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Outcomes in patients with out-of-hospital cardiac arrest according to prehospital advanced airway management timing: a retrospective observational study

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Background: In patients with out-of-hospital cardiac arrest (OHCA), guidelines recommend advanced airway (AA) management at the advanced cardiovascular life support stage; however, the ideal timing remains controversial. Therefore, we evaluated the prognosis according to the timing of AA in patients with OHCA.
Methods: We conducted a retrospective observational study of patients with OHCA at six major hospitals in Daegu Metropolitan City, South Korea, from August 2019 to June 2022. We compared groups with early and late AA and evaluated prognosis, including recovery of spontaneous circulation (ROSC), survival to discharge, and neurological evaluation, according to AA timing.
Results: Of 2,087 patients with OHCA, 945 underwent early AA management and 1,142 underwent late AA management. The timing of AA management did not influence ROSC in the emergency department (5–6 minutes: adjusted odds ratio [aOR], 0.97; $p=0.914$; 7–9 minutes: aOR, 1.37; $p=0.223$; ≥ 10 minutes: aOR, 1.32; $p=0.345$). The timing of AA management also did not influence survival to discharge (5–6 minutes: aOR, 0.79; $p=0.680$; 7–9 minutes: aOR, 1.04; $p=0.944$; ≥ 10 minutes: aOR, 1.86; $p=0.320$) or good neurological outcomes (5–6 minutes: aOR, 1.72; $p=0.512$; 7–9 minutes: aOR, 0.48; $p=0.471$; ≥ 10 minutes: aOR, 0.96; $p=0.892$).
Conclusion: AA timing in patients with OHCA was not associated with ROSC, survival to hospital discharge, or neurological outcomes.

Keywords: Airway management; Out-of-hospital cardiac arrest; Prognosis

Introduction

Out-of-hospital cardiac arrest (OHCA) is a significant problem with poor patient prognosis, which must be addressed adequately through public health policies [1]. Patients with OHCA undergo cardiopulmonary resuscitation (CPR) according to the latest American Heart Association guidelines. Rescuers begin with basic life support, followed by advanced cardiovascular life support if additional management, such as vascular access, medication injection, shockable rhythm recognition, and advanced airway (AA) management, is possible [2]. When performed, AA management changes the compression-to-ventilation ratio from 30:2 to continuous chest compressions and one ventilation every 6 seconds [2].

AA management includes endotracheal intubation and supraglottic airways (SGAs). AA management has advantages and disadvantages in OHCA. For example, AA management can provide

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optimal oxygen early and protect the airway [3]. In contrast, positive pressure ventilation after AA management can increase intrathoracic pressure, resulting in reduced venous reflux and chest compression quality [4]. Additionally, technical errors in AA management, such as multiple, prolonged, or failed attempts, can result in inefficient chest compressions and poor patient prognosis [3,5]. Therefore, performing AA management while minimizing interference with initial high-quality CPR is recommended and considered a step after defibrillating, confirming shockable electrocardiogram rhythm, obtaining intravenous/intraosseous access, and administering epinephrine [2,6].

However, the effect of AA management timing during OHCA remains unclear, with mixed research results [7-9]. Therefore, we evaluated the prognosis of patients with OHCA according to the timing of AA management in Daegu, a metropolitan city in South Korea.

Methods

Ethics statement: This study was approved by the Institutional Review Board (IRB) of Kyungpook National University Hospital (IRB No: 2016-03-027). The requirement for informed consent was waived due to the retrospective nature of the study.

1. Study design and participants

This retrospective observational study was conducted in Daegu, South Korea, from August 2019 to June 2022. All 48 fire safety centers in Daegu, involving 119 ambulances, participated in this study. All emergency centers (ECs) in Daegu, including two regional ECs (Kyungpook National University Hospital and Yeungnam University Medical Center) and four local ECs (Keimyung University Dongsan Hospital, Daegu Catholic University Medical Center, Kyungpook National University Chilgok Hospital, and Daegu Fatima Hospital) also participated in this study. This study included adult patients (aged ≥ 18 years) with OHCA who underwent AA management and visited the emergency department (ED) via emergency medical service (EMS) ambulance. We excluded patients who did not want to be resuscitated or whose cardiopulmonary arrest was not caused by illness. Patients who did not receive AA management during CPR or those who received AA after the return of spontaneous circulation (ROSC) were excluded. Patients were also excluded if the timing of AA management was not documented. Using a cutoff time of 7 minutes (the median value), the characteristics of the basic study population were identified by subdividing the population into two groups, early and late AA management. According to the results of a previous study, patient prognosis was better when AA management was less than 4 minutes, and the reference value was the same as that of the first group in the fourth quartile of this study [10]. Therefore, multivariable regression analysis for the evaluation of prognostic indicators such as ED ROSC, survival to discharge, and good neurologic outcome was conducted by dividing the group according to AA management time into quartiles and analyzing them in categorical groups of ≤ 4 minutes, 5 to 6 minutes, 7 to 9 minutes, and ≥ 10 minutes. The prognosis of the patients was further evaluated by dividing the subgroups according to shockable rhythm and the type of AA management, such as the use of SGAs or endotracheal intubation (ETI).

2. Patient management and data collection

All patients were managed faithfully according to the current CPR guidelines at the prehospital and hospital stages [2,11]. The use of AA management and drugs during the prehospital stage was determined directly by the medical directors. The choice of AA management, such as SGA or ETI use, depended on the CPR site conditions and EMS proficiency. The SGA used by the prehospital EMS was an i-gel.

Information on demographic and clinical characteristics including age, sex, previous performance, previous illness, witnesses, place, bystander CPR, automated external defibrillator use, mechanical compression, shockable rhythm, epinephrine use, multiple team dispatches, response time, on-scene time, transport time, time to AA, and multiple attempts to establish an airway was obtained from the EMS run sheet. The degree of previous performance was defined as good if the patient could walk independently and perform daily activities. Time to AA was defined as the time from EMS arrival at the scene to successful AA management. “Multiple attempts to establish an AA” was defined as two or more attempts. From electronic medical records, we also retrieved information on the use of targeted temperature management, use of extracorporeal membrane oxygenation, ROSC in the ED, survival to discharge, and cerebral performance category (CPC) scores at discharge. At discharge, a CPC score of one or two points was classified as a good neurological outcome.

3. Statistical analysis

Continuous variables are reported as medians and interquartile ranges and were compared using the Mann-Whitney U test and Student *t*-test according to their normal/non-normal distribution. Categorical variables are reported as numbers and percentages and were compared using the chi-square test or Fisher exact test. The associations of baseline characteristics, time to AA, and attempts to establish an AA with outcomes such as ROSC, survival to discharge, and good neurologic outcome were first analyzed using univariate logistic regression analysis. Variables adjusted for age, sex, performance, witnesses, bystander CPR, bystander automated external defibrillator (AED) use, mechanical compression, shockable rhythm, epinephrine use, response time, on-scene time, transport time, multiple attempts to establish an AA, and time to AA were analyzed using multivariable logistic regression analysis, and the results are reported as odds ratios (ORs) and 95% confidence intervals (CIs). For the subgroup analysis, categorized grouping was performed according to the presence of shockable rhythm and AA type. All statistical analyses were performed using IBM SPSS ver. 25.0 for Windows (IBM Corp., Armonk, NY, USA).

Results

A total of 2,087 patients with AA were transported by EMS to six participating hospitals during the study period. Of these, 945 patients (45.3%) received early AA management and 1,142 patients (54.7%) received late AA management. Of the patients who received early AA management, 712 (75.3%) had an SGA, and 233 (24.7%) received ETI. Of the patients who received late AA management, 851 (74.5%) had an SGA, and 291 (25.5%) received ETI (Fig. 1).

The mean age of the participants was 75 years, and 1,320 (63.2%) were male. A total of 1,726 patients (82.7%) had good premorbid performance in carrying out daily activities independently. The locations where OHCA occurred were mostly nonpublic (1,713, 82.3%), including residential areas. A total of 973 cardiac arrests (46.6%) were witnessed, and 1,163 patients (55.7%) underwent bystander CPR. Mechanical compression was performed on 1,926 patients (92.3%), the shockable rhythm was observed in 194 (9.3%), and an AED was used by bystanders in 31 cases (1.5%). Epinephrine was administered intravenously to 1,388 patients (66.5%). Regarding AA type, 1,563 patients (74.9%) received an SGA, and ETI was performed in 524 patients (25.1%). Securing the airway was attempted multiple times in 90 patients (4.3%). Multiple EMS dispatches occurred with most patients with OHCA (2,018, 96.7%). The median response time was 9 minutes, which was the time when EMS arrived at the scene after receiving the report. The on-scene time, which was the time from when EMS arrived at the scene until it left for the hospital, was 18 minutes. Additionally, the transport time from the scene to the hospital was 7 minutes. In the ED, ROSC occurred in 149 patients (7.1%), with 29 (1.4%) surviving to be discharged and 14 (0.7%) having good neurologic outcomes. In the group of patients with early AA management, more bystander CPR was performed (early AA, 65.2% vs. late AA, 47.9%; $p < 0.001$) and more patients showed shockable rhythms (early AA, 10.1% vs. late AA, 8.7%; $p = 0.004$). Multiple team dispatches were more common in the early AA management group (early AA, 98.6% vs. late AA, 95.1%; $p < 0.001$) and mechanical compression was more frequently performed (early AA, 93.7% vs. late AA, 91.2%; $p = 0.020$). The scene time (early AA, 16 minutes vs. late AA, 20 minutes; $p < 0.001$) and transport time to the hospital (early AA, 6 minutes vs. late AA, 7 minutes; $p < 0.001$) were also shorter in the early AA management group (Table 1).

Table 2 shows the results of the multivariable logistic regression analysis. Dividing the AA acquisition time into quartiles, we compared the resulting values with ORs based on the shortest time of

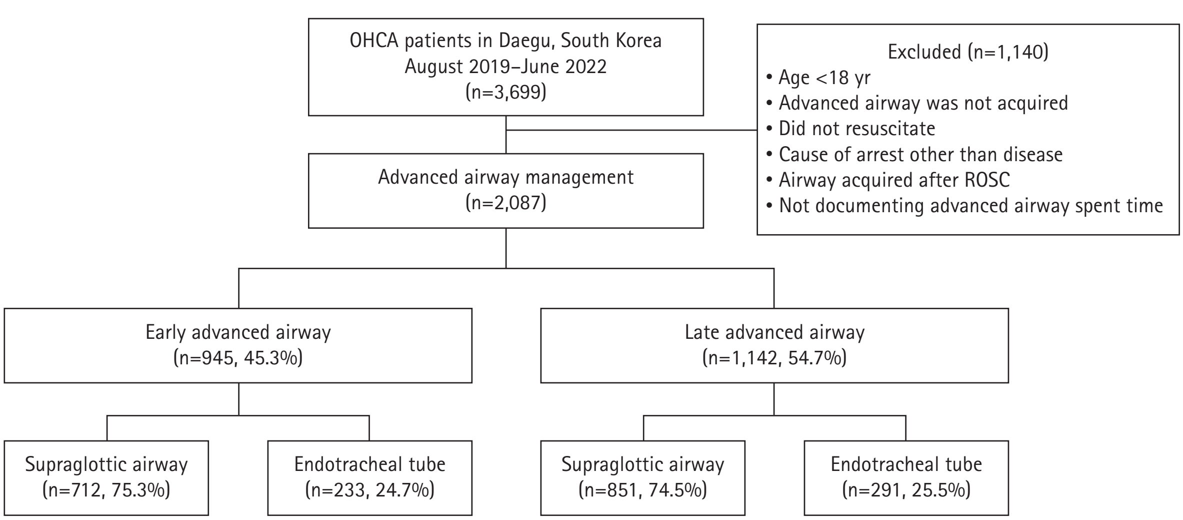

Fig. 1. The flow chart of participants. OHCA, out-of-hospital cardiac arrest; ROSC, recovery of spontaneous circulation.

Table 1. Characteristics of the study population by the timing of advanced airway (AA) management

Characteristic	Total	Early AA group	Late AA group	*p*-value
No. of patients	2,087	945	1,142	
Age (yr)	75 (63–81)	74 (64–81)	75 (63–81)	0.714
Male sex	1,320 (63.2)	598 (63.3)	722 (63.2)	0.507
Premorbid performance, good	1,726 (82.7)	784 (83.0)	942 (82.5)	0.494
Previous illness				
Previous arrest	10 (0.5)	3 (0.3)	7 (0.6)	0.262
Ischemic heart disease	211 (10.1)	96 (10.2)	115 (10.1)	0.485
Other heart diseases	223 (10.7)	91 (9.6)	132 (11.6)	0.095
Cerebrovascular accident	261 (12.5)	123 (13.0)	138 (12.1)	0.266
Hypertension	876 (42.0)	399 (42.2)	477 (41.8)	0.391
Diabetes mellitus	673 (32.2)	302 (32.0)	371 (32.5)	0.450
COPD	161 (7.7)	73 (7.7)	88 (7.7)	0.511
Chronic kidney disease	181 (8.7)	71 (7.5)	110 (9.6)	0.054
Liver cirrhosis	41 (2.0)	17 (1.8)	24 (2.1)	0.376
Malignancy	310 (14.9)	138 (14.6)	172 (15.1)	0.429
Witness	973 (46.6)	413 (43.7)	560 (49.0)	0.009
Place				< 0.001
Public	298 (14.3)	145 (15.3)	153 (13.4)	
Nonpublic	1,713 (82.1)	792 (83.8)	921 (80.6)	
Ambulance	66 (3.2)	2 (0.2)	64 (5.6)	
Others	10 (0.5)	6 (0.6)	4 (0.4)	
Bystander CPR	1,163 (55.7)	616 (65.2)	547 (47.9)	< 0.001
Bystander AED use	31 (1.5)	16 (1.7)	15 (1.3)	0.296
AA type				0.351
Supraglottic airway	1,563 (74.9)	712 (75.3)	851 (74.5)	
Endotracheal intubation	524 (25.1)	233 (24.7)	291 (25.5)	
No. of AA attempts, ≥ 2	90 (4.3)	23 (2.4)	67 (5.9)	< 0.001
EMS mechanical compression	1,926 (92.3)	885 (93.7)	1,041 (91.2)	0.020
Shockable rhythm	194 (9.3)	95 (10.1)	99 (8.7)	0.004
Intravenous epinephrine	1,388 (66.5)	628 (66.5)	760 (66.5)	0.489
Multiple team dispatch	2,018 (96.7)	932 (98.6)	1,086 (95.1)	< 0.001
Response time (min)	9 (7–11)	9 (7–11)	9 (7–11)	0.907
On-scene time (min)	18 (15–21)	16 (14–18)	20 (17–23)	< 0.001
Transport time (min)	7 (5–10)	6 (4–9)	7 (5–11)	< 0.001
TTM	43 (2.1)	23 (2.4)	20 (1.8)	0.283
ECMO	30 (1.4)	15 (1.6)	15 (1.3)	0.712
ROSC in the ED	149 (7.1)	63 (6.7)	86 (7.5)	0.249
Survival discharge	29 (1.4)	13 (1.4)	16 (1.4)	0.560
Good neurologic outcome	14 (0.7)	6 (0.6)	8 (0.7)	0.464

Values are presented as number only, median (interquartile range), or number (%).
COPD, chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; AED, automated external defibrillator; EMS, emergency medical services; TTM, targeted temperature management; ECMO, extracorporeal membrane oxygenation; ROSC, recovery of spontaneous circulation; ED, emergency department.

≤ 4 minutes. The number of AA attempts was divided into a first-pass success (FPS) group and a multiple (≥ 2 attempts) group, followed by analysis. The timing of attempts at AA establishment did not influence ROSC in the ED (adjusted ORs [aORs] of 5–6 minutes, 7–9 minutes, and ≥ 10 minutes: 0.97 [95% CI, 0.56–1.67], $p = 0.914$; 1.37 [95% CI, 0.82–2.29], $p = 0.223$; and 1.32 [95% CI, 0.75–2.33], $p = 0.345$); nor did the number of attempts (aOR, 1.11 [95% CI, 0.46–2.68]; $p = 0.824$]). The timing of attempts at AA establishment did not affect survival to discharge (aORs of 5–6 minutes, 7–9 minutes, and ≥ 10 minutes: 0.79 [95% CI, 0.26–2.44], $p = 0.680$; 1.04 [95% CI, 0.34–3.23], $p = 0.944$; 1.86 [95% CI, 0.55–6.27], $p = 0.320$); nor did the number of attempts (aOR, 2.31 [95% CI, 0.45–11.70]; $p = 0.314$). Additionally, the timing of attempts at AA establishment did not affect good neurologic outcomes (aORs of 5–6 minutes, 7–9 minutes, and ≥ 10 minutes: 1.72 [95% CI, 0.34–8.78], $p = 0.512$; 0.48 [95% CI, 0.06–3.56],

Table 2. Multivariable analysis of outcomes of patients with out-of-hospital cardiac arrest

Variable	n (%)	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
ED ROSC	149 (100)				
Time interval to AA (min)					
≤ 4	34 (22.8)	Reference			
5–6	29 (19.5)	0.89 (0.54–1.49)	0.664	0.97 (0.56–1.67)	0.914
7–9	42 (28.2)	1.18 (0.74–1.89)	0.490	1.37 (0.82–2.29)	0.223
≥ 10	44 (29.5)	1.00 (0.63–1.59)	0.998	1.32 (0.75–2.33)	0.345
No. of AA attempts		0.93 (0.40–2.16)	0.859	1.11 (0.46–2.68)	0.824
Survival discharge	29 (100)				
Time interval to AA (min)					
≤ 4	8 (27.6)	Reference			
5–6	5 (17.2)	0.65 (0.21–2.01)	0.459	0.79 (0.26–2.44)	0.680
7–9	4 (13.8)	0.47 (0.14–1.56)	0.217	1.04 (0.34–3.23)	0.944
≥ 10	12 (41.4)	1.16 (0.47–2.85)	0.754	1.86 (0.55–6.27)	0.320
No. of AA attempts		1.64 (0.39–7.02)	0.502	2.31 (0.45–11.70)	0.314
Good neurologic outcome	14 (100)				
Time interval to AA (min)					
≤ 4	4 (28.6)	Reference			
5–6	2 (14.3)	0.53 (0.10–2.88)	0.458	1.72 (0.34–8.78)	0.512
7–9	3 (21.4)	0.71 (0.16–3.17)	0.650	0.48 (0.06–3.56)	0.471
≥ 10	5 (35.7)	0.97 (0.26–3.61)	0.958	0.96 (0.91–1.01)	0.892
No. of AA attempts		3.76 (0.83–17.05)	0.086	3.69 (0.45–30.63)	0.226

The adjusted variables for ED ROSC were age, sex, premorbid performance, witnesses, bystander cardiopulmonary resuscitation (CPR), bystander automated external defibrillator (AED) use, mechanical compression, shockable rhythm, epinephrine, response time, on-scene time, transport time, and number of AA attempts. The adjusted variables for survival to discharge and good neurologic outcome were age, sex, premorbid performance, witnesses, bystander CPR, bystander AED use, mechanical compression, shockable rhythm, epinephrine, response time, on-scene time, transport time, number of AA attempts, targeted temperature management supply, and extracorporeal membrane oxygenation supply.
OR, odds ratio; CI, confidence interval; ED, emergency department; ROSC, recovery of spontaneous circulation; AA, advanced airway.

$p = 0.471$; 0.96 [95% CI, 0.91–1.01], $p = 0.892$); nor did the number of attempts (aOR, 3.69 [95% CI, 0.45–30.63]; $p = 0.226$).

When patients were divided into shockable and non-shockable subgroups, we found that AA timing did not affect ROSC, regardless of attainable rhythm. The aORs of 5–6 minutes, 7–9 minutes, and ≥ 10 minutes were as follows: for shockable rhythm: 0.60 ($p = 0.420$), 2.38 ($p = 0.129$), 3.18 ($p = 0.087$); for non-shockable rhythm: 1.12 ($p = 0.725$), 1.31 ($p = 0.360$), 1.14 ($p = 0.683$). The timing of AA management did not affect survival at discharge or good neurologic outcomes (Table 3). Even when divided into SGA and ETI subgroups by AA type, AA timing did not affect ROSC in either group. The aORs of 5–6 minutes, 7–9 minutes, and ≥ 10 minutes were as follows: for SGA: 0.96 ($p = 0.891$), 1.25 ($p = 0.455$), 1.11 ($p = 0.756$); for ETI: 1.04 ($p = 0.954$), 2.06 ($p = 0.210$), 2.21 ($p = 0.227$). In both the SGA and ETI subgroups, the timing of AA management did not affect survival to discharge or good neurologic outcomes (Table 4).

Discussion

In this study, we found that the timing and number of AA attempts in patients with OHCA did not affect patient prognosis, such as ROSC, survival to discharge, or good neurologic outcomes. When the patients were divided by AA type into SGA and ETI subgroups, the results also showed that the timing of AA did not influence the prognosis, and similar results were obtained when the subgrouping was based on having a shockable rhythm.

Several studies have been conducted to determine the optimal timing for AA management in patients with OHCA. A study of patients with OHCA in Osaka, Japan found that survival was better when EMS initiated AA management at < 4 minutes than when AA management was initiated at > 5 minutes [10]. Delayed AA treatment in patients with OHCA results in poor neurological prognosis [12]. An observational cohort study using the ROC-PRIMED (Resuscitation Outcomes Consortium Prehospital Resuscitation using an Impedance Valve and Early versus Delayed analysis) trial data in patients with OHCA in the United States and Canada also indicated that early AA management via EMS was associated with higher ROSC [13]. However, a recent large-scale cohort study in Japan showed that AA timing was not associated with survival in patients with OHCA with shockable rhythms. In contrast, in patients with non-shockable rhythms, AA performed with-

Table 3. Subgroup analysis for comparison by time to advanced airway (AA) according to primary electrocardiogram rhythm

Time interval to AA (min)	Shockable group (n = 194)					Non-shockable group (n = 1,893)				
	n (%)	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value	n (%)	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
ED ROSC	36 (100)					113 (100)				
≤ 4	10 (27.8)	Reference				24 (21.2)				
5–6	5 (13.9)	0.61 (0.19–1.95)	0.406	0.60 (0.17–2.09)	0.420	24 (21.2)	1.03 (0.58–1.85)	0.920	1.12 (0.61–2.05)	0.725
7–9	11 (30.6)	1.24 (0.48–3.24)	0.659	2.38 (0.78–7.26)	0.129	31 (25.0)	1.21 (0.70–2.10)	0.489	1.31 (0.73–2.34)	0.360
≥ 10	10 (27.8)	1.13 (0.43–3.00)	0.809	3.18 (0.75–11.91)	0.087	34 (27.4)	1.06 (0.62–1.81)	0.837	1.14 (0.60–2.19)	0.683
Survival discharge	13 (100)					16 (100)				
≤ 4	4 (30.8)	Reference				4 (25.0)				
5–6	2 (15.4)	0.64 (0.11–3.68)	0.618	0.79 (0.09–6.76)	0.831	3 (18.8)	0.77 (0.17–3.45)	0.731	1.20 (0.24–5.91)	0.827
7–9	3 (23.1)	0.80 (0.17–3.76)	0.775	0.71 (0.09–5.86)	0.750	1 (6.3)	0.23 (0.23–2.07)	0.190	0.34 (0.03–3.46)	0.359
≥ 10	4 (30.8)	1.11 (0.26–4.71)	0.886	3.09 (0.30–32.48)	0.347	8 (50.0)	1.49 (0.45–4.97)	0.520	1.35 (0.30–33.02)	0.655
Good neurologic outcome	11 (100)					3 (100)				
≤ 4	3 (27.3)	Reference				1 (33.3)				
5–6	2 (18.2)	0.87 (0.14–5.47)	0.884	1.29 (0.14–11.78)	0.824	0 (0)	0.00	0.994	0.00	0.998
7–9	3 (27.3)	1.09 (0.21–5.64)	0.923	1.23 (0.14–11.19)	0.854	0 (0)	0.00	0.994	0.00	0.987
≥ 10	3 (27.3)	1.11 (0.21–5.77)	0.902	3.42 (0.27–43.11)	0.341	2 (66.7)	1.49 (0.14–16.49)	0.745	0.01 (0–6.53)	0.704

The adjusted variables for ED ROSC were age, sex, performance, witnesses, bystander cardiopulmonary resuscitation (CPR), bystander automated external defibrillator (AED) use, mechanical compression, shockable rhythm, epinephrine, response time, on-scene time, transport time, and multiple airway attempts. The adjusted variables for survival to discharge and good neurologic outcome were age, sex, premorbid performance, witnesses, bystander CPR, bystander AED use, mechanical compression, epinephrine, response time, on-scene time, transport time, number of AA attempts, targeted temperature management supply, and extracorporeal membrane oxygenation supply.
OR, odds ratio; CI, confidence interval; ED, emergency department; ROSC, recovery of spontaneous circulation.

Table 4. Subgroup analysis for comparison by time to advanced airway (AA) according to the type of AA

Time interval to AA (min)	SGA group (n = 1,563)					ETI group (n = 524)				
	n (%)	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value	n (%)	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
ED ROSC	115 (100)					34 (100)				
≤ 4	28 (24.3)	Reference				6 (17.6)				
5–6	23 (20.0)	0.91 (0.52–1.62)	0.756	0.96 (0.52–1.77)	0.891	6 (17.6)	0.87 (0.27–2.79)	0.819	1.04 (0.30–3.54)	0.954
7–9	31 (27.0)	1.13 (0.66–1.92)	0.653	1.25 (0.70–2.22)	0.455	11 (32.4)	1.44 (0.52–4.03)	0.486	2.06 (0.61–8.04)	0.210
≥ 10	33 (28.7)	0.92 (0.55–1.55)	0.753	1.11 (0.58–2.12)	0.756	11 (32.4)	1.37 (0.49–3.82)	0.549	2.21 (0.61–8.04)	0.227
Survival discharge	26 (100)					3 (100)				
≤ 4	7 (26.9)	Reference				1 (33.3)				
5–6	4 (15.4)	0.64 (0.18–2.19)	0.473	0.82 (0.21–3.18)	0.773	1 (33.3)	0.87 (0.05–14.08)	0.922	0.00	0.999
7–9	4 (15.4)	0.57 (0.17–1.97)	0.378	0.48 (0.12–1.90)	0.297	0 (0)	0.00	0.996	0.00	0.996
≥ 10	11 (42.3)	1.23 (0.47–3.21)	0.668	1.90 (0.53–6.80)	0.323	1 (33.3)	0.72 (0.05–11.69)	0.819	0.00	0.998
Good neurologic outcome	12 (100)					2 (100)				
≤ 4	3 (25.0)	Reference				1 (50.0)				
5–6	1 (8.3)	0.37 (0.04–3.59)	0.392	0.33 (0.02–4.47)	0.403	1 (50.0)	0.88 (0.05–14.21)	0.927	0.00	0.992
7–9	3 (25.0)	1.01 (0.20–5.04)	0.990	0.54 (0.07–4.30)	0.558	0 (0)	0.00	0.996	0.00	0.994
≥ 10	5 (41.7)	1.31 (0.31–5.52)	0.712	0.77 (0.09–6.52)	0.814	0 (0)	0.00	0.996	0.00	0.997

The adjusted variables for ED ROSC were age, sex, performance, witnesses, bystander cardiopulmonary resuscitation (CPR), bystander automated external defibrillator (AED) use, mechanical compression, shockable rhythm, epinephrine, response time, on-scene time, transport time, and multiple airway attempts. The adjusted variables for survival to discharge and good neurologic outcome were age, sex, performance, witnesses, bystander CPR, bystander AED use, mechanical compression, shockable rhythm, epinephrine, response time, on-scene time, transport time, multiple attempts to airway, targeted temperature management supply, and extracorporeal membrane oxygenation supply.
SGA, supraglottic airway; ETI, endotracheal intubation; OR, odds ratio; CI, confidence interval; ED, emergency department; ROSC, recovery of spontaneous circulation.

in 15 minutes improved the 1-month survival rate [14]. Furthermore, another randomized controlled trial, the PART (Pragmatic Airway Resuscitation Trial), analyzed 2,146 patients with OHCA and found that AA timing was not associated with hospital discharge survival [15]. In previous studies, the ideal AA timing was still unclear and debatable. The present study analyzed AA timing in >2,000 patients with OHCA. To the best of our knowledge, this is the first data collection and analysis on the timing of AA in patients with OHCA in South Korea. We found that the timing of AA management through EMS in patients with OHCA at the prehospital stage was not associated with survival to discharge, neurological prognosis, or ROSC in the hospital.

AA management is used in urgent critical care, including for patients experiencing cardiopulmonary arrest, respiratory failure, and mental changes, with the aim of safe and rapid success. In hospital studies, because several attempts to establish ETI can lead to adverse events, such as dental trauma, hypoxia, aspiration, cuff leak, laryngospasm, dysrhythmia, hypotension, and even cardiac arrest, FPS is considered important [16-18]. Although numerous adverse events can develop, another study showed that FPS was not associated with 30-day mortality in patients undergoing ETI for critical care in the prehospital phase [19]. In patients with OHCA, more AA attempts are associated with worse neurological prognosis [9]. Another study indicated that FPS of AA establishment, including the use of King laryngeal tubes and ETI, influenced ROSC but was not associated with other outcomes [8].

AA management requires a high degree of proficiency, imposing a heavy burden on EMS in performing AA management at sites outside hospitals that lack monitoring, medications, and personnel. The conditions for AA management are even worse for OHCA, and EMS must perform combined management for high-quality CPR, making AA management more burdensome. In particular, uncertainty over the timing of AA management and lack of confidence in the success of the first AA attempt are major limitations for EMS in administering AA management to patients with OHCA. However, according to our study, the timing and number of attempts at AA are not related to the patient's prognosis, so there is no need to fear and be burdened by the difficulty of AA treatment, and there is no need to rush to quickly establish AA on the scene. We recommend that AA management be performed smoothly after high-quality chest compressions and defibrillation with shockable rhythms are prioritized in patients with OHCA in the field.

Our study has several limitations. First, the results were based on a retrospective analysis of an OHCA registry, EMS run sheets, and the medical records of EDs in Daegu. Thus, the study was limited by possible biases intrinsic to such a design. Second, although the study area was a metropolitan city in South Korea, the results of an EMS system targeting only one area may not be valid for other external EMS systems. Third, this study only included patients who underwent AA and excluded those who did not.

The timing of AA was not associated with ROSC, survival to hospital discharge, or neurological outcomes. Furthermore, the presence or absence of first-attempt success was not associated with any outcomes.

Article information

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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Author contributions

Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Investigation: SHL, HWR; Supervision, Validation: HWR; Visualization: SHL; Writing-original draft: SHL; Writing-review & editing: HWR.

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References

1. Tsao CW, Aday AW, Almarzooq ZI, Anderson CA, Arora P, Avery CL, et al. Heart disease and stroke statistics-2023 update: a report from the American Heart Association. Circulation 2023; 147:e93–621.
2. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, et al. Part 3: adult basic and advanced life support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2020;142(16 Suppl 2):S366–468.
3. Benoit JL, Prince DK, Wang HE. Mechanisms linking advanced airway management and cardiac arrest outcomes. Resuscitation 2015;93:124–7.
4. Wang HE, Simeone SJ, Weaver MD, Callaway CW. Interruptions in cardiopulmonary resuscitation from paramedic endotracheal intubation. Ann Emerg Med 2009;54:645–52.
5. Studnek JR, Thestrup L, Vandeventer S, Ward SR, Staley K, Garvey L, et al. The association between prehospital endotra-

cheal intubation attempts and survival to hospital discharge among out-of-hospital cardiac arrest patients. Acad Emerg Med 2010;17:918–25.

6. Carlson JN, Colella MR, Daya MR, J De Maio V, Nawrocki P, Nikolla DA, et al. Prehospital cardiac arrest airway management: an NAEMSP position statement and resource document. Prehosp Emerg Care 2022;26(Suppl 1):54–63.
7. Granfeldt A, Avis SR, Nicholson TC, Holmberg MJ, Moskowitz A, Coker A, et al. Advanced airway management during adult cardiac arrest: a systematic review. Resuscitation 2019; 139:133–43.
8. Lesnick JA, Moore JX, Zhang Y, Jarvis J, Nichol G, Daya MR, et al. Airway insertion first pass success and patient outcomes in adult out-of-hospital cardiac arrest: The Pragmatic Airway Resuscitation Trial. Resuscitation 2021;158:151–6.
9. Murphy DL, Bulger NE, Harrington BM, Skerchak JA, Counts CR, Latimer AJ, et al. Fewer tracheal intubation attempts are associated with improved neurologically intact survival following out-of-hospital cardiac arrest. Resuscitation 2021;167:289–96.
10. Izawa J, Iwami T, Gibo K, Okubo M, Kajino K, Kiyohara K, et al. Timing of advanced airway management by emergency medical services personnel following out-of-hospital cardiac arrest: a population-based cohort study. Resuscitation 2018; 128:16–23.
11. Panchal AR, Berg KM, Kudenchuk PJ, Del Rios M, Hirsch KG, Link MS, et al. 2018 American Heart Association focused update on advanced cardiovascular life support use of antiarrhythmic drugs during and immediately after cardiac arrest: an update to the American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2018;138:e740–9.
12. Fukuda T, Ohashi-Fukuda N, Inokuchi R, Kondo Y, Sekiguchi H, Taira T, et al. Association between time to advanced airway management and neurologically favourable survival during out-of-hospital cardiac arrest. Anaesth Crit Care Pain Med 2021;40:100906.
13. Benoit JL, McMullan JT, Wang HE, Xie C, Xu P, Hart KW, et al. Timing of advanced airway placement after witnessed out-of-hospital cardiac arrest. Prehosp Emerg Care 2019; 23:838–46.
14. Okubo M, Komukai S, Izawa J, Gibo K, Kiyohara K, Matsuyama T, et al. Timing of prehospital advanced airway management for adult patients with out-of-hospital cardiac arrest: a nationwide cohort study in Japan. J Am Heart Assoc 2021;10: e021679.
15. Okubo M, Komukai S, Izawa J, Aufderheide TP, Benoit JL, Carlson JN, et al. Association of advanced airway insertion timing and outcomes after out-of-hospital cardiac arrest. Ann Emerg Med 2022;79:118–31.
16. Kim J, Kim K, Kim T, Rhee JE, Jo YH, Lee JH, et al. The clinical significance of a failed initial intubation attempt during emergency department resuscitation of out-of-hospital cardiac arrest patients. Resuscitation 2014;85:623–7.
17. Higgs A, McGrath BA, Goddard C, Rangasami J, Suntharalingam G, Gale R, et al. Guidelines for the management of tracheal intubation in critically ill adults. Br J Anaesth 2018;120:323–52.
18. Sakles JC, Chiu S, Mosier J, Walker C, Stolz U. The importance of first pass success when performing orotracheal intubation in the emergency department. Acad Emerg Med 2013;20:71–8.
19. Ljungqvist H, Pirneskoski J, Saviluoto A, Setälä P, Tommila M, Nurmi J. Intubation first-pass success in a high performing pre-hospital critical care system is not associated with 30-day mortality: a registry study of 4496 intubation attempts. Scand J Trauma Resusc Emerg Med 2022;30:61.