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Impact of Physician Presence during Pre-Hospital Advanced Airway Management on One-Month Neurological Survival after OHCA: A Nationwide Multicenter Study

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Abstract

Limited evidence exists regarding whether advanced airway management (AAM) performed in the pre-hospital phase with a physician on scene leads to better outcomes after cardiac arrest than AAM delivered without physician involvement. This retrospective, multicentre cohort investigation included consecutive patients transported to participating Japanese hospitals after experiencing out-of-hospital cardiac arrest between 1 June 2014 and 31 December 2019. Eligible individuals were those aged 18 years or older, with presumed medical causes, who received pre-hospital AAM and were resuscitated upon hospital arrival. The primary endpoint—referred to as one-month favourable neurological survival—was defined as a Cerebral Performance Category (CPC) score of 1 or 2 one month after the arrest. The initial cardiac rhythm was determined using a 3-lead ECG or an automated external defibrillator in combination with carotid pulse checks. Prior work has suggested that physician involvement before hospital arrival may improve outcomes once rhythm type is accounted for ([1–4]). Consequently, the initial rhythm was classified as shockable or non-shockable. Multivariable logistic regression was conducted following propensity score matching. A total of 16,703 cases were evaluated. In the non-shockable cohort (n = 2,346), 1.2% (N = 29) reached the primary outcome. The adjusted odds ratio (aOR) for the effect of physician-attended versus non-physician AAM on the primary outcome in this group was 4.64 (95% CI: 1.81–14.4). In the shockable cohort (n = 826), 16.9% (N = 140) achieved favourable neurological survival, with an aOR of 1.05 (95% CI: 0.67–1.63). Within this multicentre retrospective cohort, the presence of a physician during pre-hospital AAM was significantly associated with better neurological outcomes in specific subsets of cardiac arrest patients compared with AAM conducted without a physician present.

Keywords: Airway management, Cardiac arrest, Cardiopulmonary resuscitation, Emergency medical services, emergency medicine, Resuscitation

Introduction

Following an out-of-hospital cardiac arrest, fewer than 10% of patients attain favourable neurological recovery (CPC 1–2) [1, 2]. The interval between collapse and initiation of appropriate interventions remains one of the strongest determinants of successful resuscitation [3–5].

In some regions, physicians may be dispatched to assist patients with critical conditions, including cardiac arrest [5–11]. In Japan, emergency medical services personnel are not legally permitted to independently decide whether to carry out advanced life support measures. Such interventions—endotracheal intubation, supraglottic airway placement, and adrenaline administration—require real-time authorization from a hospital-based physician [5, 10].

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Prior studies have linked physician presence before hospital arrival with better neurological outcomes in out-of-hospital cardiac arrest cases [6–8]. However, the precise mechanisms underlying this observed benefit remain unclear [5–11]. Because EMS personnel in Japan do not receive training to perform tracheal intubation in either the emergency department or the pre-hospital environments, a physician's participation may directly affect airway success. Supporting this, a time-dependent propensity score sequential matching analysis designed to minimize resuscitation time bias [12] found that pre-hospital AAM was advantageous mainly for patients who did not require immediate defibrillation after collapse [4]. Another investigation demonstrated that the value of having a physician present varies according to the patient's initial cardiac rhythm [5].
This study was therefore constructed to evaluate whether pre-hospital AAM performed in the presence of a physician enhances neurological outcomes for patients with specific initial cardiac rhythm categories, compared with AAM delivered without physician attendance.

Materials and Methods

Ethical consideration
This investigation used a retrospective secondary analysis of data from the Japanese Association for Acute Medicine registry for out-of-hospital cardiac arrest. All procedures documented in the registry reflect standard clinical practice, and participation in the registry imposes no additional risk on patients [5]. Requirements for written informed consent were waived under the Act on the Protection of Personal Information and the Ethical Guidelines for Medical and Biological Research Involving Human Subjects of Japan. Individuals who declined participation—either personally or through a family representative—were not included. The registry received approval from the Clinical Research Institutional Review Board of Dokkyo Medical University Saitama Medical Center (22043) and from each hospital's ethical committee as required. The project was prospectively registered in the University Hospital Medical Information Network (UMIN) Clinical Trials Registry (UMIN000007528) before enrolment commenced.

Study design, population, setting, and data quality control
This registry represents a nationwide, multicentre, hospital-based, prospective cohort managed by the Japanese Association for Acute Medicine, with its protocol detailed previously [5, 13]. The registry began on 1 June 2014 and continues without a predefined end date [5]. Pre-hospital data were collected from forms based on the Utstein Style template for reporting out-of-hospital cardiac arrest [14] and maintained by the Fire and Disaster Management Agency of Japan. For registry submission, anonymised hospital records were entered online by physicians or trained staff one month after the cardiac arrest event. Data underwent initial checks for internal consistency, followed by review from a dedicated registry committee composed of specialists in emergency medicine and clinical epidemiology. Any incomplete or unclear entries were returned to the submitting institution for clarification [5].
This study included every consecutive eligible patient transported to participating hospitals after experiencing out-of-hospital cardiac arrest between 1 June 2014 and 31 December 2019. Inclusion criteria were: receipt of pre-hospital AAM (with or without physician presence), resuscitation performed on hospital arrival, age ≥18 years, and a presumed medical cause of arrest. Cases with missing essential data were excluded.

Outcomes and definitions in this study
The primary endpoint was the neurological condition of survivors at one month, as assessed by clinical staff at each hospital, here referred to as one-month neurological survival. A favourable outcome corresponded to a Cerebral Performance Category (CPC) score of 1 or 2. CPC 1 indicates good neurological function; CPC 2, moderate disability; CPC 3, severe disability; CPC 4, coma or vegetative state; and CPC 5, death [14]. The secondary endpoint was one-month survival, regardless of neurological status.
Cardiac arrest was defined as the absence of mechanical cardiac activity confirmed by no detectable pulse [14, 15]. Emergency personnel identified cardiac rhythm using carotid pulse checks along with a 3-lead ECG or automated external defibrillator readings [15, 16]. This rhythm is referred to as the first confirmed cardiac rhythm. Rhythms were categorised as non-shockable or shockable, depending on whether electrical defibrillation could convert them [16]. Non-shockable rhythms consisted of asystole and pulseless electrical activity. Shockable rhythms included pulseless ventricular tachycardia and ventricular fibrillation. The presumed cardiac origin of arrest was determined by excluding non-medical causes—such as trauma, falls, hanging, drowning, intoxication, or asphyxia [5, 14].

Pre-hospital emergency medical system in Japan
Details of Japan's emergency medical system have been summarized previously [6, 7]. Each ambulance crew consists of three members, including at least one emergency life-saving technician (ELST) trained in advanced pre-hospital interventions. All ELSTs may establish intravenous access and insert adjunct airways. Specially

certified ELSTs may perform tracheal intubation only in cardiac arrest cases, and may administer intravenous adrenaline, but no other medications. They are prohibited from intubating after the return of spontaneous circulation.

The intubation training program requires 30 successful operating-room intubations under an anaesthesiologist's supervision [7, 17]. ELSTs are not trained to perform intubation in pre-hospital or emergency department environments and legally may not attempt intubation in anatomically difficult cases, specifically those classified as Cormack–Lehane grade 3 or 4 [5, 18]. In addition, Japanese regulations mandate that ELSTs obtain real-time physician approval by mobile phone before performing any advanced life support procedures. Thus, both AAM and adrenaline administration require telemedical physician direction [5].

Advanced life support protocols are established beforehand. Supraglottic airway devices in use include the laryngeal mask and esophageal obturator airway. Pre-hospital care follows the Japanese Resuscitation Council 2020 guidelines. Once an airway was secured, chest compressions were delivered at a 30:2 ratio, and after AAM, compressions were performed independently of ventilations.

A pre-hospital physician response

A physician assigned to pre-hospital care travelled to the patient either by ambulance or helicopter. For this study, "presence of a pre-hospital physician" indicated that the physician directly performed AAM using their technical abilities or provided non-technical assistance—such as guiding and supporting emergency medical services personnel during AAM. These physicians typically worked in local emergency medicine and were capable of delivering appropriate assessment and initial management across a broad range of urgent conditions. At present, Japan lacks a uniform protocol describing when physicians should be dispatched to cardiac arrest scenes or defining their exact responsibilities once on site [5]. For instance, dispatch criteria vary: decisions may rely on telephone assessments or on-scene requests from emergency personnel. Only select regions in Japan employ physician-dispatch systems [5, 11]. The registry did not include detailed information about the geographic areas covered by each dispatched physician or the number of hospitals operating within such systems.

Statistical analysis

We compared patient characteristics and outcome measures according to whether a physician participated in pre-hospital AAM. Multivariable logistic regression analyses were performed, generating adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Factors chosen for adjustment included clinically important variables such as age and sex—common adjustments in epidemiologic research—and additional elements reported to influence outcome evaluation [6, 7]. Potential confounders included extracorporeal membrane oxygenation (yes/no), percutaneous coronary intervention (yes/no), intra-aortic balloon pumping (yes/no), and targeted temperature management (yes/no).

To further address potential selection bias when comparing AAM with and without physician involvement, we constructed a propensity score model. Variables incorporated into the propensity score were: age (per one-year increase); sex (male/female); bystander witness status (yes/no); bystander resuscitation (yes/no); dispatcher instructions (yes/no); time interval from emergency call receipt to first EMS contact (minutes); weekday occurrence (yes/no); and season—spring (March–May), summer (June–August), autumn (September–November), or winter (December–February). All variables were assessed before completion of pre-hospital AAM. We then used one-to-one nearest neighbour matching without replacement, applying a caliper of 0.05 of the standard deviation of the logit of the propensity score. Balance of covariates before and after matching was evaluated using standardized mean differences; values below 10% were considered adequately balanced. Analyses were performed separately for the non-shockable and shockable rhythm groups in accordance with earlier studies [4, 5]. We also conducted univariate logistic regression according to the AAM device type and summarized arrest etiologies for each first confirmed rhythm category. Statistical testing was conducted in R version 3.6.2, using the Matching and tableone packages.

Results and Discussion

In total, 57,754 cases of out-of-hospital cardiac arrest were recorded during the study timeframe. After excluding individuals with missing key data, 16,703 remained eligible for inclusion **(Figure 1)**. Among these, 1,593 (9.5%) received pre-hospital resuscitation involving a physician, while 15,110 (90.5%) did not.

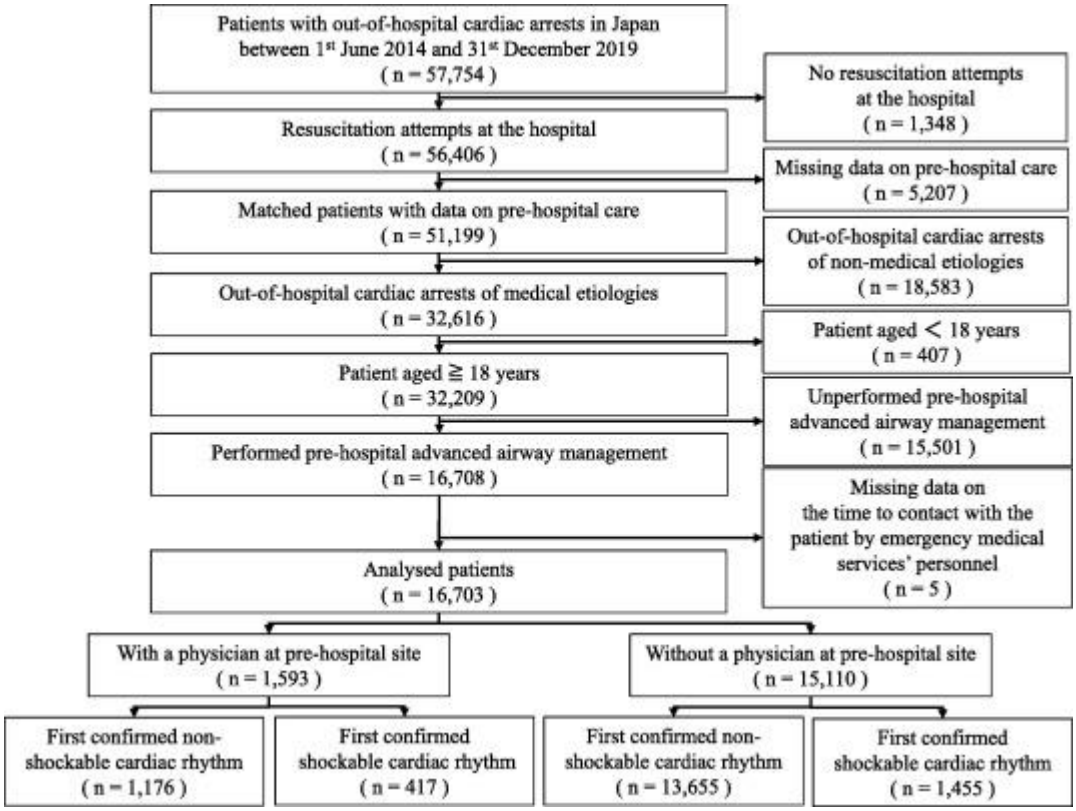

Figure 1. This diagram outlines patient selection in a nationwide, multi-centre cohort. Cardiac arrest was classified as medical in origin unless triggered by traumatic causes such as falls, hanging, drowning, overdose, or asphyxial events. The initial cardiac rhythm was determined using a 3-lead ECG or an AED, accompanied by an assessment of carotid pulsation at EMS arrival. Patients were separated into two categories according to the first identified rhythm: a non-shockable group (asystole or pulseless electrical activity) and a shockable group (pulseless ventricular tachycardia or ventricular fibrillation)

Table 1 summarises characteristics of individuals with non-shockable versus shockable rhythms, stratified by whether a pre-hospital physician was present. Prior to propensity score adjustment, cases attended by a pre-hospital physician were more frequently witnessed by laypersons in both rhythm groups, whereas patients tended to be older when no physician was on scene. Following matching in the non-shockable cohort, 1,173 participants were retained per arm, producing a strong improvement in covariate alignment, with all standardised mean differences below 10%. In the shockable cohort, matching yielded 413 subjects in each arm and similarly enhanced balance across variables.

Table 1. Baseline features of patients treated with or without a pre-hospital physician

Patients with an Initial Non-shockable Rhythm						
All patients				**Propensity score–matched patients**		
With pre-hospital physician (n = 1,176)	Without pre-hospital physician (n = 13,655)		Std. mean diff.	With pre-hospital physician (n = 1,173)		
Patient Characteristics						
Variable	**With physician**	**Without physician**	**SMD**	**With physician (matched)**	**Without physician (matched)**	**SMD**
Age, yrs, median (IQR)	75.0 (64.0–83.0)	79.0 (68.0–86.0)	0.24	75.0 (64.0–83.0)	75.0 (63.0–84.0)	0.02
Men, n (%)	716 (60.9)	8,002 (58.6)	0.05	713 (60.8)	729 (62.1)	0.03
Bystander-witnessed, n (%)	698 (59.4)	5,286 (38.7)	0.42	695 (59.2)	690 (58.8)	<0.01

Bystander CPR, n (%)	532 (45.2)	6,589 (48.3)	0.06	530 (45.2)	537 (45.8)	0.01
Dispatcher guidance, n (%)	625 (53.1)	7,499 (54.9)	0.04	623 (53.1)	644 (54.9)	0.04
Time from call to EMS contact, min, mean (SD)	7.9 (3.6)	7.3 (2.7)	0.21	7.9 (3.3)	7.9 (3.3)	<0.01
Timing Factors						
Variable	**With physician**	**Without physician**	**SMD**	**With physician (matched)**	**Without physician (matched)**	**SMD**
Weekday event, n (%)	815 (69.3)	9,003 (65.9)	0.07	813 (69.3)	794 (67.7)	0.04
Season, n (%)			0.06			0.04
Spring (Mar–May)	244 (20.7)	3,002 (22.0)		244 (20.8)	258 (22.0)	
Summer (Jun–Aug)	263 (22.4)	2,832 (20.7)		262 (22.3)	248 (21.1)	
Autumn (Sep–Nov)	301 (25.6)	3,327 (24.4)		300 (25.6)	299 (25.5)	
Winter (Dec–Feb)	368 (31.3)	4,494 (32.9)		367 (31.3)	368 (31.4)	
Patients with an Initial Shockable Rhythm						
	All patients			**Propensity score–matched patients**		
	With pre-hospital physician (n = 417)	Without pre-hospital physician (n = 1,455)	Std. mean diff.		With pre-hospital physician (n = 413)	
Patient Characteristics						
Variable	**With physician**	**Without physician**	**SMD**	**With physician (matched)**	**Without physician (matched)**	**SMD**
Age, yrs, median (IQR)	65.0 (54.0–74.0)	67.0 (56.0–76.0)	0.15	65.0 (54.0–74.0)	66.0 (55.0–76.0)	0.07
Men, n (%)	345 (82.7)	1,167 (80.2)	0.07	341 (82.6)	346 (83.8)	0.03
Bystander-witnessed, n (%)	315 (75.5)	1,027 (70.6)	0.11	311 (75.3)	307 (74.3)	0.02
Bystander CPR, n (%)	231 (55.4)	779 (53.5)	0.04	227 (55.0)	226 (54.7)	<0.01
Dispatcher guidance, n (%)	191 (45.8)	769 (52.9)	0.14	191 (46.2)	186 (45.0)	0.02
Time from call to EMS contact, min, mean (SD)	7.6 (3.6)	7.1 (2.6)	0.16	7.4 (2.8)	7.4 (2.7)	<0.01
Timing Factors						
Variable	**With physician**	**Without physician**	**SMD**	**With physician (matched)**	**Without physician (matched)**	**SMD**
Weekday event, n (%)	284 (68.1)	964 (66.3)	0.04	281 (68.0)	290 (70.2)	0.05
Season, n (%)			0.07			0.09
Spring (Mar–May)	88 (21.1)	328 (22.5)		87 (21.1)	86 (20.8)	
Summer (Jun–Aug)	95 (22.8)	348 (23.9)		93 (22.5)	83 (20.1)	
Autumn (Sep–Nov)	122 (29.3)	384 (26.4)		121 (29.3)	116 (28.1)	

Winter (Dec–Feb)	112 (26.9)	395 (27.1)	112 (27.1)	128 (31.0)

Table 2 presents primary and secondary outcomes from multivariable modelling in the matched population. Within the non-shockable subgroup, one-month favourable neurological outcome was significantly higher when care involved a pre-hospital physician (AOR = 4.64; 95% CI: 1.81–14.4). One-month survival in this group also increased under physician involvement (AOR = 1.64; 95% CI: 1.02–2.67). In contrast, among shockable cases, physician presence showed no meaningful association with neurological recovery (AOR = 1.05; 95% CI: 0.67–1.63) or one-month survival (AOR = 1.12; 95% CI: 0.78–1.62).

Table 2. Multivariable analyses of outcome measures in out-of-hospital cardiac arrest

	With pre-hospital physician	Without pre-hospital physician	Crude OR (95% CI)	Adjusted OR (95% CI)
Primary outcome: 1-month favourable neurological survival				
Before propensity score matching				
Initial non-shockable rhythm	n = 1,176	n = 13,655		
Favourable neurological outcome, n (%)	24 (2.0)	67 (0.5)	4.23 (2.59–6.66)	2.11 (1.23–3.50)
Initial shockable rhythm	n = 417	n = 1,455		
Favourable neurological outcome, n (%)	78 (18.7)	191 (13.1)	1.52 (1.14–2.03)	1.10 (0.78–1.56)
After propensity score matching				
Initial non-shockable rhythm	n = 1,173	n = 1,173		
Favourable neurological outcome, n (%)	24 (2.0)	5 (0.4)	4.88 (2.01–14.5)	4.64 (1.81–14.4)
Initial shockable rhythm	n = 413	n = 413		
Favourable neurological outcome, n (%)	78 (18.9)	62 (15.0)	1.32 (0.92–1.90)	1.05 (0.67–1.63)
Secondary outcome: 1-month survival				
Before propensity score matching				
Initial non-shockable rhythm	n = 1,176	n = 13,655		
Survival at 1 month, n (%)	64 (5.4)	322 (2.4)	2.38 (1.80–3.12)	1.33 (0.95–1.85)
Initial shockable rhythm	n = 417	n = 1,455		
Survival at 1 month, n (%)	151 (36.2)	365 (25.1)	1.70 (1.34–2.14)	1.25 (0.93–1.68)
After propensity score matching				
Initial non-shockable rhythm	n = 1,173	n = 1,173		
Survival at 1 month, n (%)	64 (5.5)	37 (3.2)	1.77 (1.78–2.70)*	1.64 (1.02–2.67)
Initial shockable rhythm	n = 413	n = 413		
Survival at 1 month, n (%)	150 (36.3)	116 (28.1)	1.46 (1.09–1.96)	1.12 (0.78–1.62)

Adjusted odds ratios and 95% confidence intervals incorporate extracorporeal membrane oxygenation, percutaneous coronary intervention, intra-aortic balloon pump therapy, and targeted temperature management within the matched sets. Propensity scores were generated from patient characteristics (age, sex, bystander witness status, bystander resuscitation, dispatcher guidance, interval from emergency call to EMS contact), and temporal factors (weekday vs weekend/holiday, and seasonal period). Favourable neurological survival corresponds to Cerebral Performance Category 1 or 2.

"Before propensity score-matched" denotes the full sample, and "after propensity score-matched" denotes the matched subsets.

Table 3 provides univariate logistic regression results based on the airway device used for AAM. Among non-shockable patients, physician-supervised pre-hospital AAM was associated with a higher likelihood of favourable neurological status at one month, regardless of the device type (crude OR = 4.50; 95% CI: 1.75–11.0; and crude OR = 4.10; 95% CI: 2.26–7.01).

Table 3. Univariate logistic regression for devices used in advanced airway management at the pre-hospital site. Favourable neurological survival corresponds to Cerebral Performance Category 1 or 2

Outcome & Airway Strategy	With pre-hospital physician	Without pre-hospital physician	Crude OR (95% CI)
Primary outcome: 1-month favourable neurological survival			
Endotracheal intubation	n = 368	n = 2,442	
Initial non-shockable rhythm, n (%)	8 (2.2)	12 (0.5)	4.50 (1.75–11.0)
Initial shockable rhythm, n (%)	13 (14.4)	29 (11.6)	1.28 (0.62–2.54)
Supraglottic airway	n = 808	n = 11,213	
Initial non-shockable rhythm, n (%)	16 (2.0)	55 (0.5)	4.10 (2.26–7.01)
Initial shockable rhythm, n (%)	65 (19.9)	162 (13.4)	1.60 (1.16–2.19)
Secondary outcome: 1-month survival			
Endotracheal intubation	n = 368	n = 2,442	
Initial non-shockable rhythm, n (%)	21 (5.7)	62 (2.5)	2.32 (1.37–3.80)
Initial shockable rhythm, n (%)	24 (26.7)	55 (22.1)	1.28 (0.73–2.22)
Supraglottic airway	n = 808	n = 11,213	
Initial non-shockable rhythm, n (%)	43 (5.3)	260 (2.3)	2.37 (1.68–3.26)
Initial shockable rhythm, n (%)	127 (38.8)	310 (25.7)	1.84 (1.42–2.37)

Table 4 outlines arrest aetiologies according to initial rhythm. Compared with shockable rhythms, non-shockable arrests were more frequently attributed to non-cardiac causes, including respiratory pathology.

Table 4. Aetiological categories of cardiac arrest based on the initial confirmed rhythm

Aetiology	With pre-hospital physician	Without pre-hospital physician
Patients with initial non-shockable rhythm	n = 1,176	n = 13,655
Cardiac cause, n (%)	896 (76.2)	11,036 (80.8)
Non-cardiac cause		
Respiratory disease, n (%)	115 (9.8)	1,317 (9.6)
Cerebrovascular disease, n (%)	124 (10.5)	865 (6.3)
Malignant tumour, n (%)	41 (3.5)	437 (3.2)
Patients with initial shockable rhythm	n = 417	n = 1,455
Cardiac cause, n (%)	411 (98.6)	1,408 (96.8)
Non-cardiac cause		
Respiratory disease, n (%)	2 (0.5)	24 (1.6)
Cerebrovascular disease, n (%)	4 (1.0)	15 (1.0)
Malignant tumour, n (%)	0 (0.0)	8 (0.5)

Drawing on data from a nationwide Japanese prospective registry, we examined outcome differences in adults who received pre-hospital AAM after cardiac arrest, comparing those treated with versus without an on-scene physician. Our analysis showed that, within the non-shockable cohort, physician involvement correlated with higher rates of favourable neurological status at one month. These findings offer useful insights for shaping pre-hospital airway management protocols and guiding regional emergency care planning.

In particular, the non-shockable group demonstrated a significant link between pre-hospital physician presence and a one-month favourable neurological outcome. One possible explanation relates to the distribution of underlying causes of arrest. As indicated in **Table 4**, non-shockable rhythms were more commonly associated with non-cardiac conditions—such as respiratory disease—compared with shockable rhythms. This suggests that hypoxia may play a more dominant role in the non-shockable subgroup. Consequently, early and effective airway management may be more impactful for these patients. Two mechanisms may influence the observed association. First, when a physician is on site, AAM-related information is transmitted directly rather than relayed remotely, reducing the likelihood of misunderstandings between EMS personnel and off-site physicians. Second, prior evidence indicates that having multiple responders is independently linked to improved one-year survival [19]. An on-scene physician may therefore enhance outcomes through more coordinated and technically advanced AAM.

Several limitations must be considered. To begin with, both selection bias and information bias could affect our findings. As noted in the Methods section, physician deployment systems in Japan operate only in limited regions. Therefore, the dataset inherently reflects substantial selection bias: approximately 10% of included patients were treated by a pre-hospital physician, whereas roughly 90% were not. This imbalance must be recognised when interpreting our results. In addition, the registry used is hospital-based and does not represent every institution nationwide. The proportion of non-participating hospitals is undocumented. Consistent with earlier publications using the same protocol [13], the registry primarily includes tertiary or critical-care emergency centres. These facilities provide advanced care for severely ill individuals, including out-of-hospital cardiac arrest cases, that may not be accessible in other care settings [5].

There is also notable selection bias in the patient groups themselves. EMS personnel in Japan are not authorised to perform intubation on patients who regain spontaneous circulation, which means we could not assess individuals who might have benefited from AAM after return of circulation when no physician was present. Furthermore, a pre-hospital physician may choose not to attempt AAM in non-shockable arrests with prolonged downtime; such cases would not appear in our dataset, creating a major additional source of bias. Outcome assessors were not blinded; however, evaluations relied on Cerebral Performance Category scores obtained from medical records, which likely limited information bias. Because this was an observational study, unmeasured confounders may also exist. For instance, criteria for physician dispatch and airway device selection vary across Japan. The registry lacks data on the number of AAM attempts, failed intubations, and arrest location. Likewise, we could not measure the technical or non-technical proficiency of physicians performing AAM, nor determine the coverage area or number of hospitals associated with each dispatch system. Finally, differences in legislation and pre-hospital practice across countries limit the external applicability of our results. In Japan, EMS personnel are legally restricted from making real-time decisions regarding advanced life support procedures, which is not the case in many other regions. This distinction likely affects the generalizability of our findings.

Conclusion

In summary, physician-supervised pre-hospital AAM was significantly associated with improved one-month favourable neurological outcomes among patients with non-shockable cardiac arrest.

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Ethics statement: None.

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