Received: 6 May 2023 | Accepted: 11 December 2023

DOI: 10.1002/ams2.912

ACUTE MEDICINE & SURGERY WILEY

ORIGINAL ARTICLE

Effect of prehospital advanced airway management on out-of-hospital cardiac arrest due to asphyxia: A JAAM-OHCA registry-based observational study in Japan

Naofumi Bunya[1] | Ohnishi Hirofumi[2] | Yutaka Igarashi[3] | Tatsuya Norii[4] | Yoichi Katayama[1] | Takehiko Kasai[1] | Keigo Sawamoto[1] | Eichi Narimatsu[1]

[1]Department of Emergency Medicine, Sapporo Medical University, Sapporo, Japan

[2]Department of Public Health, Sapporo Medical University, Sapporo, Japan

[3]Department of Emergency and Critical Care Medicine, Nippon Medical School Hospital, Tokyo, Japan

[4]Department of Emergency Medicine, University of New Mexico, Albuquerque, New Mexico, USA

Correspondence
Naofumi Bunya, Department of Emergency Medicine, Sapporo Medical University, S1W16 Chuo-ku, Sapporo, Hokkaido 060-8543, Japan.
Email: naobun1221@gmail.com

Abstract

Aim: To investigate the relationship between prehospital advanced airway management (AAM) and neurological outcomes in patients with asphyxia-related out-of-hospital cardiac arrest (OHCA).

Methods: We retrospectively analyzed data from the Japanese Association for Acute Medicine OHCA registry between June 2014 and December 2017. Patients with asphyxia-related cardiac arrest aged ≥18 years were included. The primary outcome was a 1-month favorable neurological outcome (cerebral performance category [CPC] 1–2).

Results: Of the 34,754 patients in the 2014–2017 JAAM-OHCA Registry, 1956 were included in our analysis. Cerebral performance category 1–2 was observed in 31 patients (1.6%), while CPC 3–5 was observed in 1925 patients (98.4%). Although prehospital AAM was associated with unfavorable neurological outcomes (odds ratio [OR], 0.269; 95% confidence interval [CI], 0.114–0.633; $p = 0.003$) in the univariate analysis, the association was not significant in the multivariate analysis. Compared with the AAM group, the non-AAM group showed increased rates of cardiac arrest after emergency medical service contact (4.3 vs. 7.2%, $p = 0.009$) and Glasgow Coma Scale ≥4 at hospital admission (1.9% vs. 4.7%, $p = 0.004$). Among the 903 patients for whom the time to return of spontaneous circulation (ROSC) could be calculated, the time from witnessed cardiac arrest to ROSC was significantly shorter (median, 8.5 vs. 37.0 min; $p < 0.001$) for those with favorable neurological outcomes than for those without.

Conclusion: Prehospital AAM is not associated with improved neurological outcomes among those with asphyxia-related OHCA. However, the time from cardiac arrest to the first ROSC was significantly shorter among those with favorable outcomes.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a major public health issue in developed countries, with approximately 126,000 annual cases in Japan.[1] Asphyxia is a prevalent extra-cardiac cause of arrest, accounting for approximately 16.5% of cases.[2] A recent population survey by the Ministry of Health, Labor, and Welfare reported approximately 8000 deaths per year due to accidental asphyxia.[3] Although the rate of primary return of spontaneous circulation (ROSC) is relatively higher for asphyxia-related OHCA than for cardiac arrest due to other causes, the survival rate is lower.[4] Furthermore, patients with asphyxia-related cardiac arrest are unlikely to achieve a favorable neurological outcome, even if they survive.[2] Several factors—such as younger age, presence of witnesses during cardiac arrest, early emergency medical service (EMS) response time, presence of pupil light reflex, corneal reflex, and early ROSC—have been identified as predictors of a favorable neurological outcome in asphyxia-related cardiac arrest.[2,5] Although early EMS response (call to contact with patients) has been associated with favorable neurological outcomes,[2] it remains unclear which EMS-related procedures lead to improved outcomes among those with asphyxia-related OHCA.

Cardiac arrest caused by asphyxia should be treated immediately by removing any foreign bodies from the airway while providing basic life support.[6] In a report on foreign body removal in asphyxia cases, the most favorable neurological outcome was observed when a bystander performed the removal procedure at the scene, followed by the procedure performed after the arrival of EMS at the scene; conversely, the worst outcome was reported when the removal procedure was performed after arrival at the hospital.[7] Whether bag valve mask or advanced airway management (AAM) techniques—such as endotracheal intubation or laryngeal mask/tube insertion—are more effective for OHCA remains controversial.[8]

Therefore, this study aimed to examine the relationship between AAM provided by EMS and neurological outcomes in patients with asphyxia-related OHCA.

MATERIALS AND METHODS

Study design and setting

This observational study used data from the OHCA registry of the Japanese Association for Acute Medicine (JAAM). This registry is a multicenter, prospective registry of patients with OHCA transported to critical care medical centers or hospitals with an emergency care department across Japan (JAAM-OHCA registry). The study period was from June 1, 2014, to December 31, 2017.

JAAM-OHCA registry

The JAAM-OHCA registry is a nationwide prospective registry that was established to improve OHCA-related outcomes.[9] The registry includes 295 critical care medical centers certified by the Ministry of Health, Labor, and Welfare as institutions capable of performing highly specialized care. The registry was initiated on June 1, 2014, and continues to collect data without a date of termination.[9] Methods for data collection, quality control, and combining prehospital and in-hospital information have been described previously.[9] In this registry, the cause of cardiac arrest is classified into cardiac (acute coronary syndrome, other heart diseases, and presumed cardiac cause) and noncardiac (cerebrovascular diseases; respiratory diseases; malignant tumors; and external causes, including traffic injury, falls, hanging, drowning, asphyxia, drug overdose, or any other external cause). Out-of-hospital cardiac arrest was presumed to be of medical origin unless it was caused by trauma, including falls, hanging, drowning, drug overdose, or asphyxia. The registry was approved by the Ethics Committee of Kyoto University, and each participating hospital approved the JAAM-OHCA registry protocol as necessary.

Emergency medical service system in Japan

Details regarding the EMS system and registry in Japan have been described previously.[1] Prehospital resuscitation data were obtained from the All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA). The FDMA prospectively collects data following the recommended Utstein-style international guidelines for reporting OHCA.[10] Data related to witness status, bystander-initiated cardiopulmonary resuscitation (CPR), use of public-access automated external defibrillators, dispatcher instructions, first documented rhythm, AAM, intravenous fluid, adrenaline administration, and resuscitation time course are collected. The data are relayed to the registry system of the FDMA database server, following which they are subjected to a verification process and confirmed by the implementation working group. Incomplete forms are returned to the specific fire station for completion. Although all emergency life-saving technicians (ELSTs) can perform the Heimlich maneuver and use Magill forceps to relieve choking, the details of the removal procedures are not described in the JAAM-OHCA registry.

The following is a brief description of EMS activities for OHCA. All EMS field basic life support (BLS) and ELST advanced life support (ALS) protocols followed the 2015 Japan Resuscitation Council guidelines.[11] Once an EMS provider completes the initial assessment and obtains electrocardiogram rhythm, EMS defibrillation is promptly performed. Only certified ELSTs among EMS providers are authorized to perform AAM in cases of cardiac or respiratory arrest and administer adrenaline. Advanced airway management is considered in scenarios where effective ventilation with a bag valve mask is difficult, or based on maintaining CPR quality or logistical aspects of transportation to the hospital. Japan uses a Medical Control (MC) system, involving fire agencies, local medical associations, the local government, and emergency hospitals. Nationwide BLS and ALS protocols—per the Ministry of Health and Labor Welfare's guidelines—are adopted by regional MC councils according to each region's conditions.[12] The ELSTs require online direct verbal permission from an MC physician for AAM and adrenaline administration. The ELSTs are not allowed to administer AAM or adrenaline without a physician's direct order.

Patients

We included patients with asphyxia-related cardiac arrest and excluded those with other causes of cardiac arrest, as defined in the JAAM-OHCA registry. We also excluded patients younger than 18 years of age, those for whom resuscitation was not attempted at the hospital, and those lacking prehospital data.

Outcome measurements

The primary outcome was a favorable neurological survival at 1 month, which was defined as a cerebral performance category (CPC) of 1 or 2. As such, CPC 1 denoted good cerebral performance; CPC 2, moderate cerebral disability; CPC 3, severe cerebral disability; CPC 4, comatose or vegetative state; and CPC 5, death.[10] The neurological status of survivors was evaluated by the medical staff at each institution 1 month after the event. The secondary outcomes were the relationship between the time from asphyxia-related cardiac arrest onset to the first ROSC and neurological outcomes.

Statistical analysis

Continuous variables are presented as medians with interquartile ranges; such variables were compared using the Mann–Whitney *U*-test. Categorical variables were compared using Fisher's exact test. The Kruskal–Wallis test was used to compare the neurological outcomes between each initial cardiac rhythm, and the Steel–Dwass test was used for multiple comparisons. A multivariate logistic regression analysis was carried out using a stepwise forward variable selection method to evaluate the association between AAM and neurological outcomes. The candidate variables for multivariate logistic regression analysis—using stepwise forward variable selection—were age, sex, witnessed cardiac arrest, bystander CPR attempt, initial recorded cardiac arrest rhythm, dispatcher instruction, AAM provided by EMS, adrenaline administration by EMS, presence of physician dispatched to the scene, prehospital ROSC, cardiac arrest occurred after EMS contact, cardiac rhythm at admission, Glasgow Coma Scale (GCS) ≥4 at admission, adrenaline administration after admission, endotracheal intubation after ED arrival, therapeutic temperature management, call to EMS contact with patient, and call to arrival at the hospital. Two-sided tests were carried out, and p-values of <0.05 were considered statistically significant. All statistical analyses were undertaken using SPSS version 25 (IBM Corp.) and EZR (Saitama Medical Centre, Jichi Medical University), which is a graphical user interface for R (The R Foundation for Statistical Computing).

Patient and public involvement

This was a secondary analysis of an existing registry dataset. Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

RESULTS

During the study period, documentation was collected for a total of 34,754 patients with OHCA. We excluded 737 children, 31,825 patients with cardiac arrest caused by factors other than asphyxia, and 236 patients with missing EMS data. Finally, 1956 patients were included in the study (Figure 1A). The neurological outcomes of patients with asphyxia-related cardiac arrest were as follows: 16 patients were in CPC 1, 15 in CPC 2, 65 in CPC 3, 168 in CPC 4, and 1692 in CPC 5.

Table 1 shows the characteristics of the included patients based on their neurological outcomes. Overall, 31 and 1925 patients had favorable and unfavorable neurological outcomes, respectively. Regarding baseline (prehospital) factors, patients with favorable neurological outcomes were younger and more frequently had witnesses at the time of cardiac arrest, bystanders attempting CPR, and physicians dispatched to the scene and had more frequently experienced prehospital ROSC and cardiac arrest witnessed by EMS. In contrast, initial cardiac rhythm with asystole, prehospital AAM, and prehospital administration of adrenaline were more common in those with unfavorable outcomes than in those with favorable outcomes. Patients with favorable neurological outcomes also had a higher rate of ROSC upon arrival at the hospital (rather than after hospital admission), higher GCS scores, higher rates of therapeutic temperature management on arrival, and lower rates of adrenaline administration after hospital admission.

Table 2 shows the results of the logistic regression analysis according to neurological outcomes. Regarding EMS-provided prehospital care, prehospital AAM provided by EMS was not significantly associated with favorable neurological outcomes in the univariate logistic regression analysis and was also not selected for multivariate analysis. However, the following factors were associated with neurological outcomes in the multivariate analysis: prehospital adrenaline administration, prehospital ROSC, cardiac arrest occurring after EMS contact, GCS ≥4 at hospital admission, adrenaline administration after hospital arrival, and therapeutic temperature management.

Table 3 shows the association between AAM performed by the EMS team and each factor. In the analysis of prehospital factors, compared with the non-AAM group, the AAM group showed higher rates of prehospital adrenaline administration, prehospital ROSC, a longer time from EMS contact to hospital arrival, and lower rates of cardiac arrest after EMS contact. In terms of postarrival factors, compared with the non-AAM group, the AAM group showed a higher rate of ROSC upon arrival, lower rates of ROSC after hospital arrival, adrenaline administration after arrival, and intubation after arrival, and lower GCS scores.

To determine whether the time from cardiac arrest to ROSC and prehospital AAM were associated with neurological outcomes, patients with insufficient data were excluded; therefore, we excluded 546 patients with unwitnessed cardiac arrest, 366 without ROSC, and 141 without a

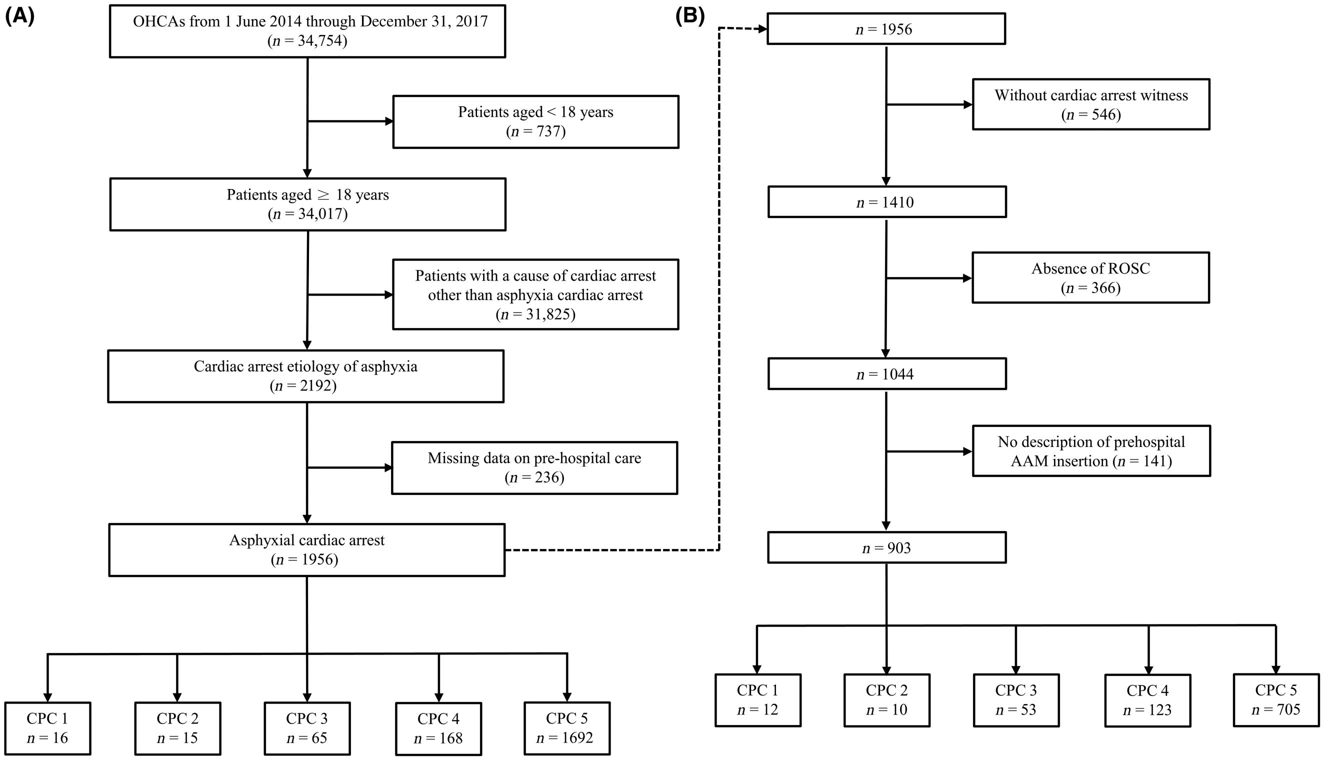

FIGURE 1 (A) Flowchart of study participant enrolment. (B) Flowchart showing patient selection for analyses of the relationship between asphyxia-related out-of-hospital cardiac arrest (OHCA) and time to return of spontaneous circulation (ROSC). AAM, advanced airway management; CPC, cerebral performance category.

description of prehospital AAM (Figure 1B). A total of 903 patients were included in the analysis examining the association between the time course of each factor and neurological outcomes (Table 4). The median time from witnessed cardiac arrest to initial ROSC was 37.0 min in all patients and was significantly shorter in patients with favorable neurological outcomes than in patients with unfavorable outcomes (8.5 vs. 37.0 min, $p < 0.001$). The median time from the call to contact between the patient and EMS was 8.0 min, without differences between patients with favorable and unfavorable neurological outcomes (7.0 vs. 8.0 min, $p = 0.127$). The median time from patient contact to prehospital AAM was 7.0 min, without differences between patients with favorable and unfavorable neurological outcomes (7.0 vs. 7.0 min, $p = 0.856$).

The distribution of time between witnessed cardiac arrest to ROSC and neurological outcomes is shown in Table 5. Among patients with reported times of ≤10 min from cardiac arrest to first ROSC, 33.3% experienced a favorable neurological outcome. As the time from cardiac arrest to initial ROSC increased, the rate of favorable neurological outcomes decreased. Except for one patient, the time from cardiac arrest to initial ROSC was 20 min in all patients who achieved a favorable neurological outcome. Table 6 shows the distribution of time from witnessed cardiac arrest to prehospital AAM. The rate of prehospital AAM was low within 10 min of cardiac arrest. As the time since cardiac arrest increased, the rate of prehospital AAM remained constant. Only 73 patients (12.4%) underwent prehospital AAM within 20 min of cardiac arrest, which represents a critical point before which patients with asphyxia-related cardiac arrest are most likely to experience a favorable neurological outcome.

DISCUSSION

In this study, we examined the relationship between prehospital AAM and neurological outcomes in patients with asphyxia-related OHCA. Our analysis revealed no significant effect of AAM provided by EMS on neurological outcomes in these patients. However, the time from cardiac arrest to the first ROSC was significantly shorter among those with favorable outcomes.

Although prehospital AAM was associated with worse neurological outcomes in the univariate analysis, this association was not significant in the multivariate analysis. Notably, GCS scores at hospital admission differed significantly between the AAM and non-AAM groups. A GCS score ≥4 has been associated with favorable neurological outcomes in patients with postcardiac arrest syndrome.[13] Although the JAAM-OHCA registry does not include information regarding consciousness level at the time of prehospital AAM, patients with GCS ≥4 at hospital admission likely experienced improvements in their GCS score during transport; these patients are more likely to experience ROSC. As the EMS crew can only perform AAM in patients with

TABLE 1 Comparison of baseline characteristics of patients with out-of-hospital cardiac arrest due to asphyxia, based on neurological outcomes.

	Favorable neurological outcome	Unfavorable neurological outcome	
	n = 31	*n* = 1925	*p*-value
Age, median (IQR)	74.0 (65.5, 84.0)	81.0 (72.0, 87.0)	0.024
Male sex	16 (51.6)	997 (51.8)	0.984
Witness of cardiac arrest	29 (93.5)	1381 (71.7)	0.004
Bystander CPR attempt	27 (87.1)	1173 (60.9)	0.003
Initial cardiac rhythm			<0.001
VF/VT	2 (6.5)	20 (1.0)	0.282*
PEA	20 (64.5)	729 (37.9)	(ref.)
Asystole	1 (3.2)	1110 (57.7)	<0.001*
Unknown	8 (25.8)	66 (3.4)	<0.001*
Dispatcher instruction (unknown, *n* = 21)	19 (61.3)	1128 (59.2)	0.856
AAM provided by EMS			
No	16 (51.6)	578 (30.0)	0.002
Yes	8 (25.8)	1074 (55.8)	
Laryngeal tube airway	7 (22.6)	594 (30.9)	
Laryngeal mask airway	0 (0.0)	66 (3.4)	
Endotracheal intubation	1 (3.2)	414 (21.5)	
Unknown	7 (22.6)	273 (14.2)	
Adrenaline administration by EMS	1 (3.2)	639 (33.2)	<0.001
Presence of physician dispatched to the scene	9 (29.0)	276 (14.3)	0.028
Prehospital ROSC	30 (96.8)	478 (24.8)	<0.001
Cardiac arrest occurred after EMS contact	9 (29.0)	108 (5.6)	<0.001
Cardiac rhythm at admission			<0.001
ROSC	28 (90.3)	347 (18.0)	
VF/VT	0 (0.0)	15 (0.8)	
PEA	2 (6.5)	505 (26.2)	
Asystole	1 (3.2)	1058 (55.0)	
ROSC after admission	1 (3.2)	924 (48.0)	<0.001
Adrenaline administration after admission (unknown *n* = 368)	1 (3.2)	1102 (57.2)	<0.001
GCS ≥4 at admission	18 (58.1)	45 (2.3)	<0.001
GCS E ≥ 2	11 (35.5)	13 (0.7)	<0.001
GCS V ≥ 2	12 (38.7)	13 (0.7)	<0.001
GCS M ≥ 2	14 (45.2)	38 (2.0)	<0.001
Endotracheal intubation after ED arrival	19 (61.3)	1345 (69.9)	0.326
Therapeutic temperature management	11 (35.5)	108 (5.6)	<0.001
ROSC during transportation or after admission	31 (100.0)	1287 (66.9)	<0.001

Note: Data are shown as *n* (%), unless otherwise indicated.

Abbreviations: AAM, advanced airway management; CPR, cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical services; GCS, Glasgow Coma Scale; IQR, interquartile range; ref., reference; VF, ventricular fibrillation; VT, ventricular tachycardia.

*The Kruskal–Wallis test was used to compare the neurological outcome between each initial cardiac rhythm, and the Steel–Dwass test was used for multiple comparisons. These *p* values were calculated by comparing pulseless electrical activity (PEA) and the other cardiac rhythms.

cardiac arrest or respiratory arrest, it is possible that AAM could not be performed in patients who resumed spontaneous breathing during treatment provided by EMS. Given that patients with GCS scores ≥4 may have resumed spontaneous breathing, prehospital AAM is not indicated in this group that was predicted to have a favorable neurological outcome. There were fewer cases of prehospital AAM among patients who experienced cardiac arrest following contact with EMS, and these patients experienced more favorable neurological outcomes based on our analysis. The higher percentage of patients with a favorable neurological outcome in the non-AAM group could reflect the fact that patients

TABLE 2 Logistic regression analysis of favorable neurological outcomes in patients with out-of-hospital cardiac arrest due to asphyxia.

Characteristic	Unadjusted odds Ratio (95% CI) *n* = 1956	*p*-value	Adjusted odds Ratio (95% CI) *n* = 1658	*p*-value
Age (years), *n* = 1956	0.978 (0.958–0.999)	0.037	–	–
Male sex, *n* = 1956	1.007 (0.495–2.049)	0.984	–	–
Cardiac arrest witnessed, *n* = 1956	5.712 (1.358–24.019)	0.017	–	–
Bystander CPR attempt, *n* = 1956	4.327 (1.508–12.416)	0.006	–	–
Initial recorded cardiac arrest rhythm, *n* = 1956				
VF or pulseless VT	111.000 (9.667–1274.58)	<0.001	–	–
PEA	30.453 (4.078–227.400)	0.001	–	–
Asystole	1.000 (ref.)	<0.001	–	–
Unknown	134.545 (16.581–1091.749)	<0.001	–	–
Dispatcher instruction, *n* = 1935	1.089 (0.526–2.257)	0.818	–	–
AAM provided by EMS, *n* = 1676	0.269 (0.114–0.633)	0.003	–	–
Adrenaline administration by EMS, *n* = 1956	0.067 (0.009–0.493)	0.008	0.057 (0.007–0.450)	0.007
Presence of physician dispatched to the scene, *n* = 1956	2.444 (1.114–5.364)	0.026	–	–
Prehospital ROSC, *n* = 1956	90.816 (12.352–667.726)	<0.001	10.368 (1.130–95.175)	0.039
Cardiac arrest occurred after EMS contact, *n* = 1956	6.883 (3.094–15.309)	<0.001	4.075 (1.158–14.347)	0.029
Cardiac rhythm at admission, *n* = 1956				
ROSC	85.372 (11.573–629.769)	<0.001	–	–
VF or pulseless VT	–	–	–	–
PEA	4.190 (0.379–46.317)	0.243	–	–
Asystole	1.000 (ref.)	<0.001	–	–
GCS ≥4 at admission, *n* = 1956	57.846 (26.724–125.212)	<0.001	7.199 (2.487–20.836)	<0.001
Adrenaline administration after admission, *n* = 1951	0.010 (0.001–0.076)	<0.001	0.070 (0.008–0.626)	0.017
Endotracheal intubation after ED arrival, *n* = 1956	0.683 (0.329–1.416)	0.305	–	–
Therapeutic temperature management, *n* = 1956	9.523 (4.324–19.804)	<0.001	6.682 (2.235–19.978)	0.002
Call to EMS's contact with patient (min), *n* = 1956	0.896 (0.772–1.040)	0.156	–	–
Call to arrival at the hospital (min), *n* = 1951	0.994 (0.966–1.023)	0.674	–	–

Abbreviations: AAM, advanced airway management; CI, confidence interval; CPR, cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical services; GCS, Glasgow Coma Scale; PEA, pulseless electrical activity; ref., reference; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

showed signs of ROSC during transport. While these results suggest that prehospital AAM does not lead to an unfavorable neurological outcome, AAM might be more common among patients who do not show signs suggestive of a favorable neurological outcome and among those more likely to have unfavorable neurological outcomes.

To explore the association between time from asphyxia-related cardiac arrest to initial ROSC and neurological outcomes, we limited our analysis to cases of witnessed cardiac arrest, ROSC, and patients with or without prehospital AAM (Table 5). Rates of favorable neurological outcomes decreased as the time from the onset of asphyxia-related cardiac arrest increased. In all but one patient, unfavorable neurological outcomes were observed when initial ROSC was not achieved within 20 min of cardiac arrest. Unfavorable neurological outcomes after cardiac arrest resuscitation are reportedly associated with longer no-flow and low-flow intervals.[14] In the same study, the median low-flow interval among patients who achieved a favorable neurological outcome was 13 min. Given that the initial cardiac rhythm in the study was shockable, many etiologies of cardiac arrest were likely included. The median time from cardiac arrest to ROSC with favorable neurological outcome in our study was 8.5 min (Table 4). Asphyxia-related cardiac arrest can cause more severe brain injury and fewer cardiac injuries than ventricular fibrillation cardiac arrest of the same duration.[15] Taken together, these results suggest that the time from cardiac arrest to ROSC—which was associated with neurological outcomes in our study—is shorter for cases of asphyxia-related cardiac arrest than for cardiac arrest due to other causes.

Regarding the time from witnessed cardiac arrest to prehospital AAM, we observed that AAM was not performed immediately after cardiac arrest in almost all patients

TABLE 3 Characteristics of patients with out-of-hospital cardiac arrest due to asphyxia with or without advanced airway management (AAM) provided by emergency medical services (EMS).

	AAM group	Non-AAM group	
	n = 1082	*n* = 594	*p*-value
Age, median (IQR)	82.0 (73.0, 88.0)	81.0 (70.0, 87.0)	0.056
Male sex	549 (50.7)	306 (51.5)	0.798
Witness of cardiac arrest	790 (73.0)	424 (71.4)	0.493
Bystander CPR attempt	652 (60.3)	372 (62.6)	0.346
Initial cardiac rhythm			<0.001
VF/VT	13 (1.2)	6 (1.0)	–
PEA	423 (39.1)	212 (35.7)	–
Asystole	621 (57.4)	337 (56.7)	–
Unknown	25 (2.3)	39 (6.6)	–
Dispatcher instruction (unknown *n* = 11)	641 (59.9)	333 (56.1)	0.146
Adrenaline administration by EMS	487 (45.0)	110 (18.5)	<0.001
Prehospital ROSC	310 (28.7)	136 (22.9)	0.011
Cardiac arrest occurred after EMS contact	47 (4.3)	43 (7.2)	0.009
Call to EMS's contact with patients (min), median (IQR)	8.0 (7.0, 10.0)	8.0 (7.0, 10.0)	0.418
Patients' contact by EMS to hospital admission (min), median (IQR)	24.0 (19.0, 30.0)	20.0 (14.0, 26.0)	<0.001
Cardiac rhythm at admission			<0.001
ROSC	261 (24.1)	77 (13.0)	
VF/VT	4 (0.4)	6 (1.0)	
PEA	298 (27.5)	141 (23.7)	
Asystole	519 (48.0)	370 (62.3)	
ROSC after admission	478 (44.2)	305 (51.3)	0.006
Adrenaline administration after admission (unknown = 4)	764 (70.8)	479 (80.8)	<0.001
GCS ≥4 at admission	21 (1.9)	28 (4.7)	0.004
GCS E > 2	5 (0.5)	14 (2.4)	0.001
GCS V > 2	3 (0.3)	14 (2.4)	<0.001
GCS M > 2	16 (1.5)	25 (4.2)	0.001
Endotracheal intubation after ED arrival	642 (59.3)	483 (81.3)	<0.001
Therapeutic temperature management	59 (5.5)	42 (7.1)	0.198
ROSC during transportation or after admission	746 (68.9)	384 (64.6)	0.081
Outcome			
CPC 1–2	8 (0.7)	16 (2.7)	0.002
Survival	151 (14.0)	74 (12.5)	0.411

Note: Data are shown as *n* (%), unless otherwise indicated.

Abbreviations: CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; ED, emergency department; GCS, Glasgow Coma Scale; IQR, interquartile range; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; VF, ventricular fibrillation; VT, ventricular tachycardia.

(Table 5). Analysis of EMS activity indicated that the time from witness arrest to EMS contact was 8 min, while that from EMS contact to AAM was 7 min (Table 4). The median time from cardiac arrest to ROSC—which was associated with a favorable neurological outcome—was 8.5 min among our patients with asphyxia-related cardiac arrest. Thus, one explanation for the lack of an association between prehospital AAM and improved neurological outcomes is the short window within ROSC (8.5 min), as the time might have elapsed before EMS contact. Prehospital AAM is likely associated with poor outcomes because AAMs are performed for patients with a high likelihood of poor neurologic prognosis and a greater time to ROSC. Considering the time required for EMS activity, it would be difficult to insert an AAM at approximately 10 min after the onset of asphyxia-related cardiac arrest – a critical window for ensuring optimal neurological outcomes, especially for cases in which cardiac arrest has already occurred before the EMS call. To clarify whether

TABLE 4 Association between the time course of each factor and neurological outcomes in patients with out-of-hospital cardiac arrest due to asphyxia.

Time course (min), median (IQR)	All *n* = 903	CPC 1–2 *n* = 22	CPC 3–5 *n* = 881	*p*-value
From witness				
To call	2.0 (0.0, 5.0)	0.0 (−9.3, 1.3)	2.0 (0.0, 5.0)	0.001
Number	898	22	876	
To bystander CPR attempt	1.0 (0.0, 5.0)	1.0 (0.0, 3.0)	1.0 (0.0, 5.0)	0.418
Number	520	13	507	
To contact by EMS	10.0 (7.0, 14.0)	6.0 (−2.0, 9.3)	10.0 (7.0, 14.0)	<0.001
Number	898	22	876	
To AAM provided by EMS	18.0 (14.0, 23.0)	11.0 (5.3, 15.8)	18.0 (14.0, 23.0)	0.006
Number	593	8	585	
To adrenaline administration by EMS	24.0 (18.0, 32.0)	13.0	24.0 (18.0, 32.0)	0.132
Number	363	1	362	
To hospital admission	36.5 (29.0, 44.0)	31.5 (24.0, 37.8)	37.0 (30.0, 44.0)	0.017
Number	898	22	876	
To ROSC	37.0 (26.0, 47.0)	8.5 (5.5, 14.0)	37.0 (27.0, 47.0)	<0.001
Number	903	22	881	
From call				
To bystander CPR attempt	0.0 (−1.0, 2.0)	1.0 (0.0, 2.0)	0.0 (−1.0, 2.0)	0.252
Number	522	13	509	
To contact by EMS	8.0 (7.0, 10.0)	7.0 (6.0, 9.3)	8.0 (7.0, 10.0)	0.127
Number	903	22	881	
To AAM provided by EMS	16.0 (13.0, 19.0)	15.0 (11.3, 20.8)	16.0 (13.0, 19.0)	0.558
Number	593	8	585	
To adrenaline administration by EMS	22.5 (18.0, 29.0)	13.0	23.0 (18.0, 29.0)	0.087
Number	368	1	367	
To hospital admission	34.0 (29.0, 41.0)	33.0 (26.8, 40.0)	34.0 (29.0, 41.0)	0.587
Number	901	22	879	
To ROSC	35.0 (25.0, 44.0)	10.0 (9.0, 16.3)	35.0 (25.5, 54.0)	<0.001
Number	903	22	881	
From contact by EMS				
To AAM provided by EMS	7.0 (5.0, 11.0)	7.0 (6.0, 10.5)	7.0 (5.0, 11.0)	0.856
Number	593	8	585	
To adrenaline administration by EMS	14.0 (10.0, 20.0)	7.0	14.0 (10.0, 20.0)	0.152
Number	368	1	367	
To hospital admission	23.0 (17.0, 29.0)	19.5 (14.5, 28.0)	23.0 (17.0, 29.0)	0.184
Number	903	22	881	
To ROSC	27.0 (16.0, 35.0)	3.5 (3.0, 9.3)	27.0 (17.0, 36.0)	<0.001
Number	903	22	881	
From AAM provided by EMS				
To hospital admission	16.0 (10.0, 21.0)	11.5 (10.3, 13.0)	16.0 (10.0, 21.0)	0.072
Number	593	8	585	
To ROSC	18.0 (9.0, 27.0)	1.0 (−1.5, 4.3)	18.5 (10.0, 28.0)	<0.001
Number	590	8	582	
From adrenaline administration by EMS				
To hospital admission	10.0 (3.0, 17.0)	13.0	10.0 (3.0, 17.0)	0.788
Number	368	1	367	

TABLE 4 (Continued)

Time course (min), median (IQR)	All *n* = 903	CPC 1–2 *n* = 22	CPC 3–5 *n* = 881	*p*-value
To ROSC	7.0 (4.0, 15.0)	3.0*[*]	7.0 (4.0, 15.0)	0.242
Number	368	1	367	

Abbreviations: AAM, advanced airway management; CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; IQR, interquartile range; ROSC, return of spontaneous circulation.

*Of the 22 patients who obtained CPC 1-2, only one case received adrenaline from EMS.

TABLE 5 Distribution of time from witnessed out-of-hospital cardiac arrest due to asphyxia to return of spontaneous circulation (ROSC), according to neurological outcome.

Time from witnessed cardiac arrest to ROSC (min)	All *n* = 903	CPC 1–2, *n* (%) *n* = 22	CPC 3–5 *n* = 881
0–5	15	5 (33.3)	10
6–10	24	8 (33.3)	16
11–15	36	6 (16.7)	30
16–20	64	2 (3.1)	62
21–25	72	0 (0.0)	72
26–30	110	0 (0.0)	110
31–35	104	0 (0.0)	104
36–40	108	0 (0.0)	108
41–45	110	0 (0.0)	110
46–50	75	1 (1.3)	74
51–55	61	0 (0.0)	61
56–60	47	0 (0.0)	47
≥61	77	0 (0.0)	77

Abbreviation: CPC, cerebral performance category.

TABLE 6 Distribution of time from witnessed out-of-hospital cardiac arrest due to asphyxia to prehospital advanced airway management (AAM).

Time from witnessed cardiac arrest to prehospital AAM (min)	AAM, *n* = 589 *n* (%)
0–5	2 (0.3)
6–10	4 (0.7)
11–15	20 (3.4)
16–20	47 (8.0)
21–25	56 (9.5)
26–30	69 (11.7)
31–35	68 (11.5)
36–40	67 (11.4)
41–45	75 (12.7)
46–50	55 (9.3)
51–55	40 (6.8)
56–60	31 (5.3)
≥61	55 (9.3)

prehospital AAM improves outcomes among those with asphyxia-related cardiac arrest, additional studies should aim to compare AAM insertion and non-insertion groups under the same temporal conditions.

Our study had some limitations. Research indicates that the removal of foreign body objects by bystanders and EMS is extremely important in determining the outcome of asphyxia. However, the registry used in the current study does not include this information.[7] Similarly, the time at which the choking incident was witnessed is not provided in the registry. Although cases of witnessed cardiac arrest are specified, the registry does not contain data related to the time required for asphyxia to progress to cardiac arrest. Third, it is unclear what caused asphyxiation in each case (e.g., food, vomit, etc.) and the region of anatomical sites of asphyxiation.[16] Fourth, some MCs set a time window of approximately 2 min to evaluate patient responsiveness to BLS before AAM insertion, but it varies from region to region. Even this short evaluation time could be disadvantageous for asphyxia-related OHCA patients who are likely to have a narrow therapeutic window. When considering the impact of the time between contact and AAM insertion, it is necessary to account for regional differences in this evaluation time; however, the impact of these time differences on the overall dataset is unknown.

CONCLUSION

The current results indicate that prehospital AAM is not associated with improved neurological outcomes in patients with asphyxia-related OHCA. However, the time from cardiac arrest to the first ROSC was significantly shorter among those with favorable outcomes. Considering the time required for EMS activity (encompassing the EMS call, time to first contact with EMS, and time to AAM), the critical window for improving neurological outcomes may have closed by the time of prehospital AAM. This could explain the lack of improvement in prognosis.

ACKNOWLEDGMENTS

We are deeply indebted to all members and institutions of the JAAM-OHCA registry for their contribution. The participating institutions of the JAAM-OHCA registry are listed at the following URL: http://www.jaamohca-web.com/list/. We also thank all EMS personnel for collecting the Utstein data.

FUNDING INFORMATION

This study did not receive formal grants from funding agencies, private agencies, or agencies in the not-for-profit sector.

CONFLICT OF INTEREST STATEMENT

Authors declare no conflict of interest for this article.

DATA AVAILABILITY STATEMENT

The JAAM-OHCA registry data belong to JAAM and are not available to the public.

ETHICS STATEMENT

Approval of the research protocol: The protocol was approved by the Ethics Committee of Kyoto University as the corresponding institution. All participating hospitals, including our hospital, approved the JAAM-OHCA registry protocol.
Informed consent: The requirement for patient informed consent was waived.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.

ORCID

Naofumi Bunya https://orcid.org/0000-0003-3605-402X
Yutaka Igarashi https://orcid.org/0000-0002-4305-2850
Tatsuya Norii https://orcid.org/0000-0001-7428-5625

REFERENCES

1. Ambulance Service Planning Office of Fire, Disaster Management Agency of Japan. Effect of first aid for cardiopulmonary arrest; 2008 (in Japanese). Cited 1 May 2022. Available from: https://www.fdma.go.jp/publication/rescue/post-2.html
2. Kitamura T, Kiyohara K, Sakai T, Iwami T, Nishiyama C, Kajino K, et al. Epidemiology and outcome of adult out-of-hospital cardiac arrest of non-cardiac origin in Osaka: a population-based study. BMJ Open. 2014;4:e006462.
3. The Ministry of Health, Labour and Welfare in Japan. A current population survey. Cited 2 Oct 2021. Available from: http://mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nengai20/index.html
4. Inamasu J, Miyatake S, Tomioka H, Shirai T, Ishiyama M, Komagamine J, et al. Cardiac arrest due to food asphyxiation in adults: resuscitation profiles and outcomes. Resuscitation. 2010;81:1082–6.
5. Wee JH, You YH, Lim H, Choi WJ, Lee BK, Park JH, et al. Outcomes of XXX asphyxia cardiac arrest patients who were treated with therapeutic hypothermia: a multicentre retrospective cohort study. Resuscitation. 2015;89:81–5.
6. Japan Resuscitation Council. Japanese guidelines for emergency care and cardiopulmonary resuscitation. Tokyo, Japan: Igakusyoin; 2021. p. 37–41.
7. Igarashi Y, Yokobori S, Yoshino Y, Masuno T, Miyauchi M, Yokota H. Prehospital removal improves neurological outcomes in elderly patient with foreign body airway obstruction. Am J Emerg Med. 2017;35:1396–9.
8. Yang Z, Liang H, Li J, Qiu S, He Z, Li J, et al. Comparing the efficacy of bag-valve mask, endotracheal intubation, and laryngeal mask airway for subjects with out-of-hospital cardiac arrest: an indirect meta-analysis. Ann Transl Med. 2019;7:257.
9. Kitamura T, Iwami T, Atsumi T, Endo T, Kanna T, Kuroda Y, et al. The profile of Japanese Association for Acute Medicine—out-of-hospital cardiac arrest registry in 2014-2015. Acute Med Surg. 2018;5:249–58.
10. Perkins GD, Jacobs IG, Nadkarni VM, Berg RA, Bhanji F, Biarent D, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein resuscitation registry templates for out-of-hospital cardiac arrest: a statement for healthcare professionals from a task force of the international liaison committee on resuscitation (American Heart Association, European resuscitation council, Australian and New Zealand council on resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, resuscitation Council of Southern Africa, resuscitation Council of Asia); and the American Heart Association emergency cardiovascular care committee and the council on cardiopulmonary, critical care, perioperative and resuscitation. Circulation. 2015;132:1286–300.
11. Japan Resuscitation Council. Japanese guidelines for emergency care and cardiopulmonary resuscitation. Tokyo, Japan: Igakusyoin; 2016.
12. Japanese Foundation Emergency Medicine. JRC resuscitation guideline 2020, For health care providers. Vol 2021. Tokyo, Japan: Herusu-Shuppan; 2021. p. 226–39.

13. Hifumi T, Kuroda Y, Kawakita K, Sawano H, Tahara Y, Hase M, et al. Effect of admission Glasgow coma scale motor score on neurological outcome in out-of-hospital cardiac arrest patients receiving therapeutic hypothermia. Circ J. 2015;79:2201–8.
14. Adnet F, Triba MN, Borron SW, Lapostolle F, Hubert H, Gueugniaud PY, et al. Cardiopulmonary resuscitation duration and survival in out-of-hospital cardiac arrest patients. Resuscitation. 2017;111:74–81.
15. Safer P, Paradis NA, Weil MH. Asphyxial cardiac arrest. In: Paradis NA et al., editors. Cardiac arrest; the science and practice of resuscitation medicine. 2nd ed. Cambridge: Cambridge University Press; 2007. p. 969–93.
16. Igarashi Y, Norii T, Sung-Ho K, Nagata S, Tagami T, Femling J, et al. New classifications for life-threatening foreign body airway obstruction. Am J Emerg Med. 2019;37:2177–81.

How to cite this article: Bunya N, Hirofumi O, Igarashi Y, Norii T, Katayama Y, Kasai T, et al. Effect of prehospital advanced airway management on out-of-hospital cardiac arrest due to asphyxia: A JAAM-OHCA registry-based observational study in Japan. Acute Med Surg. 2024;10:e912. https://doi.org/10.1002/ams2.912