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ORIGINAL ARTICLE

Tracheal intubation by paramedics under limited indication criteria may improve the short-term outcome of out-of-hospital cardiac arrests with noncardiac origin

Yutaka Takei · Miki Enami · Takahiro Yachida · Keisuke Ohta · Hideo Inaba

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Abstract

Purpose It is not clear whether advanced airway management (AAM) with an endotracheal tube (ET) by paramedics may improve the outcome of out-of-hospital cardiac arrest (OHCA) compared with the use of a bag-valve-mask device (BVMD) and other AAM devices.

Methods We analyzed 2,586 adult cases of OHCA without administration of adrenaline, witnessed or recognized by citizens in subjects transported to hospital by paramedics between 1 July 2004 and 31 March 2008 in Ishikawa, Japan, to determine whether AAM with an ET used under limited indication criteria may improve the outcome of OHCA.

Results The airway was managed with an ET in 263 cases, other AAM devices in 660 cases, and a BVMD in 1,539 cases. The AAM failed or was discontinued in 124 cases, which were excluded from the analysis. The incidence of sustained return of spontaneous circulation (ROSC) was significantly higher in cases of AAM with an ET (30%) than in AAM with other devices (20.2%) and in the standard procedure with a BVMD (21.3%). The AAM with an ET did not significantly affect 1-year survival. Multiple regression analysis indicated that tracheal intubation (odds ratio = 1.503, 95% confidence interval 1.081–2078), but not patient management by paramedics qualified for ET use, was an independent factor associated with sustained ROSC.

Conclusion When subjects with difficult airway are excluded, tracheal intubation according to the limited indication criteria and well-organized protocol in Japan may improve the short-term outcome of OHCA of noncardiac origin. A large prospective study is needed to determine the general effects of tracheal intubation on the long-term outcome of OHCA with disturbed ventilation.

Keywords Out-of-hospital cardiac arrest · Tracheal intubation · Survival

Introduction

Advanced cardiac life support (ACLS), including advanced airway management (AAM) and intravenous drug therapy, may have some benefits on the outcome of out-of-hospital cardiac arrest (OHCA) [1]. It is not clear whether AAM with an endotracheal tube (ET) in an emergency medical service (EMS) provides a better outcome of OHCA than other airway management devices [2, 3]. One controlled study in children showed that tracheal intubation did not improve clinical outcome [4]. Outcome was reported to be worsened when AAM with an ET was performed in cases of OHCA with shockable rhythms [5, 6]. Recently, Garza et al. reported that avoidance of tracheal intubation as an early airway management and an increase in the ratio of chest compressions to ventilation improved the survival rate in OHCA of cardiac origin [6].

In Japan, since July 2004, certified paramedics who have completed training programs for tracheal intubation have used ETs in patients with OHCA. The program includes 180 h of lectures and exercises in schools, as well as experience with 30 cases in hospital operating rooms. When an ET is indicated as an AAM device, the paramedics obtain instructions regarding tracheal intubation from an emergency physician in accordance with a protocol defined by the regional medical control council (MCC).

Y. Takei · M. Enami · T. Yachida · K. Ohta · H. Inaba (✉)
Department of Emergency Medical Science,
Kanazawa University Graduate School of Medicine,
13-1 Takaramachi, Kanazawa 920-8641, Japan
e-mail: hidinaba@med.kanazawa-u.ac.jp

The present population-based cohort study was performed to determine whether airway management with an ET, according to the indication criteria, would affect the outcome of OHCA in comparison with other AAM devices or a bag-valve-mask device (BVMD), and whether patient management by paramedics certified for ET use would affect the prognosis in comparison with patient management by paramedics not certified for ET use. Furthermore, we investigated whether the origin of OHCA (cardiac or noncardiac in the Utstein style) modified the effects.

Subjects, materials, and methods

Data were collected in accordance with the national guideline of ethics for the epidemiological survey (The Ministry of Health, Labor and Welfare in Japan: http://www.mhlw.go.jp/general/seido/kousei/i-kenkyu/index.html). The study was approved by the institutional review board of the Department of Emergency Medical Science, Kanazawa University Graduate School of Medicine (#843).

Populations and setting

Ishikawa prefecture encompasses an area of 4,185 km^2 on the Sea of Japan coast, and has a resident population of 1,160,000. The prefecture is divided into four administrative regions: one central or urban, and three semirural or rural regions. Sixty-two percent of the residents are located in the central (urban) region with an area of 1,432 km^2. An estimated 22% of the residents are over the age of 65. The prefecture has 704 ambulance crews, including 215 paramedics who can perform AAM with esophageal obturator airways and laryngeal masks. The numbers of paramedics certified for ET use (total number of paramedics) were 4 (174) in 2004, 23 (185) in 2005, 67 (195) in 2006, 95 (204) in 2007, and 127 (215) in 2008.

There are 11 fire departments and 55 registered ambulances in Ishikawa prefecture. There is one MCC. Ambulance crews act according to MCC protocols when patients have cardiopulmonary arrest or serious trauma. The indications and contraindications for tracheal intubation are listed in Table 1. All the paramedics begin ventilation with a BVMD. In cases in which ventilation is predicted to be difficult with a standard procedure using a BVMD, they are encouraged to obtain permission for the use of AAM devices. When ventilation is inadequate or expected to be difficult with AAM devices other than an ET, the certified paramedics are allowed to perform tracheal intubation with the approval of emergency medical physicians. The paramedics are requested to minimally interrupt cardiopulmonary resuscitation (CPR) during the intubation procedure (<30 s prior to November 2006, and <10 s since then). In cases in which AAM with an ET failed or was difficult (Cormack grade [7] = 2 or more), the paramedics are instructed to ventilate the patients with a BVMD. After successful placement of an ET or other AAM device, chest compression and ventilation are performed in a nonsynchronized manner. The paramedics are instructed to perform tracheal suction if needed.

Table 1 Indications and contraindications for tracheal intubation in OHCA by paramedics in Ishikawa prefecture

Indications
1. Ventilation is inadequate or adequate ventilation is expected to be difficult with other airway management devices
a. Aspiration
b. Backflow of stomach contents
c. Inhalation burn
d. Serious injury of face or cervix
e. Bronchial asthma
f. Transportation takes more than 20 min
2. The paramedic judges that tracheal intubation is needed
3. The medical director judges that tracheal intubation is required
Contraindications
1. Patients less than 8 years old
2. Suspected cervical spine injury
3. Difficulty of head tilt
4. Trismus
5. Difficulty of laryngoscope insertion
6. Cormack grade ≥2
7. Too much time is taken to complete intubation (Interruption of CPR for more than 30 s prior to November 2006 and more than 10 s since then)
8. The paramedic judges that tracheal intubation is inappropriate

OHCA out-of-hospital cardiac arrest, *CPR* cardiopulmonary resuscitation

Patient data

Baseline data were collected prospectively from 2,759 OHCAs that were witnessed or recognized by citizens, and confirmed by emergency medical technicians (EMTs) on arrival at the patient from 1 July 2004 to 31 March 2008. The collected data were based on the Utstein template [8, 9] and included prefectural region, patient's age, patient's sex, arrest witness, cause of arrest, bystander CPR, initial cardiac rhythm, airway management by paramedics, interval between call and arrival at the patient, interval between arrival at the patient and completion of AAM, any return of spontaneous circulation (any ROSC), sustained ROSC, 1-month survival, and 1-year survival. Sustained ROSC is defined as the continuous presence of palpable pulses for more than 20 min [9]. Survival rates at 1 year were determined either when the patient was alive in hospital at 1 year or when they were discharged alive from hospital to home or care and rehabilitation facilities within 1 year. The primary endpoint was 1-year survival. The secondary endpoints were any ROSC, sustained ROSC, and 1-month survival. The best cerebral performance category (CPC) [8] was evaluated after resuscitation in all OHCAs with sustained ROSC. Sustained ROSC with favorable neurological outcome was defined when the best CPC was 1 (good overall performance) or 2 (moderate overall disability) in patients without any neurological disturbance before the arrest event and when the best CPC was equal to the pre-arrest category in patients with neurological disturbance before the arrest event (Fig. 1).

EMTs other than paramedics are allowed to ventilate the patients only with a BVMD. One hundred and thirteen patients were transported by EMTs other than paramedics and were excluded from the analysis.

Thirty-three patients aged less than 8 years were also excluded from analysis because tracheal intubation is contraindicated in children of this age. Furthermore, we excluded the data from 27 patients in whom adrenaline was administered by a limited number of paramedics, to exclude a possible interaction between tracheal intubation and adrenaline administration. AAM was attempted in 1,047 of the remaining 2,586 patients. However, the attempted AAM failed or was discontinued in 124 arrests, which were excluded from the analysis as paramedics were obliged to ventilate this group of patients with a BVMD, resulting in insufficient ventilation and a very poor prognosis (survival 0% at 1 month). Finally, ventilation was maintained with an ET in 263 patients, other AAM devices in 660 patients and BVMD in 1,539 patients. These 3 groups were analyzed to clarify the effects of tracheal intubation. The total of 2,462 patients in these 3 groups were divided into 2 groups according to whether the patient management was done by paramedics certified or uncertified for ET, for analysis of the effect of certification for ET.

Statistical methods

Continuous variables are expressed as medians with interquartile ranges. Continuous variables were compared using nonparametric tests including the Kruskal–Wallis one-way analysis of variance on ranks test and the Wilcoxon–Mann–Whitney rank sum test. For the comparison of dichotomous variables, we used χ^2 analysis with or without Pearson's correction. When significant differences were found among the 3 groups, multiple comparisons were made using Tukey's method [10]. Multiple logistic regression analyses were used to disclose independent predictors in dichotomous or trichotomous dependent variables. Results are expressed as odds ratios (ORs) and 95% confidence intervals (CIs). All statistical analyses were performed using JMP software version 7 (SAS Institute, Cary, NC, USA).

Results

Patient characteristics

The characteristics of patients in relation to airway management are shown in Table 2. Multiple comparisons among the 3 groups were made using Tukey's method. Patient age, interval between arrival at patient and admission to ambulance, and causes of arrest were significantly different between the ET and other AAM devices. Patient age, interval between arrival at patient and admission to ambulance, duration of ambulance transportation to hospital, and region were significantly different between ET and BVMD. The interval between call and arrival at patient, the interval between arrival at patient and admission to ambulance, duration of ambulance transportation to hospital, region, and the incidence of CPR by citizens were significantly different between other AAM devices and BVMD.

The characteristics of patients in relation to type of paramedic are shown in Table 3. There were significant differences in the interval between arrival at patient and admission to ambulance and region between the 2 groups.

Comparisons of outcomes among ET, other AAM devices, and BVMD

The results of univariate analysis are shown in Table 4. The incidences of any ROSC and sustained ROSC were significantly higher in the patients managed with ET than in those managed with BVMD or other AAM devices (multiple comparisons by Tukey's method). However, the rate of sustained ROSC with favorable neurological condition did not differ significantly among the groups.

When the outcomes were analyzed in OHCA patients with noncardiac origin, the rates of any ROSC ($P = 0.0321$) and sustained ROSC ($P = 0.0090$) differed significantly among the 3 groups (χ^2 analysis). Tukey's multiple comparisons disclosed that the rate of sustained ROSC was significantly higher in patients managed with ET than in those managed with BVMD or other AAM devices. However, the rate of sustained ROSC with favorable neurological condition did not differ significantly among the groups.

To analyze the superiority of ET among the AAM devices, a comparison of outcomes only between ET and other AAM devices may be a more appropriate way than the multiple comparison among ET, other AAM devices,

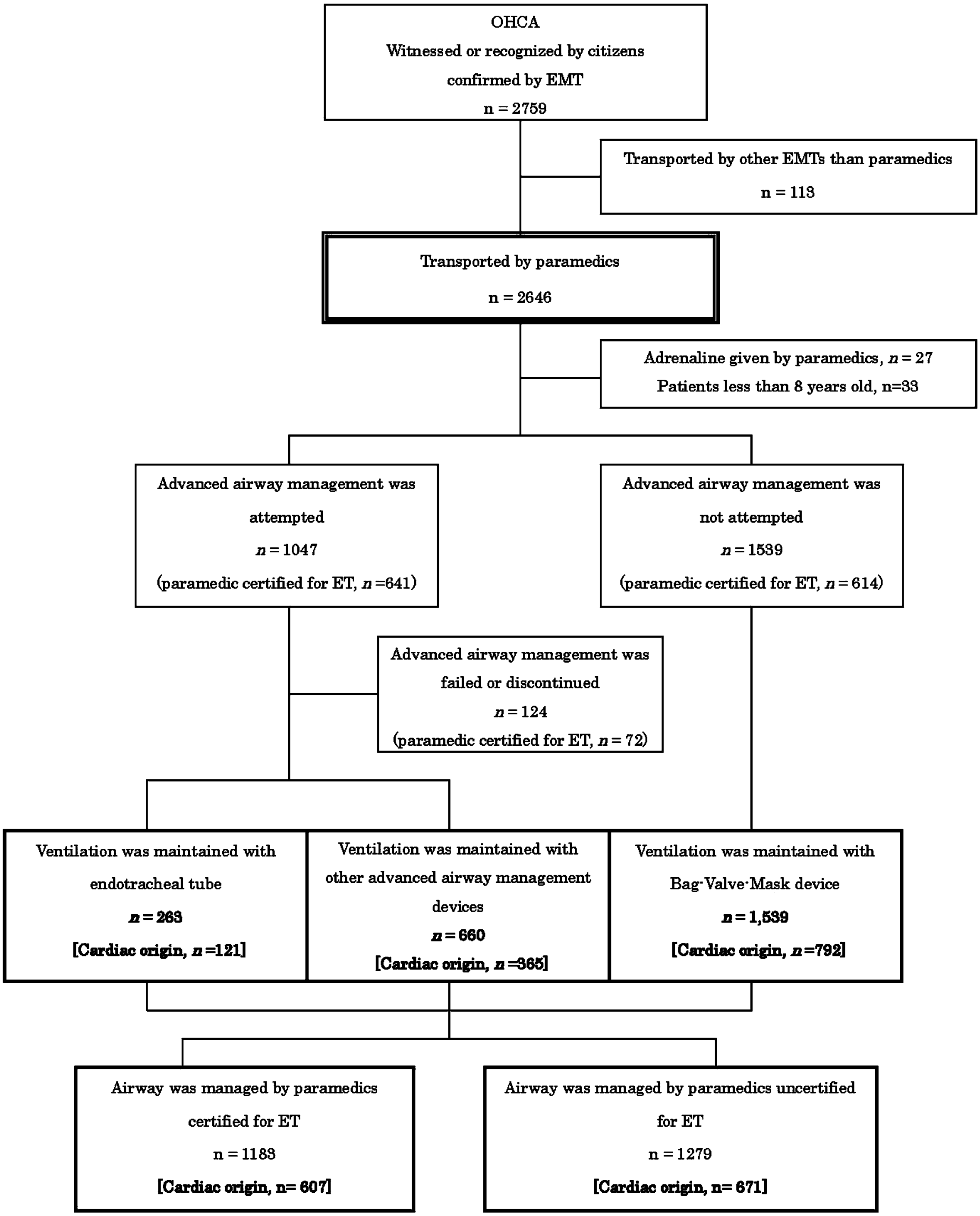

Fig. 1 Study profile. *OHCA* Out-of-hospital cardiac arrest, *ET* endotracheal tube, *EMT* emergency medical technician

and BVMD. As a whole, the results of the simple χ^2 analysis were similar to those of Tukey's multiple comparisons. However, the χ^2 analysis revealed that the survival rate at 1 month in patients with OHCA with noncardiac origin was significantly higher in those treated with an ET than with other AAM devices.

Comparisons of outcomes stratified according to paramedic groups

The results of univariate analysis are shown in Table 5. There were significant differences in the incidences of any ROSC ($P = 0.0308$) and sustained ROSC ($P = 0.0112$)

Table 2 Patient characteristics and time factors in relation to type of airway management

Characteristics	AAM devices		BVMD ($n = 1{,}539$)	P value	Multiple comparisons
	ET ($n = 263$)	Other AAM devices ($n = 660$)			
Patient age, years, median (25–75%)	79 (68–86)	76 (64–83)	76 (64–85)	0.0060†	ET vs. BVMD, ET vs. Other AAM†
Patient sex, male (%)	154 (58.6)	418 (63.3)	890 (57.8)	0.0528‡	
Interval between call and arrival at patient, min, median (25–75%)	6.3 (4.8–9)	6.6 (5–9)	6 (4.4–8.4)	0.0114†	Other AAM vs. BVMD†
Interval between arrival at patient and admission to ambulance, min, median (25–75%)	17 (13–20)	13 (10–17)	10 (8–13)	<0.0001†	ET vs. BVMD, ET vs. Other AAM Other AAM vs. BVMD†
Duration of ambulance transportation to hospital, min, median (25–75%)	11 (7–16)	10 (6.5–14)	7 (4.7–11)	<0.0001†	ET vs. BVMD, Other AAM vs. BVMD†
Region: central (urban) (%)	167 (63.5)	384 (58.2)	619 (40.2)	<0.0001‡	ET vs. BVMD, Other AAM vs. BVMD§
Origin of arrest: cardiac (%)	121 (46.0)	365 (55.3)	792 (51.5)	0.0327‡	ET vs. other AAM§
Not witnessed by citizen (%)	158 (60.1)	414 (62.7)	992 (64.5)	0.3484‡	
CPR by citizen (%)	130 (49.4)	328 (49.7)	661 (43.0)	0.0056‡	Other AAM vs. BVMD§
Initial rhythm: shockable (%)	18 (6.8)	53 (8.0)	139 (9.0)	0.4347‡	
Interval between arrival at patient and establishment of AAM, min, median (25–75%)	9.1 (5.8–12)	8 (5.4–11.3)	–	0.102†	

ET endotracheal tube, *AAM* advanced airway management, *BVMD* bag valve mask device, *CPR* cardiopulmonary resuscitation

† Kruskal–Wallis one-way analysis of variance on ranks test

‡ The χ^2 test

§ $P < 0.05$ (Tukey's multiple comparison method)

Table 3 Patient characteristics and time factors in relation to type of paramedic

Characteristics	Certified for endotracheal intubation		*P* value	Odds ratio (95% CI)
	Yes ($n = 1,183$)	No ($n = 1,279$)		
Airway management				
ET (%)	263 (22.2)	–	–	
Other AAM devices (%)	292 (24.7)	368 (28.8)	<0.0001‡,*	0.869 (0.723–1.045)
BVMD (%)	628 (53.1)	911 (71.2)		
Patient age, years, median (25–75%)	77 (64–85)	76 (64–84)	0.3880†	Undefined
Patient sex, male (%)	695 (58.8)	767 (59.9)	0.5381‡	0.951 (0.810–1.117)
Interval between call and arrival at patient, min, median (25–75%)	6.2 (4.6–8.6)	6 (4.9–9)	0.7441†	Undefined
Interval between arrival at patient and admission to ambulance, min, median (25–75%)	12 (9–16)	11 (9–14)	<0.0001†	Undefined
Duration of ambulance transportation to hospital, min, median (25–75%)	8.4 (5.2–12.1)	8 (5–13)	0.9493†	Undefined
Region: central (urban) (%)	589 (49.8)	581 (45.4)	0.0303‡	1.193 (1.019–1.399)
Origin of arrest: cardiac (%)	607 (51.3)	671 (52.5)	0.5674‡	0.946 (0.808–1.109)
Not witnessed by citizen (%)	740 (62.6)	824 (64.4)	0.3349‡	0.932 (0.791–1.098)
CPR by citizen (%)	549 (46.4)	570 (44.6)	0.3729‡	1.072 (0.914–1.256)
Initial rhythm: shockable (%)	103 (8.7)	107 (8.4)	0.7623‡	1.058 (0.797–1.404)
Interval between arrival at patient and establishment of AAM, min, median (25–75%)	8.4 (5.4–11.6)	8 (5.3–11.2)	0.3957†	Undefined

$P < 0.05$ was considered statistically significant

ET endotracheal tube, *AAM* advanced airway management, *BVMD* bag valve mask device, *CI* confidence interval, *CPR* cardiopulmonary resuscitation

† Wilcoxon–Mann–Whitney rank sum test

‡ The χ^2 test

* BVMD vs. AAM including ET and other devices

between the 2 paramedic groups (χ^2 analysis). When the outcomes were compared in subgroup analyses of patients with OHCA with cardiac origin and those with noncardiac origin, there were no significant differences according to the 2 paramedic groups.

Factors associated with sustained ROSC

The results of univariate analysis are shown in Table 6. Patient age, interval between call and arrival at patient, region, cause of arrest, arrest witness, initial rhythms, incidences of tracheal intubation, and management by paramedics certified for tracheal intubation were significantly different between patients with and without sustained ROSC.

Multiple logistic regression analysis was performed to confirm the effect of an ET on sustained ROSC (Table 7). The results indicated that ET use was an independent factor associated with sustained ROSC (OR: 1.5; 95% CI: 1.1–2.1), and the analysis identified arrest witness, origin of cardiac arrest (cardiac or noncardiac), initial rhythm (shockable or nonshockable), and call—arrival interval as other significant factors related to sustained ROSC.

Discussion

In the present study, we found a favorable effect of an ET, compared not only with a BVMD but also with other AAM devices, on the rate of sustained ROSC in adult (age 8 years or more) patients with OHCA witnessed by citizens and transported by paramedics. The favorable effects of the ET were more prominent in OHCA with noncardiac origin. Management by paramedics certified for tracheal intubation significantly influenced the sustained ROSC of all OHCAs, as shown by univariate analysis. However, multiple regression analysis revealed that an ET for AAM, but not management by a paramedic certified for ET use was an independent factor associated with sustained ROSC. When tracheal suction is expected to be required, the ET may be recommended as the initial device for AAM. The superiority of the ET in promoting a higher incidence rate

Table 4 Comparison of outcomes among airway management groups

Outcomes	AAM devices		BVMD ($n = 1{,}539$)	*P* value	Multiple comparisons†
	ET ($n = 263$)	Other AAM ($n = 660$)			
All OHCA patients (%)					
Any ROSC	83 (31.6)*	152 (23.0)*	366 (23.8)	0.0158	ET vs. other AAM, ET vs. BVMD
Sustained ROSC	79 (30.0)*	133 (20.2)*	327 (21.3)	0.0028	ET vs. other AAM, ET vs. BVMD
Sustained ROSC with favorable neurological condition	4 (1.5)	9 (1.4)	46 (3.0)	0.0519	
Alive or discharged alive at 1 month	15 (5.7)	21 (3.2)	85 (5.5)	0.0547	
Alive or discharged alive at 1 year	9 (3.4)	17 (2.6)	65 (4.2)	0.1665	
Outcomes	AAM devices		BVMD ($n = 792$)	*P* value	Multiple comparisons†
	ET ($n = 121$)	Other AAM ($n = 365$)			
OHCA patients with cardiac origin (%)					
Any ROSC	32 (26.5)	80 (21.9)	169 (21.3)	0.4498	
Sustained ROSC	29 (24.0)	67 (18.4)	148 (18.7)	0.3546	
Sustained ROSC with favorable neurological condition	3 (2.5)	6 (1.6)	35 (4.4)	0.0551	
Alive or discharged alive at 1 month	7 (5.8)	16 (4.4)	52 (6.6)	0.3404	
Alive or discharged alive at 1 year	5 (4.1)	13 (3.6)	44 (5.6)	0.3164	
Outcomes	AAM devices		BVMD ($n = 747$)	*P* value	Multiple comparisons†
	ET ($n = 142$)	Other AAM ($n = 295$)			
OHCA patients with noncardiac origin (%)					
Any ROSC	51 (35.9)*	72 (24.4)*	197 (26.4)	0.0321	ET vs. other AAM, ET vs. BVMD
Sustained ROSC	50 (35.2)*	66 (22.4)*	179 (24.0)	0.0090	ET vs. other AAM, ET vs. BVMD
Sustained ROSC with favorable neurological condition	1 (0.9)	3 (1.0)	11 (1.5)	0.6863	
Alive or discharged alive at 1 month	8 (5.6)*	5 (1.7)*	33 (4.4)	0.0633	
Alive or discharged alive at 1 year	4 (2.8)	4 (1.4)	21 (2.8)	0.3742	

ET endotracheal tube, *AAM* advanced airway management, *BVMD* bag valve mask device, *ROSC* return of spontaneous circulation, *OHCA* out-of-hospital cardiac arrest

† $P < 0.05$ (Tukey's method)

* $P < 0.05$ (subanalysis by χ^2, with or without Pearson's correction, between ET and other AAM devices)

of sustained ROSC suggests that the ET may be a good initial choice for AAM in OHCAs of respiratory etiology requiring tracheal suction.

However, the ET did not improve the long-term outcomes, including 1-month and 1-year survival, either in all OHCAs or in OHCA with noncardiac origin. Because the rate of long-term survival in the community in our study was low, a large prospective randomized control trial (RCT) study is required to clarify the effect of tracheal intubation on the long-term outcome of OHCAs with noncardiac origin.

Paramedics often attempt tracheal intubation in awkward situations, such as on the floor, in a moving ambulance, and in restricted spaces. A more complex procedure may be required than in a hospital setting. It has been reported that the incidence of ET misplacement was high when paramedics were insufficiently trained under poor medical control [11, 12]. Experienced paramedics regularly operating with physicians were reported to have a low tracheal intubation failure rate in OHCA [13]. Clinical experience of tracheal intubation has been identified as an independent factor in successful intubation [14]. The didactic curriculum for tracheal intubation in Japan is stricter than that in other countries reported to date. The national paramedic curriculum in the United States requires students to perform 5 successful tracheal intubations to graduate [15]. In the San Diego Rapid Sequence Intubation Trial, paramedics received a 7-h educational session

Table 5 Comparison of outcomes in relation to type of paramedic

Outcomes	Qualified for endotracheal intubation		*P* value	Odds ratio (95% CI)
	Yes ($n = 1,183$)	No ($n = 1,279$)		
All OHCA patients (%)				
Any ROSC	312 (26.4)	289 (22.6)	0.0308	1.227 (1.021–1.475)
Sustained ROSC	285 (24.1)	254 (19.9)	0.0112	1.281 (1.058–1.551)
Alive or discharged alive at 1 month	67 (5.7)	54 (4.2)	0.0983	1.362 (0.943–1.967)
Alive or discharged alive at 1 year	48 (4.1)	43 (3.4)	0.3930	1.216 (0.799–1.849)
Outcomes	Qualified for endotracheal intubation		*P* value	Odds ratio (95% CI)
	Yes ($n = 607$)	No ($n = 671$)		
OHCA patients with cardiac origin (%)				
Any ROSC	145 (23.9)	136 (20.3)	0.1187	1.235 (0.947–1.610)
Sustained ROSC	127 (20.9)	117 (17.4)	0.1133	1.253 (0.948–1.657)
Alive or discharged alive at 1 month	42 (6.9)	33 (4.9)	0.1285	1.437 (0.898–2.299)
Alive or discharged alive at 1 year	34 (5.6)	28 (4.2)	0.2353	1.363 (0.816–2.275)
Outcomes	Qualified for endotracheal intubation		*P* value	Odds ratio (95% CI)
	Yes ($n = 576$)	No ($n = 608$)		
OHCA patients with noncardiac origin (%)				
Any ROSC	167 (29.0)	153 (25.2)	0.1382	1.214 (0.939–1.570)
Sustained ROSC	158 (27.4)	137 (22.5)	0.0515	1.300 (0.998–1.692)
Alive or discharged alive at 1 month	25 (4.3)	21 (3.5)	0.4302	1.268 (0.702–2.292)
Alive or discharged alive at 1 year	14 (2.4)	15 (2.5)	0.9676	0.985 (0.471–2.059)

$P < 0.05$ was considered statistically significant

CI confidence interval, *ROSC* return of spontaneous circulation, *OHCA* out-of-hospital cardiac arrest

Table 6 Factors associated with sustained ROSC by univariate analysis

	Survival ($n = 545$)	Nonsurvival ($n = 1,947$)	*P* value	Odds ratio (95% CI)
Patient age, years, median (25–75%)	75 (62–83)	77 (65–85)	<0.0001[†]	Undefined
Patient sex, male (%)	328 (60.9)	1,134 (59.0)	0.4314[‡]	1.081 (0.890–1.314)
Interval between call and arrival, min, median (25–75%)	6 (4–8)	6.2 (4.9–9)	<0.0001[†]	Undefined
Interval between arrival at patient and admission to ambulance, min, median (25–75%)	11 (9–14.6)	11 (9–15)	0.4997	Undefined
Duration of ambulance transportation to hospital, min, median (25–75%)	8 (5–12)	8 (5–12.8)	0.1557	Undefined
Region: central (urban) (%)	293 (54.4)	877 (45.6)	0.0003[‡]	1.420 (1.172–1.721)
Origin of arrest: cardiac (%)	244 (45.3)	1,034 (53.8)	0.0005[‡]	0.711 (0.587–0.861)
Not witnessed by citizen (%)	224 (41.6)	1,340 (69.7)	<0.0001[‡]	0.309 (0.254–0.377)
CPR by citizen (%)	232 (43.0)	887 (46.1)	0.2039[‡]	0.883 (0.728–1.071)
Initial rhythm: shockable (%)	101 (18.7)	109 (5.7)	<0.0001[‡]	3.831 (2.874–5.128)
Use of ET (%)	79 (14.7)	184 (9.6)	0.0007[‡]	1.623 (1.222–2.155)
Use of other AAM devices (%)	133 (24.7)	527 (27.4)	0.2061[‡]	0.868 (0.696–1.081)
Management by paramedics qualified for tracheal intubation (%)	285 (52.9)	898 (46.7)	0.0112[‡]	1.281 (1.058–1.551)

ET endotracheal tube, *AAM* advanced airway management, *CPR* cardiopulmonary resuscitation, *CI* confidence interval

[†] Wilcoxon–Mann–Whitney rank sum test

[‡] The χ^2 test

Table 7 Factors associated with sustained ROSC by multiple logistic regression analysis

	Odds ratio (survival)	95% CI
Region: central	1.137	0.923–1.400
Patient age	0.994	0.988–1.000
Not witnessed by citizen	0.355	0.289–0.437
Origin of arrest: cardiac	0.571	0.459–0.708
Initial rhythm: shockable	3.185	2.286–4.438
Tracheal intubation	1.503	1.081–2.078
Interval between call and arrival	0.958	0.930–0.986
Management by paramedics qualified for tracheal intubation	1.141	0.917–1.419

CI confidence interval

without supplemental live training [16]. The certifying paramedic curriculum in Japan generally includes 180 h of lectures and practice in school and experience in 30 successful cases in operation rooms under the instruction of anesthesiologists. It is assumed that experience with 15–20 cases in a clinical setting is necessary for paramedics to become proficient [17]. Thus, the training programs in Japan are considered appropriate.

One of the major disadvantages of tracheal intubation is the interruption of chest compression. Wang et al. reported that the median duration of the first tracheal intubation–associated CPR interruption was 46.5 s and that paramedic tracheal intubation efforts were associated with multiple and prolonged CPR interruptions [18]. In our regional protocol for tracheal intubation, the interruption of chest compression was <30 s before November 2006 and <10 s since then. This rigorous protocol may diminish the disagreeable effects of the procedure.

As shown in Table 2, tracheal intubation was performed in older patients. In elderly patients there may be difficulty in managing their airway with a standard procedure using a BVMD. Cardiac arrest may be frequently caused by sunken cheeks, aspiration or choking, which are included in our regional indication criteria for tracheal intubation [19].

Adams et al. retrospectively analyzed the effects of ET on the prognosis of OHCA with cardiac origin [5]. They reported that the incidence of ET use was highest in the patients who received the greatest number of shocks, and that, among subjects receiving similar numbers of shocks, survival rates were lower in intubated patients. Recently, Garza et al. reported that a modification of the resuscitation protocol, including delaying intubation and increasing the ratio of chest compressions to ventilation, improved the survival rate in OHCA with cardiac origin [6]. In accordance with these previous reports, we found no evidence that ET had beneficial effects on the outcome of OHCA with cardiac origin. In our regional protocol, routine application of ET is not recommended in cases of OHCA with cardiac origin. ET was used less frequently in OHCA with cardiac origin that may have been complicated with aspiration and other airway problems.

Ventilation becomes more important in OHCA cases of noncardiac origin [20, 21]. Thus, more efficient airway management, including tracheal suction and ventilation, may be preferable if ventilation is inadequate or if adequate ventilation is expected to be difficult with a BVMD. OHCA with noncardiac origin includes cardiac arrest due to numerous causes. In the present study, we did not analyze the effects of tracheal intubation on the outcome in each subgroup with a different cause, as the number of intubated patients was small. There may be a subgroup of patients in which ET use has a definitive effect not only on short-term outcome but also on long-term outcome.

As shown in Table 2, the interval between arrival at patient and admission to ambulance, as well as the duration of transportation to hospital, was prolonged when AAM was performed with an ET or other devices. This implies that the administration of adrenaline was delayed in patients with AAM as all of the patients analyzed received adrenaline only after arrival at the hospital emergency room. Although there were no significant differences in the interval between arrival at the patient and admission to ambulance or in the duration of transportation to hospital between patients with and without sustained ROSC, this delay should be corrected. Recently, certified paramedics have been trained to administer adrenaline to OHCA patients in Japan. An increase in the number of certified paramedics may correct the delay of adrenaline administration.

Study limitations

Tracheal intubation was performed by paramedics certified to use an ET in accordance with limited indication criteria. Both certified and noncertified paramedics treated the OHCA patients. We did not evaluate the quality and capability of the paramedics. Therefore, the results of this cohort study may not show any general effect of tracheal intubation on the outcome of OHCA. However, it is suggested that tracheal intubation in accordance with the limited indication criteria and well-organized protocol in Japan should not be discontinued, at least in OHCA with noncardiac origin.

Another issue to be resolved is the existence of patients in whom intubation or AAM is difficult. Patient anatomy is a primary factor in failed AAM. In a recent prospective cohort study [22], the 2 most common reasons for a difficult airway reported subjectively by advanced life support providers were anterior trachea (39%) and small mouth

(30%). To perform tracheal intubation in this group of patients, further professional education programs will be required [13, 14]. Neither doctor/car systems nor on-site assistance by emergency physicians or anesthesiologists in the ambulance are commonly available in Japan.

Conclusion

When patients with difficult airways were excluded, we found that the performance of tracheal intubation according to the limited indication criteria and well-organized protocol used in Japan may improve the short-term outcome of OHCA with noncardiac origin, compared not only with a BVMD but also with other AAM devices. Because the 1 month and 1 year survivals were very low, a large randomized control trial is required to determine the general effects of tracheal intubation on the outcome of OHCA in which ventilation is inadequate with a standard procedure using aBVMD, and to identify the subgroup of OHCA with noncardiac origin, in which tracheal intubation may exert a definitive effect.

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