (8.8)	
CPR by EMS to hospital arrival, min, mean (SD)#	22.2 (10.1)	22.4 (10.0)	22.0 (10.2)	0.012
Origin of cardiac arrest				
Cardiac, n (%)	18173 (85.8)	7130 (86.7)	11043 (85.3)	0.004
Noncardiac, n (%)	2999 (14.2)	1094 (13.3)	1905 (14.7)	
CPR guidelines				
2000 AHA Guideline-based, n (%)	12148 (57.4)	5786 (70.4)	6362 (49.1)	<0.001
2005 AHA Guideline-based, n (%)	9024 (42.6)	2438 (29.6)	6586 (50.9)	
No. of shocks administered to patients who had ROSC before hospital arrival				
Median (25%–75%)	1 (1–3)	2 (1–3)	1 (1–3)	0.93
Year				
2005	6797 (32.1)	3642 (44.3)	3155 (24.4)	<0.001
2006	7183 (33.9)	2783 (33.8)	4400 (34.0)	
2007	7192 (34.0)	1799 (21.9)	5393 (41.7)	

AHA indicates American Heart Association; CPR, cardiopulmonary resuscitation; and EMS, Emergency Medical Services.

*Two hundred seventeen (1.0%) patients with missing data were excluded. Percentages were calculated on the basis of the total number of events, including those excluded.

†One hundred sixty-three (0.8%) patients with missing data were excluded. Percentages were calculated on the basis of the total number of events, including those excluded.

‡Three hundred sixty-four (1.7%) patients with missing data were excluded. Percentages were calculated on the basis of the total number of events, including those excluded.

§Twenty-six (0.1%) patients whose data were missing were excluded. The mean value and SD were calculated without the excluded data.

‖Eight hundred thirty-five (3.9%) patients in whom there was >18 min between the time of call to CPR by EMS were excluded. Percentages were calculated on the basis of the total number of events, including the excluded data.

#Twenty-three (0.1%) patients whose data were missing were excluded. The mean value and SD were calculated without the excluded data.

patients between monophasic and biphasic defibrillators. Second, because many factors contribute to the outcome of 1-month cerebral function, such as where cardiac arrest occurs, bystander treatment, prehospital EMS treatment, and intensive care at the admitting hospital, any association may be decreased to an extent that it cannot be detected. When the second case was considered, although good neurological outcome is the ultimate desired outcome of all resuscitations, as an index to measure the direct effects of different defibrillators, we consider it would be desirable to include whether a defibrillation terminated VF. However, because we did not collect data on whether VF was terminated by each shock, we could not compare the probability of terminating VF and the number of shocks necessary to terminate VF between the different types of defibrillators. Our study was an observational study that compared the association of the biphasic defibrillator and monophasic defibrillator with outcome in a large number of OHCA patients. Because the monophasic defibrillator is being replaced by the biphasic defibrillator in Japan (Figure 2), as in other developed counties,[1] this study may be the last large-scale observational study to compare outcomes by type of defibrillator—monophasic and biphasic—and provide a valuable comparison in OHCA patients.

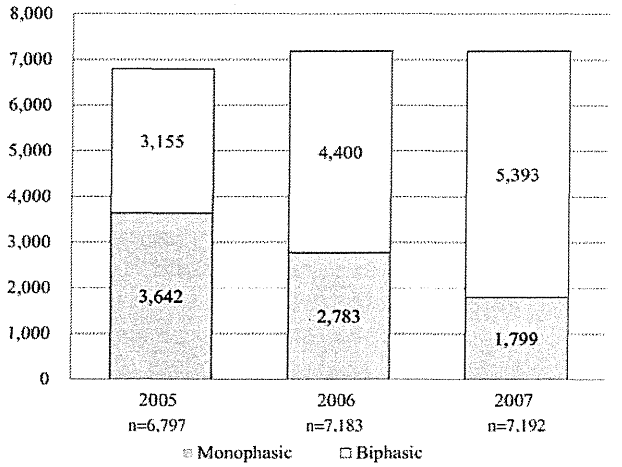

Figure 2. Number of patients who received shocks by monophasic and biphasic defibrillator by year. The proportion in the biphasic defibrillator group increased year on year.

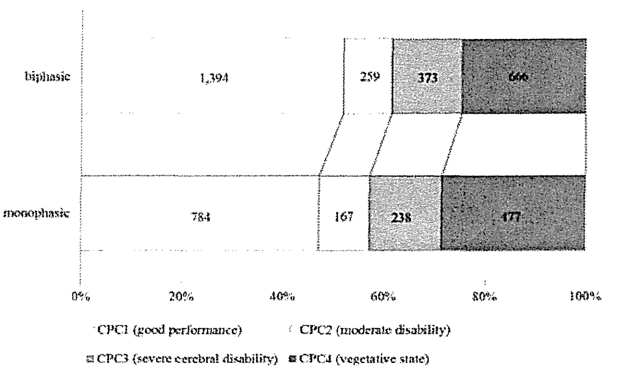

Figure 3. The cerebral performance category (CPC) status of survivors of eligible patients by defibrillator type (monophasic/biphasic).

Study Limitations

This study has several limitations. First, bias on the basis of its observational design is a potential limitation. It is possible that EMS personnel who used the monophasic defibrillator were less well supported by public funds, thus received a lower frequency of training, and this could have influenced the results. Second, as mentioned above, data on whether VF was terminated by shock were not collected, so we could not directly compare the probability of terminating VF. However, to investigate the association of replacing the monophasic defibrillator by the biphasic defibrillator, a comparison of the survival at 1

Table 2. Outcomes of All Patients and Subgroups

	ROSC Before Hospital Arrival			Survival at 1 mo			Survival at 1 mo With Minimal Neurological Impairment		
	n	(%)	*P*	n	(%)	*P*	n	(%)	*P*
All patients (n=21 172)									
Monophasic (n=8224)	1740	21.2%	0.043	1641	20.0%	0.080	951	11.6%	0.011
Biphasic (n=12 948)	2892	22.3%		2713	21.0%		1653	12.8%	
Time from emergency call to CPR by EMS									
Early response (0–6 min)									
Monophasic (n=2719)	706	26.0%	0.046	694	25.5%	0.099	402	14.8%	0.019
Biphasic (n=4317)	1215	28.1%		1179	27.3%		731	17.0%	
Moderate response (7–12 min)									
Monophasic (n=4526)	809	17.9%	0.17	744	16.4%	0.057	397	8.8%	0.045
Biphasic (n=7001)	1323	18.9%		1247	17.8%		694	9.9%	
Late response (>12 min)									
Monophasic (n=654)	123	18.8%	0.70	102	15.6%	0.33	65	10.0%	0.85
Biphasic (n=1094)	197	18.0%		152	13.9%		112	10.3%	
Origin of cardiac arrest									
Cardiac									
Monophasic (n=7130)	1574	22.1%	0.007	1505	21.1%	0.008	888	12.5%	0.002
Biphasic (n=11 043)	2629	23.8%		2516	22.8%		1554	14.1%	
Noncardiac									
Monophasic (n=1094)	166	15.2%	0.30	136	12.4%	0.079	63	5.8%	0.49
Biphasic (n=1950)	263	13.8%		197	10.3%		99	5.2%	
CPR guidelines									
2000 Guideline-based									
Monophasic (n=5786)	1189	20.5%	0.66	1097	19.0%	0.49	607	10.5%	0.55
Biphasic (n=6362)	1287	20.2%		1175	18.5%		648	10.2%	
2005 Guideline-based									
Monophasic (n=2438)	551	22.6%	0.080	544	22.3%	0.30	344	14.1%	0.17
Biphasic (n=6586)	1605	24.4%		1538	23.4%		1005	15.3%	

ROSC indicates return of spontaneous circulation; CPR, cardiopulmonary resuscitation; and EMS, Emergency Medical Services.

Table 3. Odds ratios of Outcomes for Biphasic vs Monophasic Defibrillators in the Logistic Regression Models

	ROSC Before Hospital Arrival			Survival at 1 mo			Survival at 1 mo With Minimal Neurological Impairment		
	OR	(95% CI)	*P*	OR	(95% CI)	*P*	OR	(95% CI)	*P*
All patients (n=21 172)	1.03	(0.91–1.16)	0.64	1.02	(0.92–1.14)	0.69	1.07	(0.91–1.26)	0.42
All patients, propensity-score–adjusted analysis (n=21 172)	1.04	(0.94–1.16)	0.44	1.03	(0.93–1.14)	0.57	1.07	(0.93–1.23)	0.34
Propensity-score–matched patients (n=14 586)	1.05	(0.94–1.17)	0.42	1.06	(0.94–1.18)	0.39	1.07	(0.92–1.25)	0.36
Early response subgroup (0–6 min for the time from emergency call to CPR by EMS) (n=7036)	1.06	(0.90–1.25)	0.45	1.04	(0.86–1.26)	0.70	1.10	(0.86–1.40)	0.45
Cardiac origin subgroup (n=18 173)	1.05	(0.93–1.19)	0.45	1.05	(0.94–1.17)	0.42	1.09	(0.93–1.29)	0.30
2005 AHA Guideline-based subgroup (n=9024)	1.11	(0.93–1.33)	0.24	1.08	(0.93–1.25)	0.31	1.16	(0.94–1.43)	0.17

ROSC indicates return of spontaneous circulation; OR, odds ratio; CI, confidence interval; CPR, cardiopulmonary resuscitation; EMS, Emergency Medical Services; and AHA, American Heart Association.

All models included age, sex, cause of arrest, the type of bystander CPR performed (no bystander CPR, compression only CPR, or conventional CPR), the type of guideline-based CPR performed (2000 AHA Guideline-based or 2005 AHA Guideline-based), time from emergency call to CPR by the EMS (early response, moderate response, or late response), time from CPR by EMS to hospital arrival, and whether the collapse was witnessed by a bystander, whether an advanced airway device was inserted, whether epinephrine was injected, and calendar year. Regression analyses did not include patients with missing data.

month with minimal neurological impairment is considered to be a good index. Third, because of the lack of data, we were unable to account for several potential confounders, including body mass index and preshock pause of chest compressions (time for ECG analysis and energy charge). In particular, postcardiac arrest care (eg, therapeutic hypothermia and percutaneous coronary intervention) that became increasingly adopted over the study period deserves attention as one of the major confounders. However, we believe this was partly, if not completely, accounted for by incorporating the calendar year in our multivariable logistic regression analysis. Furthermore, considering that the use of a biphasic defibrillator also increased over the study period, improvement of postcardiac arrest care would have affected the odds ratio in favor of the biphasic defibrillator, but we still failed to find a statistically significant difference in the primary outcome. Fourth, the present study did not compare individual defibrillator types but rather collapsed the defibrillator models into 2 groups according to the type of waveform. Fifth, this study is based on a retrospective observational design and, therefore, more susceptible to bias and confounding when compared with randomized controlled trials. However, we believe our study have strength in that it reflects daily clinical practice more closely than randomized controlled trials, as well as in that it includes a large number of patients. Sixth, accuracy of the recorded cerebral performance category scores was not confirmed. Despite these limitations, we believe that our results are valid, given the use of uniform data collection and consistent definitions based on the Utstein guidelines,[14,15,20] the large sample size, and the nationwide, population-based design. In addition, because all consecutive cases of OHCA patients transferred by the EMS in Japan were included in the database, selection and reporting bias was minimal.

Conclusion

Although monophasic defibrillators are being replaced by biphasic defibrillators, our nationwide population-based observational study could not confirm a parallel improvement in survival at 1 month with minimal neurological impairment.

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Disclosures

None.

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Impact of telephone dispatcher assistance on the outcomes of pediatric out-of-hospital cardiac arrest

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Objective: Most previous studies of pediatric out-of-hospital cardiac arrest have typically examined relatively small datasets from small study regions. Although several studies have reported the impact on adult out-of-hospital cardiac arrest, little information is available on the impact of telephone dispatcher assistance on the outcomes of pediatric out-of-hospital cardiac arrest. We set out to examine the impact of cardiopulmonary resuscitation instruction by telephone dispatcher on the outcomes of pediatric out-of-hospital cardiac arrest.

Design: Population-based, observational study.

Setting: Japan-wide population-based setting.

Patients: We identified 1,780 pediatric out-of-hospital cardiac arrest patients (67.8% male) with witnessed collapse from a nationwide, population-based, out-of-hospital cardiac arrest database.

Intervention: None.

Measurement and Main Results: We assessed the impact of telephone dispatcher assistance on the outcomes of 1-month survival rates and favorable neurologic status among the groups. The overall rate of bystander-performed chest compression and mouth-to-mouth ventilation among the witnessed pediatric out-of-hospital cardiac arrests were 39.5% and 25.6%, respectively. Telephone dispatcher assistance was offered in 28.4% of the witnessed pediatric out-of-hospital cardiac arrest cases and resulted in a significant increase in both chest compression (adjusted odds ratio 6.04; 95% confidence interval 4.72–7.72) and mouth-to-mouth ventilation (adjusted odds ratio 3.10; 95% confidence interval 2.44–3.95), and a significant improvement in 1-month survival rate (adjusted odds ratio 1.46; 95% confidence interval 1.05–2.03), but no significant effect on favorable neurologic outcomes at 1 month (adjusted odds ratio 1.15; 95% confidence interval 0.70–1.88). Potential confounding factors included age categories, sex, bystander type, cause of cardiac arrest, bystander cardiopulmonary resuscitation, and attempted defibrillation.

Conclusions: Telephone dispatcher assistance could significantly increase bystander cardiopulmonary resuscitation among witnessed pediatric out-of-hospital cardiac arrests. Although there was only a small, nonsignificant effect on the improvement in favorable neurologic outcome at 1 month, the improved survival associated with telephone dispatcher assistance in pediatric out-of-hospital cardiac arrest is clinically important, and is of major public health importance. In cases where cardiac arrest was uncertain from the bystander's replies during the call to emergency medical services, telephone dispatcher assistance was not offered, which could affect the adjusted odds ratio of the present study. (Crit Care Med 2012; 40:000–000)

Key Words: bystander effect; cardiopulmonary resuscitation; heart arrest; pediatrics; survival rate; telephone

Sudden out-of-hospital cardiac arrest (OHCA) is associated with a high mortality rate, even when patients receive appropriate treatment in accord with the "chain of survival" concept, consisting of rapid access to the emergency medical service (EMS), cardiopulmonary resuscitation (CPR), and defibrillation. Although OHCA is one of the most common causes of death in middle and old age, it is uncommon in the young.

Most previous studies of pediatric OHCA typically examined relatively small datasets in North America (1–4). The survival rate to hospital discharge following pediatric OHCA was reported as approximately 10% (5, 6). Although recent studies reported the outcomes of pediatric OHCA in a prospective, population-based study in a large area (7, 8), data from a large, nationwide population-based study is still lacking. Recently, a cohort study of pediatric OHCA reported the characteristics and outcomes of pediatric OHCA (9). However, only a small study reported the impact of telephone dispatcher assistance on the outcomes of pediatric OHCA (10), whereas several studies have reported the impact on adult OHCA (11–14). The small pediatric study reported that although telephone dispatcher-assisted CPR instructions improves the numbers of children in whom bystander CPR is attempted, the effectiveness is likely to be limited by significant delays in actually delivering basic life support (10). However, this study was limited because of its size and was not a population-based study.

The aim of the present study was to assess the impact of CPR instruction by telephone dispatcher on the attempted rate of bystander CPR and the outcomes of pediatric OHCA events. We analyzed a Japan-wide population-based database of OHCA between 2005 and 2008.

PATIENTS AND METHODS

Study Design and Data Source

Japan has approximately 128 million residents in an area of 377,914 km². The Fire and

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Disaster Management Agency (FDMA) of Japan administers the EMS, providing the only ambulance service system in Japan. There are 807 local fire departments with dispatch centers, and this service can be accessed by all citizens. All OHCA cases transported to hospital by the EMS are recorded in a national OHCA database by the FDMA. In the present study, we extracted data from the national database to perform a nationwide, population-based observational study of all recorded cases of OHCA in Japan over a 4-yr period from January 2005 to December 2008.

Data were gathered by EMS personnel into a database belonging to local fire departments in Japan (15, 16). All data were verified and anonymized locally, then transferred and stored in the national OHCA database at the FDMA. We analyzed this database with the permission of the FDMA and the study was approved by the Ethical Committee of Nara Medical University (Authorization Code: 260).

Items and Outcome of the Database

The OHCA data entry form was largely based on the Utstein form (17), and extended to include details of OHCA of noncardiac origin and nonwitnessed cases (15, 16, 18). Thus the database included OHCA of cardiac and noncardiac origin, such as stroke, asphyxia, trauma, etc. In addition, the data included witnessed as well as nonwitnessed cases.

The main items of the database were as follows: patient information, including age and sex; the cause of OHCA (cardiac or noncardiac); the initially identified cardiac rhythm; whether OHCA was bystander witnessed or not; whether bystander CPR was performed; bystander category (whether they were a family member, a layperson other than family, or EMS personnel); the interval from a call to arrival of the EMS (minutes); and the outcome in terms of survival and cerebral performance category (CPC) level 1 month after OHCA. The initial cardiac rhythm data were categorized by EMS personnel, and included ventricular fibrillation (VF), pulseless ventricular tachycardia (VT), pulseless electrical activity, and asystole. Bystander CPR was defined as either chest compression only or mouth-to-mouth ventilation in the present study. The etiology of cardiac arrest was determined clinically by the physician in charge, in collaboration with EMS personnel.

The presence or absence of telephone dispatcher assistance was also recorded in the database. The FDMA provided a standard outline for telephone dispatcher assistance and recommended local fire departments to modify the contents of telephone dispatcher assistance according to the actual circumstances of the local area. Telephone dispatcher assistance was offered when the dispatcher judged the necessity of the assistance to the bystander of OHCA. The dispatcher asked the bystander whether they had any skill or knowledge to perform mouth-to-mouth ventilation. For a bystander with the skill and knowledge, the dispatcher offered instruction in CPR, including chest compression and mouth-to-mouth ventilation. For a bystander without the skill and knowledge, the dispatcher offered instruction in chest compression with or without mouth-to-mouth ventilation, depending on the operational procedure of the local fire department. In cases where a bystander refused to accept assistance, as a result of panic or a barrier to attempted CPR, such as being trapped, the dispatcher discontinued the offer of assistance. Dispatcher assistance for bystander CPR was not offered in cases where cardiac arrest was uncertain during the call.

Outcomes, including the 1-month survival and neurologic outcome, were collected by EMS personnel from the hospitals that received the patients, in cooperation with the physicians in charge of the patients. All OHCA patients were followed up by the EMS personnel in charge for up to 1 month to determine whether they survived after the OHCA event. The neurologic status was determined with the CPC at 1 month by follow-up interview.

Subjects

During the 4-yr study period, data of 431,950 patients who suffered an OHCA were included in the national database. Of these, 9,308 patients were younger than 20 yrs (defined as pediatric OHCA in the present study). To determine the impact of telephone dispatcher assistance, we selected witnessed pediatric OHCA patients, with cases of VF/VT, pulseless electrical activity, and asystole as initial cardiac rhythm, and an interval between the call to the EMS and their arrival on the scene of ≤60 min. We excluded cases with bystander-performed automatic external defibrillation, or with EMS personnel as a bystander, and cases of unknown etiology or malignant tumors. In total, data from 1,780 pediatric OHCA cases were analyzed. Figure 1 shows a flow diagram depicting the inclusion/exclusion criteria used in the present study.

Data Analysis

To assess the characteristics of witnessed pediatric OHCA patients, we stratified the cases into three age groups as follows: infants (<1 yr: 390 patients), children (1–11 yrs: 543 patients), and adolescents (12–19 yrs: 847 patients). For each group we determined the sex of the cases, whether bystander CPR was performed, whether an initial VF/VT cardiac rhythm was exhibited, and whether the cause of cardiopulmonary arrest was cardiac or noncardiac in origin. We measured outcomes in terms of the 1-month survival and favorable neurologic outcome at 1 month in the three groups. "Favorable neurologic outcome" was defined as category 1 (good cerebral performance) or 2 (moderate cerebral disability) of the CPC (19). These characteristics were compared according to the three age groups.

Statistical analyses were conducted using the chi-square test. Logistic regression analyses were performed to identify the effects of telephone dispatcher assistance on bystander CPR rate, using "not offered" as a reference. Potential confounding factors included age groups, sex, bystander type, cause of cardiac arrest, and the interval between call to the EMS and arrival at the scene. Logistic regression analyses were also performed to identify the effects of telephone dispatcher assistance for outcomes at 1 month, with the potential confounding factors of age groups, bystander CPR, attempted defibrillation, cause of cardiac arrest, and the time between call to the EMS and arrival at the scene. Statistical significance was defined as $p < .05$. All statistical analyses were conducted using PASW version 18 (SPSS, Chicago, IL).

RESULTS

Among the 1,780 witnessed pediatric OHCA patients, males accounted for 67.8%. The proportion of VF/VT as an initial cardiac rhythm was higher in adolescents (21.3%) than in infants (11.8%) and children (6.6%). The overall bystander-performed CPR rate of each maneuver, chest compression and mouth-to-mouth ventilation, were 39.4% and 25.5%, respectively.

The overall survival rate for all pediatric patients was 13.4%. Table 1 shows 1-month survival and favorable CPC rates by initial cardiac rhythm, bystander CPR, age group and cause of OHCA. Chest compression with mouth-to-mouth ventilation showed the highest survival and favorable CPC rates compared with other resuscitation maneuvers. Although the 1-month survival rates of OHCA of noncardiac and cardiac origin were very similar in infants and children, a marked difference in adolescent survival rates was seen in 1-month survival rates between OHCA of noncardiac (4.8%) and of cardiac origin (32.8%).

Telephone dispatcher assistance was offered in 505 cases among 1,780 witnessed pediatric OHCA cases (28.4%). In cases where telephone dispatcher assistance was given, the numbers of patients with VF/VT, pulseless electrical activity, and asystole as initial cardiac rhythm were 82 (16.2%), 131 (25.9%), and 292

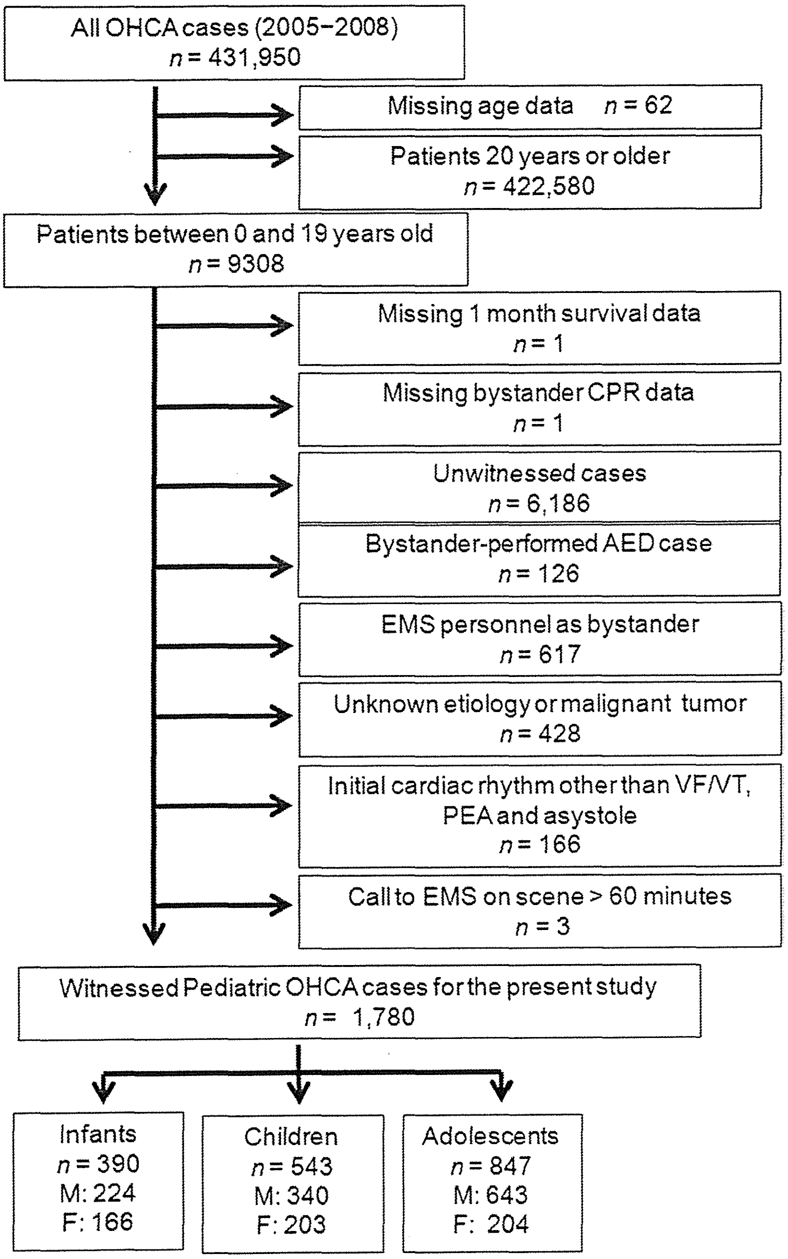

Figure 1. Flow diagram of inclusion/exclusion criteria. Infants, <1 yr; children, 1–11 yrs; adolescents, 12-19 yrs. *OHCA*, out-of hospital cardiac arrest; *CPR*, cardiopulmonary resuscitation; *AED*, automatic external defibrillation; *EMS*, emergency medical service; *VF*, ventricular fibrillation; *VT*, pulseless ventricular tachycardia; *PEA*, pulseless electrical activity; *M*, male; *F*, female.

(57.8%), respectively. In nonoffered cases, the numbers were 180 (14.1%), 366 (28.7%), and 729 (57.2%), respectively. Table 2 shows the rate of bystander-performed CPR and unadjusted 1-month outcomes by presence or absence of telephone dispatcher assistance in the witnessed pediatric OHCA. Thus, 27.8% (354 of 1275 cases) and 68.7% (347 of 505) received chest compression in nonoffered and offered cases of telephone dispatcher assistance, respectively; 18.4% (234 of 1275) and 43.6% (220 of 505) received mouth-to-mouth ventilation in nonoffered and offered cases, respectively. In nonoffered and offered cases of telephone dispatcher assistance, 16.2% (207 of 1275) and 37.6% (190 of 505) patients, respectively, received both chest compression and mouth-to-mouth ventilation. Telephone dispatcher assistance was mostly given to a family member. Telephone dispatcher assistance was associated with a significant increase in the rates of bystander-performed CPR, including chest compression (68.7% vs. 27.8% with no assistance, $p < .001$) and mouth-to-mouth ventilation (43.6% vs. 18.4% with no assistance, $p < .001$).

Tables 3 and 4 show the results of logistic regression analyses for bystander-performed CPR rate and for outcomes at 1 month. Telephone dispatcher assistance significantly increased both chest compression (odds ratio [OR] 6.04; 95% confidence interval [CI] 4.72–7.72) and mouth-to-mouth ventilation (OR 3.10; 95% CI 2.44–3.95) (Table 3). This was also associated with a significant improvement in 1-month survival (OR 1.46; 95% CI 1.05–2.03), although there was a smaller effect on the improvement in favorable neurologic outcome at 1 month (OR 1.15; 95% CI 0.70–1.88) (Table 4).

DISCUSSION

The present study clearly revealed that telephone dispatcher assistance improved the rate of bystander-performed CPR in witnessed cases of pediatric OHCA. When telephone dispatcher assistance was offered, the rate of bystander-performed chest compression and mouth-to-mouth ventilation increased, with a concomitant increase in 1-month survival rate.

Several papers have described the effects of dispatcher-assisted telephone CPR instruction in adult OHCA cases (10–14). Generally, dispatcher-assisted telephone CPR instruction can increase the frequency of bystander-performed CPR, resulting in an improved survival rate from OHCA. One study reported that dispatcher-assisted, bystander-performed CPR was associated with a 25% increase in the proportion of arrest patients who received bystander CPR, and concluded that dispatcher-assisted, bystander-performed CPR seems to increase survival after a cardiac arrest (11). However, only a small study described the impact of telephone dispatcher assistance on the outcomes of survival rate and neurologic status as well as the rate of bystander-performed CPR after a pediatric OHCA event (10).

Although the present study analyzed witnessed cases of pediatric OHCA, the rate of bystander-performed CPR was 27.8% and 18.4% for chest compression and mouth-to-mouth ventilation, respectively, in cases where telephone dispatcher assistance was not offered. The rate in the present study was similar to a previous report that only 17% of pediatric

Table 1. Overall 1-month survival and favorable cerebral performance category rates by initial cardiac rhythm and each bystander cardiopulmonary resuscitation

Variable	n (%)	1-Month Survival	Favorable Cerebral Performance Category
Initial cardiac rhythm, n (%)			
Ventricular fibrillation/pulseless ventricular tachycardia	262 (14.7)	101 (38.5)	66 (25.2)
Pulseless electrical activity	497 (27.9)	59 (11.9)	18 (3.6)
Asystole	1021 (57.4)	79 (7.7)	17 (1.7)
Bystander cardiopulmonary resuscitation, n (%)			
No bystander cardiopulmonary resuscitation	1022 (57.4)	91 (8.9)	32 (3.1)
Chest compression only	304 (17.1)	51 (16.8)	26 (8.6)
Mouth-to-mouth ventilation only	57 (3.2)	8 (14.0)	2 (3.5)
Chest compression with mouth-to-mouth ventilation	397 (22.3)	89 (22.4)	41 (10.3)
Age group, n (%)			
Infant			
Overall	390 (21.9)	54 (13.8)	19 (4.9)
Cardiac causes	235 (13.2)	34 (14.5)	14 (6.0)
Noncardiac causes	155 (8.7)	20 (12.9)	5 (3.2)
Children			
Overall	543 (30.5)	70 (12.9)	14 (2.6)
Cardiac causes	178 (10.0)	22 (12.4)	7 (3.9)
Noncardiac causes	365 (20.5)	48 (13.2)	7 (1.9)
Adolescent			
Overall	847 (47.6)	115 (13.6)	68 (8.0)
Cardiac causes	265 (14.9)	87 (32.8)	57 (21.5)
Noncardiac causes	582 (32.7)	28 (4.8)	11 (1.9)

Infants (<1 yr), children (1–11 yrs), adolescents (12–19 yrs).

Table 2. Bystander cardiopulmonary resuscitation and 1-month outcomes of patients with or without telephone instruction among the witnessed pediatric out-of-hospital cardiac arrest

Characteristic and outcome	Telephone Instruction: Not Offered (1275)	Telephone Instruction: Offered (505)	p
Bystander type, n (%)			
Nonfamily	794 (62.3)	142 (28.1)	
Family	481 (37.7)	363 (71.9)	<.001
Bystander cardiopulmonary resuscitation maneuver, n (%)			
Chest compression maneuver performed			
Overall	354 (27.8)	347 (68.7)	<.001
Nonfamily bystander	221 (27.8)	107 (75.3)	<.001
Family bystander	133 (27.7)	240 (66.1)	<.001
Mouth-to-mouth ventilation maneuver performed			
Overall	234 (18.4)	220 (43.6)	<.001
Nonfamily bystander	146 (18.4)	46 (32.4)	<.001
Family bystander	88 (18.3)	174 (47.9)	<.001
One-month outcomes, n (%)			
Survival			
Overall	143 (11.2)	96 (19.0)	<.001
Bystander type			
Nonfamily bystander	79 (9.9)	29(20.4)	.001
Family bystander	64 (13.3)	67 (18.5)	.044
Favorable cerebral performance category (cerebral performance categories 1 and 2)			
Overall	64 (5.0)	37 (7.3)	.068
Bystander type			
Nonfamily bystander	46 (5.8)	17 (12.0)	.011
Family bystander	18 (3.7)	20 (5.5)	.243

p values were calculated by chi-square test.

OHCA patients received bystander CPR, even when the event occurred at home with family members (20). In the present study, the overall rate of bystander-performed CPR increased with telephone dispatcher assistance from 27.8% to 69.0% for chest compression, and from 18.4% to 43.8% for mouth-to-mouth ventilation, compared with cases without telephone assistance. Subsequently, telephone dispatcher assistance significantly improved overall unadjusted 1-month survival rates, whereas no significant difference was observed for favorable neurologic outcome. The multivariate adjusted OR for survival was 1.46 (95% CI: 1.05–2.03, $p = .02$) for telephone dispatcher assistance offered to OHCA cases using not-offered cases as reference, whereas no significant effect was observed for favorable neurologic outcome. A possible reason for the lack of improvement in neurologic outcome might be the quality of CPR performed by the bystander. To improve the rates of favorable neurologic outcome, further effort may be necessary, e.g., effective public training program of bystander CPR to improve the quality of CPR for pediatric OHCA patients.

In the present study, telephone dispatcher assistance had a greater impact on the use of mouth-to-mouth ventilation in children aged 1–11 yrs than in the other age groups. Our detailed analysis (data not shown) indicated that nonfamily bystanders tended to attempt CPR for OHCA of cardiac origin rather than noncardiac origin, regardless of the patients' age. In contrast, a family bystander tended to attempt mouth-to-mouth ventilation in children regardless of the cause of the arrest. The results in Table 3 included cases with either family or nonfamily bystanders: the rate of mouth-to-mouth ventilation for children was affected by family bystander behavior. Even in analyses of family and nonfamily bystanders separately, telephone dispatcher assistance had a significant impact on the rate of performed bystander CPR. We think that further study will be necessary regarding this point, i.e., on which cases bystanders are willing to perform each resuscitation maneuver of chest compression and mouth-to-mouth ventilation.

Performing mouth-to-mouth ventilation can be one of the barriers to bystanders attempting CPR. Furthermore, chest compression with mouth-to-mouth ventilation may be regarded as a complex task that is difficult to teach, learn, and attempt. Therefore, chest compression only

Table 3. Multivariate logistic regression analyses for bystander cardiopulmonary resuscitation rate

Factor	n (%)	Chest Compression Attempt			Mouth-to-Mouth Ventilation Attempt		
		Odds Ratio	95% Confidence Interval	p	Odds Ratio	95% Confidence Interval	p
Telephone instruction							
Not offered	1275 (71.6)		Reference			Reference	
Offered	505 (28.4)	6.04	4.72–7.72	<.001	3.10	2.44–3.95	<.001
Age group							
Infants	390 (21.9)		Reference			Reference	
Children	543 (30.5)	1.10	0.82–1.48	.54	1.47	1.08–1.99	.01
Adolescents	847 (47.6)	0.98	0.73–1.33	.91	0.86	0.62–1.19	.36
Sex							
Male	1207 (67.8)		Reference			Reference	
Female	573 (32.2)	1.03	0.82–1.30	.79	1.04	0.82–1.32	.76
Bystander type							
Nonfamily	844 (47.4)		Reference			Reference	
Family	936 (52.6)	0.69	0.53–0.90	.01	0.94	0.72–1.24	.68
Causes of arrest							
Noncardiac	1102 (61.9)		Reference			Reference	
Cardiac	678 (38.1)	2.67	2.13–3.35	<.001	1.91	1.51–2.42	<.001
Call to emergency medical service on scene time (1-min increase)		1.03	1.01–1.06	.01	1.03	1.00–1.05	.07

Infants (<1 yr), children (1–11 yrs), adolescents (12–19 yrs). Odds ratios were obtained by multivariate logistic regression analyses with potential confounding factors, including age group, sex, bystander type, cause of cardiac arrest, and the interval between call to the emergency medical service and arrival at the scene.

Table 4. Multivariate logistic regression analyses for outcomes at 1 month

Factor	n (%)	Survival at 1 Month			Favorable Cerebral Performance Category at 1 Month		
		Odds Ratio	95% Confidence Interval	p	Odds Ratio	95% Confidence Interval	p
Telephone instruction							
Not offered	1275 (71.6)		Reference			Reference	
Offered	505 (28.4)	1.46	1.05-2.03	.02	1.15	0.70–1.88	.58
Age group							
Infants	390 (21.9)		Reference			Reference	
Children	543 (30.5)	1.06	0.71-1.59	.77	0.62	0.30–1.29	.20
Adolescents	847 (47.6)	0.77	0.51-1.15	.20	1.06	0.58–1.95	.85
Bystander cardiopulmonary resuscitation							
Not performed	1022 (57.4)		Reference			Reference	
Performed	758 (42.6)	1.79	1.29-2.48	<.001	2.01	1.21–3.34	.01
Defibrillation							
Not performed	1503 (84.4)		Reference			Reference	
Performed	276 (15.5)	4.20	2.88-6.13	<.001	6.89	4.01–11.86	<.001
Causes of arrest							
Noncardiac	1102 (61.9)		Reference			Reference	
Cardiac	678 (38.1)	1.37	0.98-1.91	.06	2.18	1.24–3.82	.01
Call to emergency medical service on scene time (1-min increase)		0.84	0.80-0.89	<.001	0.82	0.75–0.90	<.001

Odds ratios were obtained by multivariate logistic regression analyses with potential confounding factors, including age groups, bystander cardiopulmonary resuscitation, attempted defibrillation, cause of cardiac arrest, and the time between call to the emergency medical service and arrival at the scene.

was recommended for bystander CPR in OHCA, especially for cases of cardiac origin (21). Recently, however, a few studies reported that chest compression with mouth-to-mouth ventilation is associated with better outcomes for selected patients, such as pediatric patients (18, 22). Thus, instruction for mouth-to-mouth ventilation may be included in dispatcher-assisted instruction during pediatric OHCA where bystanders are willing to attempt CPR.

In literature describing pediatric OHCA, the neurologic outcome was generally determined by pediatric CPC (PCPC) (23, 24), developed from the CPC for adult patients. The adult CPC consists of five categories: 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; the PCPC has one additional category for mild disability. This category was added because even mild functional impairment has a more significant impact on development in children than in adults. The neurologic outcome in the present study was not defined by the PCPC, thus we could not compare the present result with previous studies that used the PCPC. In this regard, outcomes for pediatric patients, such as PCPC and pediatric overall performance category, should be added to the database used in the present study.

The overall survival rates were very similar in infants, children, and adolescents in the witnessed pediatric OHCA, but the survival rates of noncardiac and cardiac origin OHCA in adolescents were lower and higher, respectively, than in infants and children. The higher VF/VT rate in adolescents compared with infants and children could account for the difference in survival rates. The present result also indicated that presentation with a VF rhythm could be a predictor of survival after an OHCA event in pediatric patients.

Limitations

Several limitations of our study should be acknowledged. First, the database did not include information about the bystander, i.e., age and gender, quality of bystander CPR, including chest compression and mouth-to-mouth ventilation, or whether the bystander had taken a basic life support or advanced life support training course previously. In the case where a bystander was a child, the EMS dispatcher might discontinue telephone assistance. Therefore, we could not assess whether telephone dispatcher assistance improved the quality of bystander CPR and whether age and gender of the bystander affected the outcomes. Second, in cases where cardiac arrest was uncertain from the bystander's replies during the call to EMS, telephone dispatcher assistance was not offered, resulting in lower 1-month survival rates than if assistance had been offered in all cases of OHCA. There was no information in the database regarding the number of OHCA cases in which assistance was not offered due to this uncertainty. Although we suppose that the percentage of these cases among the OHCA in the present study was not very high, this could affect the adjusted OR of the present study. Third, the neurologic outcome in the database was not defined by PCPC (23), thus we could not compare our results with previous results that used PCPC. Fourth, the content of telephone dispatcher assistance might vary among local dispatch centers, i.e., whether the instruction to perform mouth-to-mouth ventilation was offered to a bystander lacking the skill and knowledge. The database did not include this information, thus we could not assess what types of instruction were effective to facilitate the bystander CPR. Fifth, the outcomes, such as survival and neurologic outcomes, in pediatric OHCA might vary among hospitals, with the medical staff in children's hospitals or certain emergency centers with tertiary care having a greater knowledge and experience of pediatric OHCA patient care compared with staff in general hospitals. Donoghue et al (25) reported the effect of hospital and physician staffing characteristics on 24-hr survival after in-hospital CPR in children, where improved survival was associated with the presence of pediatric residents and fellows. The database also did not include hospital information, such as physician staffing characteristics. As such, we were unable to adjust for this factor in the present study. However, we assumed that the characteristics were distributed similarly among infants, children, and adolescents because the current database was huge and nationwide, thus we believe that any differences in hospital characteristics did not affect the results. Sixth, there was no intervention in the present study because the study was an observational study using a nationwide, population-based, prospectively registered database. Therefore, interventions, such as a randomized controlled trial, may be needed to confirm the present results.

CONCLUSION

Telephone dispatcher assistance could significantly increase the rate of bystander-performed CPR among witnessed pediatric OHCAs. Although there was a small, nonsignificant effect on the improvement in favorable neurologic outcome at 1 month, the improved survival associated with telephone dispatcher assistance in pediatric OHCA is clinically important, and is of major public health importance.

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総　説

病院外心停止傷病者への胸骨圧迫のみと従来法（胸骨圧迫＋人工呼吸）の予後に関する一考察

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抄　録：病院外で発生した心停止傷病者（病院外心停止傷病者）に対する一般市民による心肺蘇生の予後に与える影響について，胸骨圧迫のみと従来法（胸骨圧迫および人工呼吸）の両手技の効果について議論となっており，決着がついていない。本稿では，筆者らが2011年に英国医学雑誌（BMJ）に発表した胸骨圧迫のみと従来法の予後を比較した研究結果を中心に概説する。

従来法実施症例は胸骨圧迫のみ実施症例に比べて１カ月生存率が高く，有意差がみられた（8.7% vs 10.3%，調整済みオッズ比：1.17, 95%信頼区間：1.06 ～ 1.29）。脳機能カテゴリー良好割合でも同様に有意差がみられた（4.6% vs 5.6%，調整済みオッズ比：1.17, 95%信頼区間：1.01 ～ 1.35）。また，非心原性症例では年齢が若くなるほどその予後が良く有意差（P=0.025）がみられたほか，目撃から心肺蘇生開始までの時間が長いほど，非心原性（P=0.015）および全症例（P=0.037）で従来法の予後が良く，有意差がみられた。

【結論】従来法の心肺蘇生は，胸骨圧迫のみに比べ全体として予後が良く，有意差がみられた。この傾向は，若年層の非心原性症例や目撃から時間が経過した全症例および非心原性症例で顕著であった。本研究の結果は，今後のガイドライン作成等に活用できるものと期待される。

キーワード：心肺蘇生，バイスタンダー，胸骨圧迫，人工呼吸，生存率
Key words：cardiopulmonary resuscitation（CPR），bystander，chest compression only CPR，conventional CPR，survival rate

はじめに

病院外で発生した心停止傷病者（病院外心停止傷病者）に対しては，早期の通報や，心肺蘇生，除細動，高度医療処置のいずれもが円滑に実施されることが重要であり，これらは「救命の連鎖」と呼ばれている[1)]。このうち，早期の通報や，心肺蘇生，除細動については，心停止時点で近くにいた通行人や家族などのいわゆるバイスタンダーの役割が重要である[2)]。

バイスタンダーによる心肺蘇生については，従来は人工呼吸と胸骨圧迫を併用した心肺蘇生（以下，従来法）が推奨されてきたが，昨今は胸骨圧迫のみの心肺蘇生も普及しつつある。その理由として，人工呼吸の実施が，一般市民には技術的にやや難しいことや，感染症の危険性などが心理的な抵抗となり心肺蘇生の実施率の低迷や実施遅れの原因となることが懸念されていることがあげられる[3, 4)]。また，従来法と胸骨圧迫のみの予後の比較において，条件によっては胸骨圧迫のみのほうが良いとの報告[5)]，あるいはほぼ同等との研究結果が報告され

Analysis of outcomes of chest compression only CPR versus conventional CPR conducted by lay people in patients with out of hospital cardiopulmonary arrest witnessed by bystanders
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ていることも大きな理由である[6-8]。これらを踏まえ，アメリカ心臓病学会（AHA：American Heart Association）の2005年の心肺蘇生ガイドライン[9]では，バイスタンダーによる心肺蘇生は従来法が良いとしながらも，胸骨圧迫のみの心肺蘇生も推奨している。また，2008年のAHAの科学調査委員会（Science Research Committee）[10]によると，従来法は十分に訓練を受け，また実施が可能であると自ら判断したバイスタンダーにより実施されるべきで，一般のバイスタンダーによる心肺蘇生は胸骨圧迫のみで良いと結論づけられている。しかしながら，従来法のほうが胸骨圧迫のみによる心肺蘇生よりも予後が良いとの意見も根強く残っている[11]。

このような状況において，筆者らは，わが国の「救急蘇生統計」の2005～2007年のデータを用いて胸骨圧迫のみと従来法の予後の比較を実施し，その結果を2011年2月に英国医学雑誌（BMJ）に発表した（以下，BMJ研究）[12]。本稿では，筆者らの研究結果を概観したうえで2010年のAHAガイドラインを踏まえ，バイスタンダーによる心肺蘇生について考察を行う。

1．BMJ発表論文で用いた方法

1）分析対象

わが国において院外発生で救急搬送されたすべての心停止傷病者の情報は，総務省消防庁により集計され「救急蘇生統計」として整備されている。「救急蘇生統計」は平成17年（2005年）より集計が開始されており，心停止傷病者を搬送した各消防本部によって，ウツタイン様式でのデータ収集・入力が実施されている。「救急蘇生統計」には，傷病者の性，年齢などの基本情報に加え，心停止の目撃に関する情報，バイスタンダーの種別と実施された心肺蘇生の内容，初期心電図波形，救命救急処置等の内容，目撃，覚知から病院収容に至るまでの時間経過，心停止の推定原因，１ヶ月後の転帰および予後などの情報が収載されている。データには，消防隊員によりバイスタンダーや担当医師へのインタビュー等で収集されたものも含まれている。「救急蘇生統計」における予後としては，心停止の発生より１ヶ月後の生存の有無と，グラスゴー・ピッツバーグ脳機能・全身機能カテゴリ－による脳機能，全身機能の評価が収載されている。そのうち脳機能カテゴリー（CPC：cerebral performance categories）とは，発生より１ヶ月後の脳機能の状態を，CPC 1は機能良好，CPC 2は中等度障害，CPC 3は高度障害，CPC 4は昏睡，植物状態，CPC 5は死亡もしくは脳死，の5段階で評価されている。収集された情報は救急隊員によりオンラインなどで入力され，匿名化された後に消防庁に送られる。消防庁ではデータのチェックを行い，必要に応じて消防本部に再確認し，その精度向上を図っている。筆者らはBMJ研究の執筆に際し，総務省消防庁に対してこのデータ利用申請を行い，使用許可を得て分析を実施した。なお，BMJ研究は公立大学法人奈良県立医科大学倫理委員会の承認を受けて実施した（承認番号：260）。

BMJ研究で用いた「救急蘇生統計」の2005～2007年データには，318,141例の心停止傷病者の情報が収載されている。BMJ研究では，これらのデータのうち，家族，同僚，友人，通行人など一般市民により心停止を目撃され，また一般市民により胸骨圧迫のみ，あるいは従来法（胸骨圧迫および人工呼吸）のいずれかを実施された症例を抽出した。非目撃症例（190,646例）や救急隊員などによる目撃症例（25,521例），目撃した人が不明な症例（193例）などは除外し，さらにバイスタンダーによる心肺蘇生が実施されなかった症例（56,851例）と，人工呼吸だけ実施された症例（1,670例），さらに心肺蘇生を実施したバイスタンダーが不明な症例（3,225例）を分析から除外した。その結果，胸骨圧迫のみの実施の20,707例，従来法の実施19,328例を分析対象症例として抽出した。なお，これらの分析対象症例にはすべての年齢層が含まれているほか，心停止の原因としては心原性のみならず，溺水や呼吸器系疾患，循環器系疾患など非心原性症例が含まれている。

2）統計解析

BMJ研究においては，一般市民により目撃され，かつ胸骨圧迫のみあるいは従来法の心肺蘇生を実施された症例の予後を比較した。分析に用いた予後としては，１ヶ月後の生存率と脳機能カテゴリー良好

	胸骨圧迫のみ	従来法	調整済みオッズ比	
			ratio	p
一ヶ月生存率	8.7% (1799/20707)	10.3% (1997/19327)	1.17 (1.06-1.29)	0.002*
脳機能カテゴリー良好割合	4.6% (943/20662)	5.6% (1070/19247)	1.17 (1.01-1.35)	0.037*

＊有意差あり

表１　胸骨圧迫のみと従来法（胸骨圧迫＋人工呼吸）の予後比較（小川ら[12]より筆者改変）

割合（CPC 1 あるいは 2）[13]を用いた。分析にあたり，心停止傷病者は原因別（心原性，非心原性）ごとに分析したほか，心停止傷病者を 20 歳ごとの年齢階級群（1 ～ 19 歳，20 ～ 39 歳，40 ～ 59 歳，60 ～ 79 歳，80 ～ 99 歳，100 歳以上）で分析した。また，バイスタンダーによる目撃からバイスタンダーによる心肺蘇生実施までの経過時間を２分ごとの時間階級群（0，１～２分，３～４分，５～６分，７～８分，9 ～ 10 分）で分析を実施した。なお，バイスタンダーによる目撃から心肺蘇生実施までの時間が 10 分以上の症例（3,237 例）と，経過時間が不明の症例（1,387 例）は，時間階級群の分析からは除外した。

統計解析にあたり，有意差の検定方法として，カイ二乗検定および信頼区間 95％のオッズ比を算出し $p<0.05$ を有意差とした。平均値の比較には，独立したサンプルの t 検定を実施した。予後の比較は，ロジスティック回帰分析により信頼区間 95％の調整済みオッズ比を算出して比較した。両手技の比較にあたっては，ロジスティック回帰分析により予後に関連する各種要因を調整した。また心肺蘇生と年齢群，心肺蘇生と経過時間それぞれの交互作用について，交絡因子を調整した多項相互作用分析（multi-adjusted interaction model）を実施した。これらの統計解析はすべて PASW v.18（現 SPSS v. 18，IBM 社）を用いた。

２．BMJ 発表論文で得られた結果

胸骨圧迫のみと従来法の実施症例の１カ月生存率を比較すると，従来法実施症例の１カ月生存率が高く，有意差がみられた（8.7% vs 10.3%，調整済みオッズ比：1.17，95％信頼区間：1.06 ～ 1.29，表１）。同様に，脳機能カテゴリー良好割合も従来法実施症例が高く，有意差がみられた（4.6% vs 5.6%，調整済みオッズ比：1.17，95％信頼区間：1.01 ～ 1.35，表１）。

次に，脳機能カテゴリー良好割合を用いて，年齢階級別・原因別にその予後を比較した結果，非心原性症例では年齢が若くなるほどその予後が良く，有意差がみられた（P=0.025）。一方，全症例（P=0.109）と心原性症例（P=0.951）では有意差はみられなかった（図１）。また，目撃から一般市民による心肺蘇生法開始までの時間が長いほど，非心原性（P=0.015）および全症例（P=0.037）で従来法の予後が良く，有意差がみられた。一方で心原性症例では有意差がみられなかった（P=0.369，図１）。

３．考　察

BMJ 研究によると従来法は胸骨圧迫のみに比べ全体として予後が良く，有意差がみられ，この傾向は，若年層の非心原性症例や，目撃から時間が経過した全症例および非心原性症例で顕著であった。本研究の結果は，胸骨圧迫のみと従来法の両手技の予後がほぼ同等である[6-8]，あるいは胸骨圧迫のみのほうが予後は良い[5]という既存研究とは異なった傾向であることが示唆された。その理由は，分析に用いたサンプルサイズの違いがまず考えられる。BMJ 研究では，2005 年から 2007 年の３年間でわが国において院外発生の救急搬送された全心停止傷病者のうち，一般市民により目撃され，かつ心肺蘇生が実施された症例を抽出しており，分析対象の症例数は両群を合わせて約４万件であった。この症例数はこれまでにわが国[5,7]や北欧[6,8]，シンガポール[14]などで実施されたどの既存研究よりも大きな

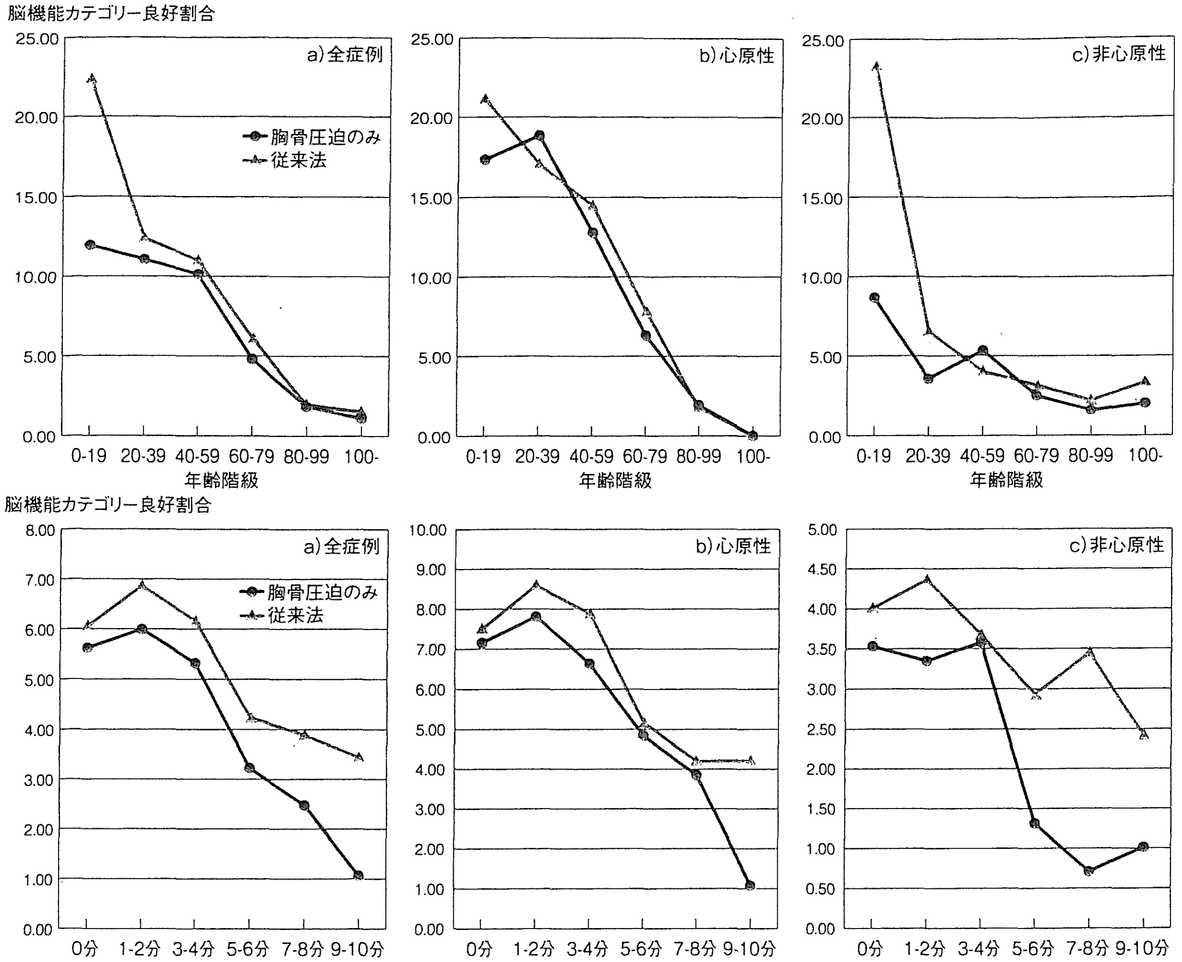

図１　胸骨圧迫のみと従来法の年齢階級別（上段），時間階級別（下段）の予後比較（総数，心原性，非心原性）（小川ら[12]より筆者改変）

ものであり，そのため統計的に有利であったといえよう。また，わが国で発生した全症例を用いた分析であることから，症例選択によるバイアスは最小に抑えられていると考えられる。

BMJ 研究により，20 歳未満の若年層かつ非心原性の症例においては，従来法は胸骨圧迫よりも予後が良いことが示唆された。特に若年層において，溺水や外傷などを含む外因性の非心原性症例において従来法の予後が胸骨圧迫のみに比べて顕著に良い傾向が見られたことから，これらの症例の予後が従来法全体の予後を引き上げた可能性が考えられる。なお，若年層での両手技の予後については，北村らが同じ救急蘇生統計の 17 歳以下の症例を用いて分析しているが，彼らも BMJ 研究と同様に従来法の予後が良いと結論づけている[15]。

20 歳以上の成人症例については，BMJ 研究により胸骨圧迫のみと従来法の両手技の予後に差がないことが示唆された。この結果は，わが国で 18 歳以上の心原性症例について石見ら[7]および SOS-KANTO[5]よって実施された既存研究の結果と同様であった。一方 Hupfl ら[16]は成人症例のメタアナリシスを実施し，胸骨圧迫のみのほうが従来法に比べて予後が良い，あるいはほぼ同等と結論づけている。この結果は BMJ 研究とは異なった結論であるが，その理由としては，メタアナリシスの対象文献では心原性のみを選択したものや，年齢の一部に限定した分析であったのに対して，BMJ 研究では心原性，非心原性の両方を含み，またすべての年齢を含む分析であったことが，その結果の違いを生んだと考えられる。

バイスタンダーによる目撃から心肺蘇生実施までの経過時間による胸骨圧迫のみと従来法の両手技の予後の違いについては，目撃から時間が経過した症例では，胸骨圧迫のみに比べて従来法の予後が全症

例と非心原性症例で良い傾向がみられ，特に非心原性症例でその傾向が顕著にみられた。一方SOS-KANTOでは，バイスタンダーにより目撃から4分以内に心肺蘇生が実施された症例では，胸骨圧迫のみの予後が従来法よりも良いと報告されており，BMJ研究とは異なる結果であった。この理由は，BMJ研究ではすべての年齢階級を含んでいるのに対して，SOS-KANTOでは成人症例のみによる分析であり，この分析対象群の違いによるものと考えられる。

2010年のAHAガイドライン[17]によれば，心肺蘇生を含むBLS（basic life support）の手順としては，従来のA-B-C（気道，呼吸，胸骨圧迫）から，C-A-B（胸骨圧迫，気道，呼吸）に変更することを勧告している。その理由としては，心停止症例の多くが成人の心室細動（VF）あるいは無脈性心室頻拍（VT）症例であり，これらの症例に対しては迅速な胸骨圧迫と除細動が重要とされているからであり，その観点から気道確保，人工呼吸を優先して実施する従来のBLS手順よりも胸骨圧迫を優先することは適切であると結論づけている。また，心停止傷病者の多くがバイスタンダーによる心肺蘇生を受けてないとの報告もあり，その理由が十分な訓練を受けていないバイスタンダーにとっては気道確保や人工呼吸の実施が困難であることがあげられる。

BMJ研究では，成人症例では胸骨圧迫のみと従来法の予後には差がみられなかったことから，2010年のAHAガイドラインのBLS手順の変更は，成人に対しては問題ないと思われる。しかしながら，BMJ研究により20歳未満の症例に対しては従来法の予後が良いという結果が示されたことで，若年層に対するBLS手順は従来通りのA-B-C（気道，呼吸，胸骨圧迫）を維持することを再検討すべきであると考えられよう。

なお，BMJ研究には以下の課題が存在する。BMJ研究では，「救急蘇生統計」に収載されている院外発生で救急搬送された心停止傷病者のうち，一般市民による目撃症例を用いて分析したが，一般市民にとっては救急の現場で患者の心肺機能が停止したかどうかの判断が難しいため，一部心肺機能が停止しなかった症例が混在している可能性がある。そのためBMJ研究の結果はやや過剰評価の可能性があるが比較研究であることから，これらの非停止症例は両群に均等に存在すると考えられ，両群比較の結果には影響はないと思われる。第二に，年齢別の分析においては，40歳未満の症例数が少ないため，これらの年齢群においては交絡因子の影響が大きいと予想される。第三に，目撃からバイスタンダーによる心肺蘇生実施までの経過時間に関する分析においては，時間情報はバイスタンダーに対する聞き取り調査により把握しており，救急の現場でこれらの時間が正確には把握できていない可能性がある。第四に交絡因子の選択については，医学的な見地から実施したが，必要な交絡因子をすべて選択できたかどうかは十分に検討できない。第五に，心停止傷病者の予後は，実施された心肺蘇生の質に左右されるといわれている[18]が，「救急蘇生統計」においては実施された心肺蘇生の質に関する情報は存在しない。したがって，実施された心肺蘇生はすべて同じ質であったと仮定した。第六に，胸骨圧迫のみと従来法の両群の予後は全症例で差がみられたが，その差は調整前後ともあまり大きくないのが現状で，そのためType 1エラーの危険性が存在する。このためには，さらなるデータ収集と解析が必要であろう。第七に，予後として用いた生存率や脳機能カテゴリー良好割合は発生から1ヶ月後のものであり，本来はより長期の予後について検討すべきと考えられる[19]が，「救急蘇生統計」では1ヶ月後の予後のみが記載されているため，より長期の予後については検討できないのが現状である。最後に，わが国の全国データを用いた分析であったため，他国への適用が可能かどうかについては不透明である。

4．結　論

BMJ研究により，院外発生の心停止傷病者に対してバイスタンダーによる従来法（胸骨圧迫＋人工呼吸）の予後は，胸骨圧迫のみに比べて良いことが示唆された。特に，非心原性の若年層，あるいは非心原性で目撃からある程度経過してから心肺蘇生を実施された症例で，従来法の予後が胸骨圧迫のみに比べて良いことが示唆された。この結果は，今後の

ガイドライン作成等に活用できるものと期待される。

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Selected Topics: Prehospital Care

COMPARISON OF NEUROLOGICAL OUTCOME BETWEEN TRACHEAL INTUBATION AND SUPRAGLOTTIC AIRWAY DEVICE INSERTION OF OUT-OF-HOSPITAL CARDIAC ARREST PATIENTS: A NATIONWIDE, POPULATION-BASED, OBSERVATIONAL STUDY

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□ Abstract—Background: The effect of prehospital use of supraglottic airway devices as an alternative to tracheal intubation on long-term outcomes of patients with out-of-hospital cardiac arrest is unclear. Study Objectives: We compared the neurological outcomes of patients who underwent supraglottic airway device insertion with those who underwent tracheal intubation. Methods: We conducted a nationwide population-based observational study using a national database containing all out-of-hospital cardiac arrest cases in Japan over a 3-year period (2005–2007). The rates of neurologically favorable 1-month survival (primary outcome) and of 1-month survival and return of spontaneous circulation before hospital arrival (secondary outcomes) were examined. Multiple logistic regression analyses were performed to adjust for potential confounders. Advanced airway devices were used in 138,248 of 318,141 patients, including an endotracheal tube (ETT) in 16,054 patients (12%), a laryngeal mask airway (LMA) in 34,125 patients (25%), and an esophageal obturator airway (EOA) in 88,069 patients (63%). Results: The overall rate of neurologically favorable 1-month survival was 1.03% (1426/137,880). The rates of neurologically favorable 1-month survival were 1.14% (183/16,028) in the ETT group, 0.98% (333/34,059) in the LMA group, and 1.04% (910/87,793) in the EOA group. Compared with the ETT group, the rates were significantly lower in the LMA group (adjusted odds ratio 0.77, 95% confidence interval [CI] 0.64–0.94) and EOA group (adjusted odds ratio 0.81, 95% CI 0.68–0.96). Conclusions: Prehospital use of supraglottic airway devices was associated with slightly, but significantly, poorer neurological outcomes compared with tracheal intubation, but neurological outcomes remained poor overall. © 2012 Elsevier Inc.

□ Keywords—out-of-hospital cardiac arrest; tracheal intubation; supraglottic airway device; neurological outcome; airway management

INTRODUCTION

Tracheal intubation has long been considered the gold standard for airway management during resuscitation after cardiac arrest. However, this method is now being

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