Clinical paper

Impact of different medical direction policies on prehospital advanced airway management for out-of hospital cardiac arrest patients: A retrospective cohort study

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Abstract

Background: Although optimal prehospital airway management after out-of-hospital cardiac arrest (OHCA) remains undetermined, no studies have compared different advanced airway management (AAM) policies adopted by two hospitals in charge of online medical direction by emergency physicians. We examined the impact of two different AAM policies on OHCA patient survival.

Methods: This observational cohort study included adult OHCA patients treated in Okayama City from 2013 to 2016. Patients were divided into two groups: the O group - those treated on odd days when a hospital with a policy favoring laryngeal tube ventilation (LT) supervised, and the E group - those treated on even days when the other hospital with a policy favoring endotracheal intubation (ETI) supervised. Multiple logistic regression analysis was performed to assess airway device effects. The primary outcome measure was seven-day survival.

Results: Of 2,406 eligible patients, 50.1% were in the O group and 49.9% were in the E group. O group patients received less ETI (1.0% vs. 12.0%) and more LT (53.3% vs. 43.0%) compared with E group patients. In univariate analysis, no differences were observed in seven-day survival (9.4% vs 10.1%). Multiple regression analysis revealed neither LT nor ETI had a significant independent effect on seven-day survival, considering bag-valve mask ventilation as a reference (OR, 0.78; 95% CI, 0.54 to 1.13, OR, 0.79; 95% CI, 0.36 to 1.72, respectively).

Conclusion: Despite different advanced airway medical direction policies in a single city, there were no substantial impact on outcomes for OHCA patients.

Keywords: Medical direction, Out-of-hospital cardiac arrest, Advanced airway management, Emergency medical services

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health concern in many countries.[1,2] Although significant progress has been made in managing patients after OHCA over the past couple of decades, the survival rate remains considerably poor.[3] Prehospital care for OHCA provided by emergency medical services (EMS) personnel has been recognized to play an important role in the chain of survival.[4] EMS personnel generally care for OHCA patients under regional protocols and remote support using mobile phones described as online medical direction by a physician.[5] Previous studies have demonstrated that real-time medical supervision by emergency physicians contributes to beneficial effects on patient outcomes after OHCA.[6,7]

Prehospital airway management is considered a crucial component of prehospital care for OHCA.[8] However, optimal airway management (i.e., supraglottic airway (SGA) devices such as i-gel and laryngeal tube (LT) vs. endotracheal intubation (ETI) vs. bag-valve mask (BVM) ventilation) may still be regarded as uncertain, given the results of three recent randomized clinical trials (RCTs).[8,9,10] In Japan, specially-trained EMS personnel known as emergency life-saving technicians (ELSTs) are permitted to perform advanced airway management (AAM) under real-time supervision by a physician.[11] Remarkably, this system of online medical control varies from region to region: it is operated by a regional dispatch center in Tokyo, whereas it is conducted by each base hospital in Osaka.[5] Meanwhile, Okayama City has a unique system: two tertiary hospitals are in charge of direct medical control, alternating on odd and even days within each calendar month. Of note, the two hospitals have different policies for prehospital AAM, with one hospital in favor of ETI only under very limited circumstances. Considering our region-specific online medical control system and the fact that optimal airway management in the prehospital setting is still under debate, we conducted retrospective study to examine whether these different prehospital AAM policies affect the outcomes of patients after OHCA.

The aim of this study was to investigate the impact of the two different policies, comparing the effects of the policy "in favor of LT" and the policy "in favor of ETI" on the survival of OHCA patients. The differing policies of the two hospitals were applied patients in a pseudo-randomized manner based upon odd or even calendar days.

Methods

Study design, population, and setting

This was a retrospective cohort study using population-based data for OHCA patients in the urban and suburban city of Okayama, Japan. This study enrolled all OHCA patients that were resuscitated and transported by EMS personnel to acute care hospitals from January 1, 2013 to December 31, 2016. Patients under 18 years old and those with incomplete primary outcome data were excluded. The study was approved by the Ethics Committee of Okayama University (K1804-034). The requirement for written informed consent was waived.

General EMS system in Japan

Once an emergency call is received, the regional dispatch center sends the closest available ambulance from the local fire station to the scene 24/7. In general, each ambulance is staffed with a crew of three EMS personnel, including at least one ELST who is nationally certified for advanced life support. They are authorized to use semi-automated external defibrillators, place peripheral venous catheters, administer intravenous adrenaline, and establish advanced airways (i.e., ETI or SGA) for patients with OHCA under the remote supervision of a medical consultant. ETI is indicated for patients with asphyxia due to foreign-body airway obstruction or at the discretion of the medical director. When managing patients with OHCA, EMS personnel operate in accordance with Japanese cardiopulmonary resuscitation (CPR) guidelines as well as local specific protocols and real time medical control through remote consultation.[12] EMS personnel are obligated to resuscitate all patients with OHCA, unless there are obvious signs of death (i.e., decapitation

or rigor mortis). The EMS system in Japan has been described in detail previously.[12]

Regional EMS in Okayama city

Okayama City has a population of approximately 0.72 million within an area of 789 km^2. There are 20 local fire stations that respond to emergency calls, which are coordinated by a single dispatch center. To provide appropriate prehospital care, EMS personnel at the scene of OHCA are required to seek the involvement of medical directors (emergency physicians) at two different hospitals equipped with tertiary emergency medical facilities using a hands-free mobile phone. Each shift for online medical direction is assigned in a random fashion based on the calendar days. Specifically, Japanese Red Cross Okayama Hospital is responsible on odd days and Okayama University Hospitals on even days. The operation is changed at 8:30 am on a daily basis. Importantly, these two hospitals have different prehospital AAM policies. In particular, Japanese Red Cross Okayama Hospital has a policy that securing an airway by ETI should be limited to those OHCA patients with possible asphyxia. In contrast, Okayama University Hospital permits EMS personnel to perform ETI based upon the physician's judgement. Presumably, OHCA patients in Okayama City tended to receive LT in the prehospital setting on odd days instead of ETI and vice versa on even days. These different AAM policies attributed to the inconsistent results of previous studies and the fact that the medical directors at Japanese Okayama Red Cross hospital had raised concerns regarding adverse events associated with ETI such as tube misplacement, dislodgement, multiple intubation attempts, and hypoxia.[11,13] The other policies including adrenaline administration were not different between the two hospitals. This medical direction system has been implemented since 2006 and these different AAM policies have been effective since 2013. The schematic summary is illustrated in Supplement 1.

Data collection

According to the Utstein style template, data are collected in the database of the OHCA registry in Okayama City, which is organized by the Okayama City Fire and Disaster Management Department.[14,15] As for prehospital airway management, only final device type used by each EMS personnel was available. Physicians in charge of the patients were required to report the etiology of each patient's cardiac arrest and their outcomes. Patients with cerebral performance category scores of 1 or 2 were regarded as having a favorable neurological outcome.[16,17] Return of spontaneous circulation (ROSC) was defined as the restoration of any spontaneous circulation regardless of its duration after OHCA.[18] Additional information in terms of percutaneous coronary intervention (PCI) availability of the destination hospital was obtained.

Patient grouping and endpoint

To compare the effects of different polices of the two hospitals in charge of providing real-time medical direction to the EMS personnel regarding prehospital AAM, OHCA patients were divided into two groups: those treated with medical direction from Japanese Red Cross Okayama Hospital on odd days (O group) and those by Okayama University Hospital on even days (E group). All OHCA patients were therefore assumed to be in a pseudo-random manner that is independent of any patient characteristics or EMS personnel preferences allocated to either of the two groups based upon the date of the event (technically, each day begins at 8:30 am as men-

tioned above). The primary outcome measure was seven-day survival. We chose this outcome, which data were routinely collected with minimum missing data, given our relatively small sample sizes.[8] Secondary outcome measures included one-month survival and one-month favorable neurological outcome.

Data analysis

Continuous variables were described using median with interquartile ranges (IQR) and the Mann-Whitney U test was used to compare the groups due to nonparametric data distribution. Categorical variables are presented as frequencies with percentages. To analyze the categorical variables, chi-square test was used and followed by residual analysis to identify the categories of significance. EMS call to hospital arrival time was divided into quartiles. A univariate analysis was performed for primary and secondary outcomes. A multiple logistic regression analysis was conducted estimating odds ratios (OR) and their 95% confidence intervals (CI) for seven-day survival adjusting for age, gender, initial rhythm, etiology, witness status, presence of bystander CPR, defibrillation, prehospital administration of adrenalin, airway management, hospital in charge of direct medical control, EMS call to hospital arrival, and availability of PCI at receiving hospital. A sensitivity analysis was undertaken excluding those who received BVM ventilation, because the patients who achieved early ROSC before hospital arrival were unlikely to receive AAM. Statistical analysis was performed using Stata version 17 (StataCorp LP, College Station, TX). P values below 0.05 were considered statistically significant.

Results

Of 2,449 OHCA patients treated between January 2013 to December 2016, a total of 2,406 patients met the criteria, 1,206 (50.1%) in the O group and 1,200 (49.9%) in the E group (Fig. 1). Table 1 shows patient characteristics. The median age of enrolled patients was 79 years, and 56.1% were male. Patient demographics, initial rhythm, proportion of patients with cardiac etiology, witnessed collapse, receiving bystander CPR, adrenaline, defibrillation, EMS call

to hospital arrival, and characteristics of receiving hospitals were similar between groups.

Of 2,406 patients, 1,316 received AAM, 1,159 (48.1%) with LT and 157 (6.5%) with ETI. Chi-square test demonstrated significant differences in prehospital airway management between groups. Consistent with each policy, residual analysis revealed that fewer patients received ETI in the O group compared with those in the E group (1.0% vs. 12.0%). In contrast, more patients received LT in the O group compared with those in the E group (53.3% vs. 43.0%) (Supplement 2).

In univariate analysis, no differences were observed in seven-day survival (9.4% vs. 10.1%), one-month survival (6.3% vs. 7.3%), and one-month favorable neurological outcome (3.2% vs. 3.4%) between the O group and the E group (Table 2).

Table 3 demonstrates the covariates associated with seven-day survival following OHCA. After adjusting for confounders, younger age, female gender, witnessed collapse, and ventricular fibrillation/ventricular tachycardia were significant predictors for seven-day survival. However, neither LT nor ETI insertion had significant independent effects on seven-day survival considering BVM ventilation as a reference (OR, 0.78; 95% CI, 0.54 to 1.13, OR, 0.79; 95% CI, 0.36 to 1.72, respectively). Furthermore, the hospital in charge of direct medical control was not a significant factor in determining seven-day survival, considering the O group as a reference (OR, 1.17; 95% CI, 0.84 to 1.65).

In further analysis excluding those who received BVM ventilation, univariate analysis identified no differences in seven-day survival (6.5% vs. 7.5%), ROSC (25.0% vs. 25.2%), one-month survival (3.5% vs. 4.7%), and one-month favorable neurological outcome (0.7% vs. 1.2%) between groups (Table 4). The results of multiple logistic regression analysis are shown in Table 5. Older age, unwitnessed collapse, and longer EMS call to hospital arrival were significantly associated with seven-day mortality. In contrast, prehospital AAM was not significantly associated with seven-day survival using LT insertion as a reference (OR, 1.05; 95% CI, 0.48 to 2.27). Similarly, the hospital in charge of direct medical control had no significant effect on seven-day survival, considering odd days as a reference (OR, 1.15; 95% CI, 0.71 to 1.84).
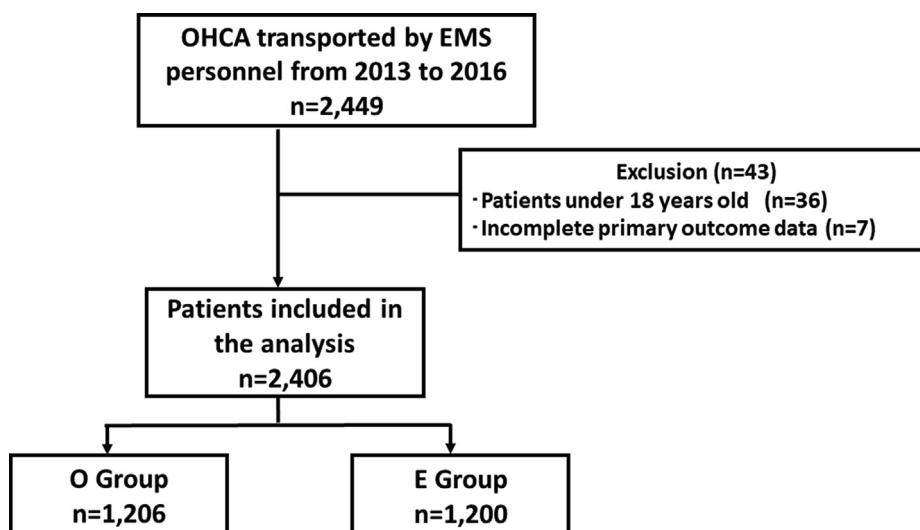

Fig. 1 – Study flowchart. OHCA: out-of-hospital cardiac arrest, EMS: emergency medical services.

Table 1 – Demographics and characteristics of OHCA patients.

Characteristic	All (n = 2,406)	O group (n = 1,206)	E group (n = 1,200)
Male gender, n (%)	1,352 (56.1)	671 (55.6)	681 (56.7)
Age – median [IQR], y	79 [67–87]	80 [67–87]	79 [67–86]
Initial rhythm, n (%) [a]			
VF/VT	140 (6.1)	73 (6.4)	67 (5.8)
PEA/Asystole	2,126 (93.8)	1,056 (93.5)	1,070 (94.1)
Cardiac etiology, n (%)	1,207 (50.1)	607 (50.3)	600 (50.0)
Witnessed collapse, n (%)	1,090 (45.3)	555 (46.0)	535 (44.5)
Bystander CPR, n (%)	1,386 (57.6)	689 (57.1)	697 (58.0)
EMS call to hospital arrival, n (%)			
0–13 min	497 (20.6)	254 (21.0)	243 (20.2)
14–18 min	609 (25.3)	312 (25.8)	297 (24.7)
19–24 min	646 (26.8)	324 (26.8)	322 (26.8)
25- min	654 (27.1)	316 (26.2)	338 (28.1)
Administration of adrenaline, n (%) [b]	249 (10.3)	114 (9.4)	135 (11.2)
Defibrillation, n (%)	186 (7.7)	96 (7.9)	90 (7.5)
Receiving hospital characteristics, n (%)			
PCI availability	2,210 (91.8)	1,118 (92.7)	1,092 (91.0)

OHCA: out-of-hospital cardiac arrest, IQR: interquartile range, VF/VT: ventricular fibrillation/ventricular tachycardia, PEA: pulseless electrical activity, CPR: cardiopulmonary resuscitation, EMS: emergency medical services, PCI: percutaneous coronary intervention.
[a] Of 2,406, 77 and 63 patients were missing in the O group and the E group, respectively.
[b] Of 2,406, 5 and 1 patients were missing in the O group and the E group, respectively.

Table 2 – OHCA patient outcomes in the O group and E group.

Outcomes, No. (%)	All (n = 2,406)	O group (n = 1,206)	E group (n = 1,200)	OR (95% CI)
Primary Outcomes				
Seven-day survival	236 (9.8)	114 (9.4)	122 (10.1)	1.08 (0.82–1.41)
Secondary Outcomes				
One-month survival [a]	165 (6.8)	77 (6.3)	88 (7.3)	1.15 (0.84–1.59)
Favorable neurological outcome [b]	80 (3.3)	39 (3.2)	41 (3.4)	1.05 (0.67–1.65)

OHCA: out-of-hospital cardiac arrest, OR: odds ratio, CI: confidence interval.
O group (ref).
[a] One patient was missing in the O group.
[b] One patient was missing in the O group.

Discussion

Despite the observational design of our study, our unique medical direction system allowed us to examine optimal prehospital AAM in OHCA patients who had been in a pseudo-randomized manner assigned by calendar day to care based on "in favor of LT" or "in favor of ETI" policies. Our results indicate that these two different policies of two different medical directors did not affect seven-day survival after OHCA.

EMS systems vary greatly from country to country or even region to region based upon demographics and adaptations. Unlike most of the European countries, physicians are normally not involved in the care of OHCA patients within the EMS system in the majority of Asian countries.[5,19] In such countries, remote medical oversight by emergency physicians is an important element in providing appropriate patient care. Recent upsurges in smartphone adoption have enabled us to implement video communication-based real-time medical direction by emergency physicians, which contributes to improving the outcomes of OHCA patients, possibly by ensuring high-quality CPR.[6,7] Meanwhile, the decision of whether or not to provide advanced life support on the scene or where to transport patients

with OHCA based upon transport time or necessary treatment potentially affects outcomes.[20,21] Airway management is one of the most essential and challenging aspects of prehospital care of OHCA patients worldwide. As in other Asian countries, specially-trained EMS personnel in Japan are authorized to place advanced airways under real-time medical direction by physicians.[5] However, optimal airway management is still unclear. Substantially, prehospital airway devices are selected under regional standing orders and the supervising physician's discretion. This study for the first time investigated the different AAM policies of two hospitals and outcomes after OHCA within a single EMS area. Theoretically, the measurable covariates were mitigated because baseline characteristics were balanced between groups, except for AAM.

Prior data from Japan showed that 41.3% of adult patients with OHCA received prehospital AAM, 33.2% with SGA devices (the majority of them were LT) and 8.1% with ETI.[22] The 6.5% ETI placement rate presented here is similar to the nationwide rate. OHCA patients in Japan are less likely to receive ETI compared with those in the United States, where 52.6% of OHCA patients received ETI according to one study.[23] These differences could be attributable to variations in EMS systems and national practices. Another study

Table 3 – Multivariable logistic regression associated factors with seven-day survival of OHCA patients in this study.

Variable	Adjusted OR (95% CI)
Male	0.62 (0.44–0.88)
Age	0.97 (0.96–0.98)
VF/VT	3.78 (1.30–11.03)
Cardiac etiology	0.95 (0.65–1.38)
Witnessed collapse	3.04 (2.12–4.36)
Bystander CPR	0.86 (0.61–1.20)
EMS call to hospital arrival	
0–13 min	Reference
14–18 min	0.97 (0.60–1.56)
19–24 min	0.77 (0.46–1.26)
25- min	0.60 (0.35–1.03)
Administration of adrenaline	0.98 (0.54–1.78)
Defibrillation	1.78 (0.63–4.97)
Hospital with PCI availability	1.95 (0.82–4.63)
Prehospital airway management	
Bag valve mask	Reference
Laryngeal tube	0.78 (0.54–1.13)
Endotracheal intubation	0.79 (0.36–1.72)
Hospital in charge of direct medical control	
Japanese Red Cross Okayama Hospital (odd days)	Reference
Okayama University Hospital (even days)	1.17 (0.84–1.65)

Variables for the outcomes in the multivariable logistic regression included age, gender, initial rhythm, etiology, witness status, presence of bystander CPR, defibrillation, prehospital administration of adrenalin, airway management, availability of PCI at receiving hospital, EMS call to hospital arrival, and hospital in charge of direct medical control. OHCA: out-of-hospital cardiac arrest. CI: confidence interval, OR: odds ratio, VF/VT: ventricular fibrillation/ventricular tachycardia, CPR: cardiopulmonary resuscitation, EMS: emergency medical services, PCI: percutaneous coronary intervention.

Table 4 – Subgroup analysis of patients with OHCA in the O group and E group, excluding cases with bag valve mask ventilation.

Outcomes, No. (%)	All (n = 1,316)	O group (n = 656)	E group (n = 660)	OR (95% CI)
Primary Outcomes				
Seven-day survival	93 (7.0)	43 (6.5)	50 (7.5)	1.16 (0.76–1.78)
Secondary Outcomes				
ROSC [a]	328 (25.1)	163 (25.0)	165 (25.2)	1.01 (0.78–1.29)
One-month survival	54 (4.1)	23 (3.5)	31 (4.7)	1.35 (0.78–2.35)
Favorable neurological outcome	13 (0.9)	5 (0.7)	8 (1.2)	1.59 (0.51–4.90)

OHCA: out-of-hospital cardiac arrest, ROSC: return of spontaneous circulation, OR: odds ratio, CI: confidence interval.
O group (ref).
[a] Of 1,316 patients, four and six patients were missing in the O and E group, respectively.

demonstrated the significant regional variations in prehospital AAM and their effects on the outcomes of OHCA patients across four Asian EMS systems.[24] On the other hand, even in Japan, the AAM rate ranged from 27.2% to 62.1% after dividing Japan into seven geographic regions.[25] These findings can be interpreted as that the policies or strategies for prehospital AAM markedly differ according to region in Japan. As we demonstrated in our study, remarkable variations in AAM can be seen even within a single EMS area.

In general, there are both upsides and downsides to ETI and SGA use. ETI has been considered a definitive airway technique since no regurgitation and aspiration occur once placed; however, ETI requires extensive technical skills and continuous training, and can be potentially harmful due to unrecognized esophageal intubation, interruption of chest compressions, and hyperventilation.[26,27] Conversely, an SGA is simple to insert and requires minimal training, but may not protect against regurgitation and aspiration.[9] The recent AIRWAYS-2 RCTs representing 4,886 SGA patients and 4,410 ETI

patients revealed that SGA did not result in favorable neurological outcomes on hospital discharge or at 30 days (6.4% vs. 6.8%; adjusted risk difference, −0.6%; 95% CI, −1.6% to 0.4%).[9] Another RCT comparing 1,505 patients with LT and 1,499 patients with ETI demonstrated that a strategy of initial LT insertion (not the efficacy of the device) significantly improved 72-hour survival compared with a strategy of initial ETI (18.3% vs. 15.4%; adjusted difference, 2.9%; 95% CI, 0.2% to 5.6%).[8] This study, however, raised several concerns, including pragmatic design, practice setting, and the low success rate of ETI. The authors therefore concluded that further research was necessary.[8] As we reported in our study, these data suggest that the optimal prehospital AAM for OHCA patients is still inconclusive. In a specific cohort of patients, prehospital AAM worsened neurological outcomes after OHCA resulting from respiratory disease, regardless of the type of device placed.[28] Although the data cannot tell us the details of AAM, asphyxia-induced OHCA patients who had received prehospital AAM exhibited worse neurological out-

Table 5 – Multivariable logistic regression associated factors with seven-day survival of OHCA patients in this subgroup analysis.

Variable	Adjusted OR (95% CI)
Male	0.64 (0.39-1.03)
Age	0.97 (0.96-0.99)
VF/VT	3.06 (0.72-12.91)
Cardiac etiology	0.70 (0.42-1.16)
Witnessed collapse	2.26 (1.40-3.65)
Bystander CPR	0.63 (0.40-1.01)
EMS call to hospital arrival	
0-13 min	Reference
14-18 min	0.72 (0.35-1.48)
19-24 min	0.44 (0.21-0.93)
25- min	0.27 (0.12-0.60)
Administration of adrenaline	1.04 (0.52-2.06)
Defibrillation	1.63 (0.41-6.35)
Hospital with PCI availability	1.06 (0.40-2.78)
Prehospital airway management	
Laryngeal tube	Reference
Endotracheal intubation	1.05 (0.48-2.27)
Hospital in charge of direct medical control	
Japanese Red Cross Okayama Hospital (odd days)	Reference
Okayama University Hospital (even days)	1.15 (0.71-1.84)

Variables for the outcomes in the multivariable logistic regression analysis included age, gender, initial rhythm, etiology, witness status, presence of bystander CPR, defibrillation, prehospital administration of adrenalin, airway management, availability of PCI at receiving hospital, EMS call to hospital arrival, and hospital in charge of direct medical control. CI: confidence interval, OR: odds ratio, VF/VT: ventricular fibrillation/ventricular tachycardia, CPR: cardiopulmonary resuscitation, EMS: emergency medical services, PCI: percutaneous coronary intervention.

comes than those who had not received AAM.[29] Of cautionary note, these findings could be influenced by resuscitation time bias.[30] Our data showed similar results, even after excluding patients who had been ventilated with BVM, given resuscitation time bias that OHCA patients who achieved "early" ROSC inevitably would not have received AAM.

Limitations

This study has several limitations. First, the data were only available for final airway devices reported by each EMS member. This means that discrepancies between the device medical director initially ordered and the one finally used may occur. Some patients were potentially exposed to multiple AAM strategies, which could have affected the results. Second, the number of LT or ETI insertion attempts and the individual experience of EMS personnel were unknown. This should have been taken into account, given the results that fewer ETI attempts were associated with better neurological outcomes.[31] However, both groups had similar EMS call to hospital arrival time in our study. Third, we did not split the data according to the initial rhythm due to small sample sizes. Previous literature showed that both SGA and ETI improved survival in patients with non-shockable rhythm but not shockable rhythm.[32] Fourth, information regarding the timing of AAM was unavailable. A recent paper reported that AAM within 15 minutes after EMS-

initiated CPR was associated with improved survival for non-shockable rhythm.[22] Fifth, we did not evaluate long-term neurological conditions as a primary outcome, which might be preferable to seven-day survival in terms of patient quality of life. This was chosen because of the small study population and to more focus on the effects of prehospital airway management rather than post-cardiac arrest treatment.[8,33] Lastly, the study could not assess the influence of chest compression, ventilation quality, and/or in-hospital treatment due to lack of information on these factors in the database.

Conclusions

In this observational study within a single EMS area, we evaluated the different prehospital AAM policies applied by two different hospitals in charge of direct medical control based upon calendar days. Neither the "in favor of LT" policy nor the "in favor of ETI" policy affected seven-day survival after OHCA.

Ethics approval and consent to participate

The study was performed according to the Helsinki Declaration and institutional review board approval was duly obtained (ID: K1804-034).

Consent for publication

Consent for publication was waived.

Availability of data and materials

The data for the study is obtained from database of the OHCA registry in Okayama City, which is organized by the Okayama City Fire and Disaster Management Department; the authors do not have permission to share data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2022.100210.

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