JAMA Surgery | Original Investigation

Association of Prehospital Advanced Life Support by Physician With Survival After Out-of-Hospital Cardiac Arrest With Blunt Trauma Following Traffic Collisions
Japanese Registry-Based Study

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Invited Commentary

Supplemental content

IMPORTANCE Controversy remains as to whether advanced life support (ALS) or basic life support (BLS) is superior for critically ill and injured patients, including out-of-hospital cardiac arrest (OHCA) and major trauma, in the prehospital setting.

OBJECTIVE To assess whether prehospital ALS should be provided for traumatic OHCA and who should perform it.

DESIGN, SETTING, AND PARTICIPANTS Japanese government-managed nationwide population-based registry data of patients with OHCA transported to an emergency hospital were analyzed. Patients who experienced traumatic OHCA following a traffic collision from 2013 to 2014 were included. Patients provided prehospital ALS by a physician were compared with both patients provided ALS by emergency medical service (EMS) personnel and patients with only BLS. The data were analyzed on May 1, 2017.

EXPOSURES Advanced life support by physician, ALS by EMS personnel, or BLS only.

MAIN OUTCOMES AND MEASURES The primary outcome was 1-month survival. The secondary outcomes were prehospital return of spontaneous circulation and favorable neurologic outcomes with the Glasgow-Pittsburgh cerebral performance category score of 1 or 2.

RESULTS A total of 4382 patients were included (mean [SD] age, 57.5 [22.2] years; 67.9% male); 828 (18.9%) received prehospital ALS by physician, 1591 (36.3%) received prehospital ALS by EMS personnel, and 1963 (44.8%) received BLS only. Among these patients, 96 (2.2%) survived 1 month after OHCA, including 26 of 828 (3.1%) for ALS by physician, 25 of 1591 (1.6%) for ALS by EMS personnel, and 45 of 1963 (2.3%) for BLS. After adjusting for potential confounders using multivariable logistic regression, ALS by physician was significantly associated with higher odds for 1-month survival compared with both ALS by EMS personnel and BLS (adjusted OR, 2.13; 95% CI, 1.20-3.78; and adjusted OR, 1.94; 95% CI, 1.14-3.25; respectively), whereas there was no significant difference between ALS by EMS personnel and BLS (adjusted OR, 0.91; 95% CI, 0.54-1.51). A propensity score–matched analysis in the ALS cohort showed that ALS by physician was associated with increased chance of 1-month survival compared with ALS by EMS personnel (risk ratio, 2.00; 95% CI, 1.01-3.97; *P* = .04). This association was consistent across a variety of sensitivity analyses.

CONCLUSIONS AND RELEVANCE In traumatic OHCA, ALS by physician was associated with increased chance of 1-month survival compared with both ALS by EMS personnel and BLS.

JAMA Surg. doi:10.1001/jamasurg.2018.0674
Published online April 25, 2018.

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More than 120 000 Japanese individuals have an out-of-hospital cardiac arrest (OHCA) annually.[1-3] Although the survival rate from OHCA is improving, no more than approximately 10% of patients with OHCA survive 1 month after OHCA.[1-3] Patients with traumatic OHCA, accounting for less than 10% of the total patients with OHCA, have an extremely low survival rate, not only in Japan[4] but also throughout the world.[5-8]

Prehospital advanced life support (ALS) for critically ill and injured patients, including those with OHCA and major trauma, has been introduced,[9-13] developed, and expanded in many emergency medical service (EMS) systems.[14-17] Emergency medical service system models are quite varied around the world. Some countries (such as France) have the Franco-German EMS system, in which a physician is brought to the patient,[18,19] while other countries (such as the United States, Japan, and Australia) have the Anglo-American EMS system, in which a patient is brought to the physician (that is, prehospital care is provided by nonphysicians).[20-22] Tiers of care provided by EMS system also vary depending on countries.[20-22] In the United States, EMS system models are numerous and varied depending on areas.[21] In Japan, the EMS system is principally the Anglo-American EMS system and 1-tiered, and some municipalities have their own physician-staffed EMS system.[20,23]

Thus far, to our knowledge, the benefit of prehospital ALS for traumatic OHCA has not been established. To our knowledge, no randomized clinical trials comparing ALS with basic life support (BLS) have been conducted in the traumatic OHCA population, and such a trial may be ethically difficult to conduct. In addition, observational studies of traumatic OHCA comparing ALS and BLS are scarce. Previous high-quality studies of OHCA or major trauma patients comparing ALS and BLS failed to find the survival benefit of ALS over BLS, although most studies on OHCA excluded trauma cases, and studies on major trauma usually included non-cardiac arrest cases.[24-27] One of the potential reasons for those failures to show the benefit of ALS vs BLS may be a lack of consideration of who should perform prehospital ALS. Although there is controversy as to who should perform prehospital ALS,[28] several studies have indicated the potential effectiveness of physician involvement in prehospital ALS in OHCA or major trauma cases.[23,29-31]

To simultaneously examine both whether prehospital ALS should be provided and who should perform prehospital ALS, we sought to assess whether prehospital ALS by a physician would be associated with an increased chance of favorable outcomes in OHCA with blunt trauma following a traffic collision compared with both ALS by EMS personnel and BLS.

Key Points

Question Is physician involvement in prehospital advanced life support (ALS) associated with increased chance of favorable outcomes after traumatic out-of-hospital cardiac arrest?

Findings In this Japanese nationwide, population-based registry study, including 4382 patients with traumatic out-of-hospital cardiac arrest, ALS by physician was associated with increased chance of prehospital return of spontaneous circulation and 1-month survival compared with both ALS by emergency medical service personnel and basic life support. Advanced life support by physician was also associated with increased chance of neurologically favorable survival compared with ALS by emergency medical service personnel, although there was no difference between ALS by physician and basic life support.

Meaning Physicians should probably be involved in prehospital ALS in traumatic out-of-hospital cardiac arrest cases; however, further well-designed studies are required to determine the optimal prehospital care for patients with traumatic out-of-hospital cardiac arrest.

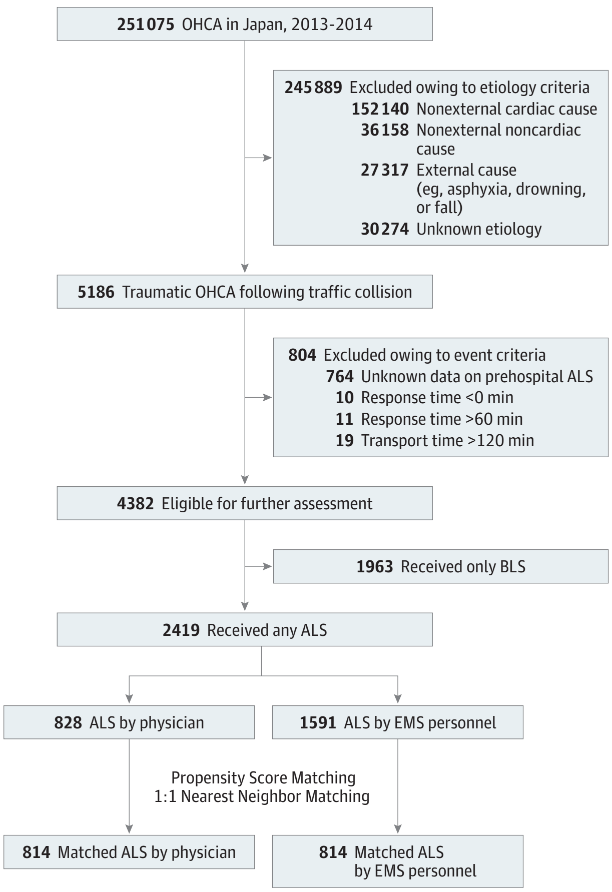
Methods

Data Source, Study Setting, and Participants

The All-Japan Utstein Registry is a nationwide, population-based registry of patients with OHCA sponsored by the Fire and Disaster Management Agency. In this registry, data were prospectively collected using the Utstein-style uniform reporting.[32,33] As has been described in detail previously,[1-3] trained EMS personnel prospectively collect data on patients with OHCA transported to an emergency hospital. This registry included almost all patients with OHCA, including those with do-not-resuscitate orders, because EMS personnel in Japan are not allowed to terminate out-of-hospital resuscitation except in specific situations (eg, decapitation, rigor mortis, livor mortis, and decomposition). Data are collected from 3 sources (1-1-9 dispatch centers, fire stations, and receiving hospitals) and are integrated into the All-Japan Utstein Registry system on the Fire and Disaster Management Agency database server. The certification by the Fire and Disaster Management Agency and the logical internal checks with standardized software secure the integrity, accuracy, and completeness of the data.

In Japan, all EMS personnel perform cardiopulmonary resuscitation (CPR) according to the Japanese CPR guidelines, which basically conform to the American Heart Association guidelines, although EMS personnel have different authorization depending on their completed training program.[34] An ambulance generally has a crew of 3 EMS personnel. Although a physician accompanies an ambulance in some municipalities, physician-staffed ambulances are not yet widespread. Instead, most ambulances include at least 1 emergency life-saving technician (ELST), certified to insert an intravenous catheter and a supraglottic airway device (since 1991). In addition, a specially trained ELST, who has completed an extensive training program, can administer epinephrine and insert an endotracheal tube. Epinephrine administration and endotracheal intubation by specially trained ELST officially started in April 2006 and July 2004, respectively. As of 2014, almost all (97.4%) ambulances included at least 1 ELST, and most (82.9%) were specially trained ELSTs.[34] However, ALS procedures cannot be performed without the instruction of a medical director in each municipality. In addition, EMS personnel in Japan are not allowed to perform other advanced interventions (eg, surgical airway, chest drain, or intraosseous access). This means that EMS personnel in Japan can perform

Figure. Study Flow Diagram



ALS indicates advanced life support; BLS, basic life support; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest.

only intravenous catheter insertion and fluid infusion, intravenous epinephrine administration, and endotracheal intubation, even if they do all they can. On the other hand, physicians who accompany an ambulance to treat a patient with traumatic OHCA commonly specialize in emergency medicine and can perform any procedure (including blood transfusion, thoracotomy, resuscitative endovascular balloon occlusion of the aorta, or extracorporeal CPR) as long as the equipment and skills permit. Patients with traumatic OHCA are usually transported to a tertiary emergency medical center in each region, and these centers have similar level of capacity to perform sufficient treatment. As of 2012, there were 246 tertiary emergency medical centers; each center covered 500 000 people.

This study included patients with traumatic OHCA following a traffic collision submitted to the All-Japan Utstein Registry between January 1, 2013, and December 31, 2014. We excluded patients with unrealistic or contradictory (ie, negative or considerably long) times and patients with unknown data on prehospital ALS (**Figure**). Patients who received at least 1 prehospital ALS procedure (ie, intravenous catheter insertion, epinephrine administration, or advanced airway treatment including supraglottic airway device and endotracheal tube) were assigned to the ALS group, whereas patients who did not receive any ALS procedure were assigned to the BLS group.

This study was conducted according to the amended Declaration of Helsinki, with a waiver of informed consent owing to the anonymous nature of the data. The study was approved by the institutional review board of University of the Ryukyus, Okinawa, Japan.

Data Collection

Data on patient characteristics (ie, sex and age), bystander characteristics (ie, witnesses and bystander CPR), cardiac arrest characteristics (ie, first documented rhythm and etiology of cardiac arrest), and prehospital care characteristics (ie, intravenous catheter insertion, epinephrine administration, advanced airway treatment, and physician involvement in prehospital ALS) were collected in this registry. A series of EMS activity times (ie, emergency call receipt, contact with patient, and hospital arrival) were recorded by each EMS squad. Time intervals were calculated based on those variables recorded in whole minutes; the response time represents the interval between emergency call and contact with patient, and the transport time represents the interval between contact with patient and hospital arrival. The calculated interval of 1 minute represents that 1 event occurred within the next whole minute after the other event, whereas the time interval of 0 minutes indicates that 2 events occurred within the same whole minute. The etiology of cardiac arrest was determined by attending physicians in the emergency department in collaboration with EMS personnel. To reconfirm the etiology of the cardiac arrest and collect the outcome data on survival and neurological status, a 1-month follow-up survey was conducted by each fire department, based on an inquiry for the receiving hospital. If the patient was transferred or discharged from the hospital within 1 month, further investigations were conducted by the fire department in cooperation with the hospital personnel.

Outcomes

The primary outcome was 1-month survival. The secondary outcomes were prehospital return of spontaneous circulation (ROSC) and favorable neurologic outcome. Neurologic outcome was assessed by inpatient attending physicians using the Glasgow-Pittsburgh cerebral performance category scores 1 month after OHCA. A cerebral performance category score of 1 (good performance) or 2 (moderate disability) was considered a favorable neurologic outcome, and a cerebral performance category score of 3 (severe disability), 4 (vegetative state), or 5 (death) was considered a poor neurologic outcome.[33,35]

Statistical Analysis

The study cohort was characterized using descriptive statistics. Categorical variables were presented as counts with proportions, and the χ^2 test was used to evaluate differences between the 2 groups. Continuous variables were presented as means with standard deviations or medians with interquartile ranges (IQRs), and the *t* test or the Wilcoxon Mann-

Whitney test was used, respectively, to evaluate differences between the 2 groups.

Multivariable logistic regression models were used to determine the association between the type of prehospital care and outcomes, both with and without distinguishing the type of ALS professional. The following variables that could influence the outcomes after OHCA were included in the models: sex, age, witness, bystander CPR, first rhythm, response time, transport time, and a treatment variable (BLS vs ALS, or BLS vs ALS by EMS personnel vs ALS by physician). Adjusted odds ratios (ORs) with 95% confidence intervals were reported.

To further characterize the association between the type of ALS professional (EMS personnel vs physician) and outcomes after OHCA, propensity score analyses were performed in the prehospital ALS cohort. The propensity score for each patient receiving prehospital ALS by physician or EMS personnel was estimated using a multivariable logistic regression model. The model included the following variables with pretreatment characteristics: sex (male or female), age (≤17 years, 18-64 years, or ≥65 years), witness (witnessed or unwitnessed), bystander CPR (any CPR or no CPR), first rhythm (ventricular fibrillation, ventricular tachycardia, pulseless electrical activity, asystole, or others), and response time (<10 minutes or ≥10 minutes). A 1:1 nearest-neighbor matching was performed using a caliper of 0.2 without replacement between patients receiving ALS by physician and ALS by EMS personnel.[36] The success of the matching procedure was confirmed by comparing the baseline characteristics with standardized differences within 0.1.[37] Risk ratios (RRs) of each outcome for patients receiving prehospital ALS by physician vs EMS personnel were reported with 95% confidence intervals. Absolute risk reduction (ARR) and the number needed to treat (NNT) were also calculated.

Sensitivity analyses were performed for the primary outcome to verify that the results of the comparison between ALS by physician and ALS by EMS personnel did not depend on the method of covariate adjustment of the propensity score matching (eFigure in the Supplement). JMP Pro, version 11.2.0 software (SAS Institute Inc) was used for all statistical analyses. A 2-sided *P* value of .05 was considered significance level for all hypothesis tests.

Results

During the study period, we identified 4382 patients with traumatic OHCA eligible for analysis (Figure). Of these, 1963 (44.8%) received only BLS in the prehospital settings. Of the remaining 2419 (55.2%), prehospital ALS was performed by physician in 828 patients (18.9%), and by EMS personnel in 1591 patients (36.3%).

Table 1 summarizes the baseline characteristics of the total cohort according to the type of prehospital care. In the total cohort of traumatic OHCA, although most cases (3067 patients [70.0%]) were witnessed, the frequency of bystander CPR was low (863 patients [19.7%]). The median response time was 9 minutes (IQR, 7-12; mean [SD], 10.3 [86.1] minutes). The first rhythm was commonly the nonshockable rhythm (ie, pulseless electrical activity in 1595 patients [36.4%] and asystole in 2364 patients [53.9%]).

Table 2 shows the outcomes of patients with traumatic OHCA by the type of prehospital care in the total cohort. In a comparison between BLS and ALS without distinguishing the type of ALS professional, prehospital ALS was not associated with increased chance of 1-month survival (adjusted OR, 1.24; 95% CI, 0.81-1.91) or neurologic outcome (adjusted OR, 0.90; 95% CI, 0.39-2.04), although prehospital ALS was associated with a higher rate of prehospital ROSC compared with BLS (adjusted OR, 1.87; 95% CI, 1.43-2.46). In a comparison between BLS and ALS distinguishing the type of ALS professional (Table 2; eTable in the Supplement), although there was no difference in 1-month survival between ALS by EMS personnel and BLS (adjusted OR, 0.91; 95% CI, 0.54-1.51), physician involvement in prehospital ALS was associated with increased chance of 1-month survival compared with both BLS (adjusted OR, 1.94; 95% CI, 1.14-3.25) and ALS by EMS personnel (adjusted OR, 2.13; 95% CI, 1.20-3.78). In addition, a significant difference was observed in neurologic outcome between ALS by physician and ALS by EMS personnel (adjusted OR, 3.76; 95% CI, 1.14-14.51), although there was no difference between ALS by physician and BLS (adjusted OR, 1.77; 95% CI, 0.66-4.45).

Table 3 summarizes the baseline characteristics of the propensity score–matched cohort according to the type of ALS professional. After propensity score matching, the baseline characteristics were well balanced on pretreatment characteristics between the ALS by physician and ALS by EMS personnel. For posttreatment characteristics, the transport time was significantly longer in the ALS by physician group compared with the ALS by EMS personnel group.

Table 4 shows the outcomes of patients with traumatic OHCA by the type of ALS professional in the propensity score–matched cohort. Physician involvement in prehospital ALS was associated with increased chance of 1-month survival compared with ALS by EMS personnel (24 of 814 [3.0%] vs 12 of 814 [1.5%]; RR, 2.00; 95% CI, 1.01-3.97; *P* = .04; ARR, 1.47%; NNT, 67.83). Similar associations were observed for prehospital ROSC (87 of 814 [10.7%] vs 57 of 814 [7.0%]; RR, 1.53; 95% CI, 1.11-2.10; *P* = .009; ARR, 3.69%; NNT, 27.13), and favorable neurologic outcome (7 of 814 [0.9%] vs 0 of 814; *P* = .008; ARR, 0.86%; NNT, 116.28).

Discussion

Principal Findings

In this nationwide population-based observational study of traumatic OHCA, physician involvement in prehospital ALS was associated with increased chance of 1-month survival compared with both ALS by EMS personnel and BLS, although no difference was observed between ALS by EMS personnel and BLS. The association of the type of ALS professional with 1-month survival was consistent across a variety of sensitivity analyses, which indicated that the relationship was robust. Advanced life support by physician was also associated with increased chance of favorable neurologic outcome com-

Table 1. Baseline Characteristics of the Total Cohort According to the Type of Prehospital Care

	Total Cohort, No. (%)			Prehospital ALS Cohort, No. (%)		
Characteristic	BLS (n = 1963)	ALS (n = 2419)	*P* Value	By EMS Personnel (n = 1591)	By Physician (n = 828)	*P* Value
Pretreatment variable						
Calendar year						
2013	1002 (51.0)	1263 (52.2)	.44	826 (51.9)	437 (52.8)	.69
2014	961 (49.0)	1156 (47.8)		765 (48.1)	391 (47.2)	
Sex						
Male	1306 (66.5)	1670 (69.0)	.08	1095 (68.8)	575 (69.4)	.75
Female	657 (33.5)	749 (31.0)		496 (31.2)	253 (30.6)	
Age, mean (SD), y	55.9 (22.6)	58.8 (21.9)	<.001	59.2 (21.5)	58.1 (22.5)	.26
≤17	96 (4.9)	96 (4.0)	.001	54 (3.4)	42 (5.1)	.07
18-64	1003 (51.1)	1124 (46.5)		731 (45.9)	393 (47.5)	
≥65	864 (44.0)	1199 (49.6)		806 (50.7)	393 (47.5)	
Witness						
Witnessed	1374 (70.0)	1693 (70.0)	>.99	1129 (71.0)	564 (68.1)	.15
Unwitnessed	589 (30.0)	726 (30.0)		462 (29.0)	264 (31.9)	
Bystander CPR						
Any CPR	317 (16.1)	546 (22.6)	<.001	367 (23.1)	179 (21.6)	.42
No CPR	1646 (83.9)	1873 (77.4)		1224 (76.9)	649 (78.4)	
First rhythm						
VF	52 (2.6)	51 (2.1)	.001	39 (2.5)	12 (1.4)	.02
VT	1 (0.1)	5 (0.2)		4 (0.3)	1 (0.1)	
PEA	698 (35.6)	897 (37.1)		591 (37.1)	306 (37.0)	
Asystole	1039 (52.9)	1325 (54.8)		881 (55.4)	444 (53.6)	
Other	173 (8.8)	141 (5.8)		76 (4.8)	65 (7.9)	
Response time from emergency call to contact with patient, min						
Median (IQR)	8 (6-11)	9 (7-13)	<.001	9 (7-12)	9 (7-14)	.01
Mean (SD)	9.7 (5.8)	10.7 (6.3)	<.001	10.5 (6.0)	11.3 (6.8)	.002
Response time interval, min						
<10	1211 (61.7)	1325 (54.8)	<.001	907 (57.0)	418 (50.5)	.002
≥10	752 (38.3)	1094 (45.2)		684 (43.0)	410 (49.5)	
Posttreatment variable						
Transport time from contact with patient to hospital arrival, min						
Median (IQR)	22 (16-30)	27 (20-39)	<.001	26 (20-36)	31 (20-47)	<.001
Mean (SD)	25.4 (14.9)	31.8 (16.8)	<.001	29.7 (14.5)	35.9 (20.0)	<.001
Total time from emergency call to hospital arrival, min						
Median (IQR)	31 (24-42)	38 (29-51)	<.001	36 (28-48)	43 (30-59)	<.001
Mean (SD)	35.1 (17.2)	42.6 (19.3)	<.001	40.2 (17.0)	47.1 (22.5)	<.001

Abbreviations: ALS, advanced life support; BLS, basic life support; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; IQR, interquartile range; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia.

pared with ALS by EMS personnel, although there was no difference in neurologic outcome between ALS by physician and BLS.

Previous Studies and Important Differences With This Study

To our knowledge, there are no randomized clinical trials comparing ALS vs BLS in traumatic OHCA, regardless of distinguishing the type of ALS professional. Even if study population is not limited to traumatic OHCA but expanded to nontraumatic OHCA or major trauma without cardiac arrest, there are no randomized clinical trials but several high-quality studies comparing ALS and BLS. However, those studies failed to find the survival benefit of ALS vs BLS[24,26]; on the contrary, several studies indicated that ALS might be associated with worse outcomes compared with BLS.[25,27] One of the limitations of those studies, or a potential reason for failures to show the benefit of ALS vs BLS, may be lack of consideration on who should perform prehospital ALS because several studies have indicated the advantage of physician involvement in prehospital ALS in OHCA or major trauma cases.[23,29-31] Actually, our findings indicated ALS by physician was associated with increased

Table 2. Outcomes of Patients With Traumatic OHCA by the Type of Prehospital Care in the Total Cohort[a]

	Prehospital ROSC		One-Month Survival		Neurologic Outcome (CPC 1 or 2)	
Group	Events, No. (%)	Adjusted OR (95% CI)	Events, No. (%)	Adjusted OR (95% CI)	Events, No. (%)	Adjusted OR (95% CI)
BLS (n = 1963)	95 (4.8)	1 [Reference]	45 (2.3)	1 [Reference]	14 (0.7)	1 [Reference]
ALS (n = 2419)	204 (8.4)	1.87 (1.43-2.46)	51 (2.1)	1.24 (0.81-1.91)	12 (0.5)	0.90 (0.39-2.04)
By EMS personnel (n = 1591)	110 (6.9)	1.60 (1.19-2.16)	25 (1.6)	0.91 (0.54-1.51)	4 (0.3)	0.47 (0.13-1.35)
By physician (n = 828)	94 (11.4)	2.41 (1.74-3.35)	26 (3.1)	1.94 (1.14-3.25)	8 (1.0)	1.77 (0.66-4.45)

Abbreviations: ALS, advanced life support; BLS, basic life support; CPC, Glasgow-Pittsburgh cerebral performance category; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; ROSC, return of spontaneous circulation.

[a] The variables that could influence outcomes after OHCA were included in the models.

chance of 1-month survival compared with BLS; however, without distinguishing the type of ALS professional, there was no difference in survival between ALS and BLS. Our study extends the findings of previous studies by distinguishing ALS by physician from ALS by EMS personnel, comparing ALS by physician with both ALS by EMS personnel and BLS, including a large study sample, evaluating 1-month neurologic outcomes in addition to survival, and using several robust covariate adjustment methods.

Differences Between ALS by Physician and ALS by EMS Personnel

Several reasons were considered to explain the advantages of ALS by physicians compared with ALS by EMS personnel. Physicians can perform ALS based on their own judgment, but EMS personnel need permission or instruction from a medical director in each municipality to perform ALS, which may prevent EMS personnel from timely treatments. There might be differences in the proficiency in ALS procedures between physician and EMS personnel. Systematic reviews and meta-analyses indicated that there was a significant difference in the success rate of prehospital endotracheal intubation between physician and EMS personnel.[38,39] The lower success rate of advanced interventions could lead to longer interruption of CPR or lower quality of CPR, which would be fatal. Because establishing vascular access is essential to administer needed fluids or medications, intraosseous access can be substituted for intravenous access if an ALS professional has difficulty rapidly establishing intravenous access.[40-44] However, EMS personnel are not allowed to establish intraosseous access in Japan. In addition, there are other advanced interventions that EMS personnel are not allowed to perform (eg, surgical airway, chest drain, pericardial drain, or thoracotomy). Such advanced interventions that only physicians can perform might have a great effect on survival after traumatic OHCA.[45-49] Unfortunately, the information on such interventions could not be obtained from the All-Japan Utstein Registry data.

Limitations

First, despite using a variety of analytical techniques in an effort to control for selection bias and confounders, unmeasured confounding could remain. The life support technique, BLS or ALS, provided by the EMS personnel was not random and depended on the instruction of the medical director in each municipality. However, we cannot know why the medical director chose BLS or ALS from this registry. Whether a physician would accompany an ambulance was determined for each municipality. However, we cannot identify which patient belonged to which municipality in this registry. Although there are approximately 800 fire departments (each fire department covers 1 or several municipalities) in Japan, we were able to obtain information on only 47 prefectures (each prefecture consists of numerous municipalities) in this registry. Because municipalities in each prefecture are not homogenous, we could not adjust for regional clusters.[50] In addition, EMS personnel in Japan are not allowed to terminate out-of-hospital resuscitation, whereas physicians can declare death out of the hospital and can decide not to transport the patient. That might cause survivorship bias, although almost all patients are transported to the hospital on procedural grounds.

Second, the generalizability of our findings to any type of traumatic OHCA is uncertain. Because the etiology of cardiac arrest among the patients included in this study was mostly blunt trauma following a traffic collision, it is uncertain whether our findings can be generalized to penetrating trauma. In addition, we could not know the detailed injured area (eg, head, chest, abdomen, or extremities) or injury severity (eg, injury severity score, or abbreviated injury scale score).

Third, the generalizability of our findings to other countries is unknown. The Japanese style of EMS system may differ from that in other countries; compared with Japan, physicians might be more commonly involved in prehospital care, EMS personnel might have more chance to perform ALS procedures, or EMS personnel might be allowed to perform more advanced interventions.

Fourth, the quality of ALS procedure was not assessed. Because failed attempts at ALS procedures were not recorded in this registry, some patients for whom the attempt to provide ALS procedure had been made might be assigned to the BLS group.

Fifth, the data on in-hospital or postresuscitation care that could affect the outcomes after traumatic OHCA were

Table 3. Baseline Characteristics of the Propensity Score–Matched Cohort According to the Type of ALS Professional

Characteristic	Propensity Score–Matched Cohort ALS by Physician (n = 814)	ALS by EMS Personnel (n = 814)	Standardized Difference	P Value
Pretreatment variable				
Calendar year				
2013	432 (53.1)	424 (52.1)	0.0200	.69
2014	382 (46.9)	390 (47.9)	−0.0200	
Sex				
Male	546 (69.3)	567 (69.7)	−0.0087	.87
Female	250 (30.7)	247 (30.3)	0.0087	
Age, mean (SD), y	58.5 (22.2)	58.4 (22.2)	0.0045	.90
≤17	36 (4.4)	31 (3.8)	0.0303	.82
18-64	387 (47.5)	392 (48.2)	−0.0140	
≥65	391 (48.0)	391 (48.0)	0.0000	
Witness				
Witnessed	553 (67.9)	561 (68.9)	−0.0215	.67
Unwitnessed	261 (32.1)	253 (31.1)	0.0215	
Bystander CPR				
Any CPR	173 (21.3)	164 (20.1)	0.0296	.58
No CPR	641 (78.7)	650 (79.9)	−0.0296	
First rhythm				
VF	12 (1.5)	10 (1.2)	0.0260	.97
VT	1 (0.1)	2 (0.2)	−0.0258	
PEA	304 (37.3)	303 (37.2)	0.0021	
Asystole	444 (54.5)	444 (54.5)	0.0000	
Other	53 (6.5)	55 (6.8)	−0.0120	
Response time from emergency call to contact with patient, min				
Median (IQR)	9 (7-14)	9 (7-13)	NA	.84
Mean (SD)	11.3 (6.8)	11.1 (6.5)	0.0301	.91
Response time interval, min				
<10	413 (50.7)	409 (50.2)	0.0100	.84
≥10	401 (49.3)	405 (49.8)	−0.0100	
Posttreatment variable				
Transport time from contact with patient to hospital arrival, min				
Median (IQR)	31 (20-47)	27 (20-37)	NA	<.001
Mean (SD)	35.8 (20.0)	29.9 (13.9)	0.3426	<.001
Total time from emergency call to hospital arrival, min				
Median (IQR)	43 (30-59)	37 (29-49)	NA	<.001
Mean (SD)	47.1 (22.5)	40.9 (16.6)	0.3136	<.001

Abbreviations: ALS, advanced life support; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; IQR, interquartile range; NA, not applicable; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia.

unavailable, although patients with traumatic OHCA are principally transported to a tertiary emergency medical center in each region and these centers have similar levels of capability. Because comparing the registry data with the medical record data at the patient level was impossible owing to anonymization, our analyses could not be adjusted for characteristics on in-hospital or postresuscitation care.[51]

Finally, the effectiveness of physician involvement in prehospital ALS on neurologic outcome was uncertain compared with BLS. The sample size was likely too small to detect differences in neurologic outcome. In addition, scoring the cerebral performance category could cause interrater bias. An adequately powered and well-designed study would be required.

Conclusions

The results of this nationwide, population-based observational study of traumatic OHCA from 2013 to 2014 indicated that physician involvement in prehospital ALS was associated with increased chance of prehospital ROSC and 1-month survival com-

Table 4. Outcomes of Patients With Traumatic OHCA by the Type of ALS Professional in the Propensity Score–Matched Cohort

Outcome	Favorable Outcomes, No. (%) ALS by Physician (n = 814)	ALS by EMS Personnel (n = 814)	RR (95% CI)	*P* Value
Prehospital ROSC	87 (10.7)	57 (7.0)	1.53 (1.11-2.10)	.009
1-mo Overall survival	24 (3.0)	12 (1.5)	2.00 (1.01-3.97)	.04
Neurologic outcome (CPC 1 or 2)	7 (0.9)	0	NA	.008
CPC 1	5 (0.6)	0	NA	NA
CPC 2	2 (0.3)	0	NA	NA
CPC 3	6 (0.7)	3 (0.4)	NA	NA
CPC 4	10 (1.2)	8 (1.0)	NA	NA
CPC 5	791 (97.2)	803 (98.6)	NA	NA

Abbreviations: ALS, advanced life support; CPC, Glasgow-Pittsburgh cerebral performance category; EMS, emergency medical service; NA, not applicable; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation; RR, risk ratio.

pared with both ALS by EMS personnel and BLS. Advanced life support by physician was also associated with increased chance of favorable neurologic outcome compared with ALS by EMS personnel, but no difference was observed compared with BLS.

Our findings have important policy implications, although further well-designed studies (including a cost-effectiveness analysis) are required. To improve outcomes after traumatic OHCA, increasing physician-manned ambulances may be effective. Another effective option may be to permit EMS personnel to perform ALS based on their own judgment and/or expand the range of available procedures that EMS personnel can learn, practice, and perform.

ARTICLE INFORMATION

Accepted for Publication: January 29, 2018.

Published Online: April 25, 2018. doi:10.1001/jamasurg.2018.0674

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Author Contributions: Dr Fukuda had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: Fukuda.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Fukuda.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Fukuda.
Obtained funding: Fukuda.
Administrative, technical, or material support: Fukuda.
Supervision: Fukuda.
Other: Ohashi-Fukuda, Kondo, Hayashida, Kukita.

Conflict of Interest Disclosures: None reported.

Funding/Support: This study was supported by University of the Ryukyus, Okinawa, Japan.

Role of the Funder/Sponsor: The funding source had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Additional Contributions: We thank the Fire and Disaster Management Agency, who collected and managed the All-Japan Utstein Registry data.

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