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Clinical paper

Airway management and out-of-hospital cardiac arrest outcome in the CARES registry☆

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ABSTRACT

Background: Optimal out of hospital cardiac arrest (OHCA) airway management strategies remain unclear. We compared OHCA outcomes between patients receiving endotracheal intubation (ETI) versus supraglottic airway (SGA), and between patients receiving [ETI or SGA] and those receiving no advanced airway.

Methods: We studied adult OHCA in the Cardiac Arrest Registry to Enhance Survival (CARES). Primary exposures were ETI, SGA, or no advanced prehospital airway placed. Primary outcomes were sustained ROSC, survival to hospital admission, survival to hospital discharge, and neurologically-intact survival to hospital discharge (cerebral performance category 1–2). Propensity scores characterized the probability of receiving ETI, SGA, or no advanced airway. We adjusted for Utstein confounders. Multivariable random effects regression accounted for clustering by EMS agency. We compared outcomes between (1) ETI vs. SGA, and (2) [no advanced airway] vs. [ETI or SGA].

Results: Of 10,691 OHCA, 5591 received ETI, 3110 SGA, and 1929 had no advanced airway. Unadjusted neurologically-intact survival was: ETI 5.4%, SGA 5.2%, no advanced airway 18.6%. Compared with SGA, ETI achieved higher sustained ROSC (OR 1.35; 95%CI 1.19–1.54), survival to hospital admission (1.36; 1.19–1.55), hospital survival (1.41; 1.14–1.76) and hospital discharge with good neurologic outcome (1.44; 1.10–1.88). Compared with [ETI or SGA], patients receiving no advanced airway attained higher survival to hospital admission (1.31; 1.16–1.49), hospital survival (2.96; 2.50–3.51) and hospital discharge with good neurologic outcome (4.24; 3.46–5.20).

Conclusion: In CARES, survival was higher among OHCA receiving ETI than those receiving SGA, and for patients who received no advanced airway than those receiving ETI or SGA.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health problem affecting over 300,000 persons in the United States each year.[1] Airway management is a core element of OHCA resuscitation. In the United States, 80% of OHCA resuscitations receive prehospital airway management, and the most common advanced airway intervention is endotracheal intubation (ETI).

Supraglottic airways (SGA) such as the Esophageal-Tracheal Combitube (ETC), Laryngeal Mask Airway (LMA) and King Laryngeal Tube (King LT), offer an alternative approach to advanced airway management. There is growing enthusiasm for the use of SGA insertion during OHCA resuscitation due to its simpler insertion versus ETI. Many EMS personnel choose primary SGA insertion to avoid interruptions in cardiopulmonary resuscitation chest compression continuity.[2,3] Despite the growing out-of-hospital use of SGA, there have been relatively few comparisons of OHCA outcomes between patients receiving ETI and those receiving SGA insertion.[4] More recently, select studies have even suggested improved survival without the insertion of any advanced airway device in OHCA.[5]

The Cardiac Arrest Registry to Enhance Survival (CARES) Surveillance Group is the largest multi-site network characterizing OHCA care and outcomes in North America.[6] In the present study, we sought to evaluate the impact of EMS airway management strategy

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upon outcomes after OHCA in CARES. Specifically, we compared OHCA outcomes between patients receiving endotracheal intubation (ETI) versus supraglottic airway (SGA), and between patients receiving [ETI or SGA] and those receiving no advanced airway.

2. Methods

2.1. Study design and setting

This study was approved by the Institutional Review Boards of the University of Cincinnati and the University of Alabama at Birmingham. We conducted a secondary analysis of out-of-hospital cardiac arrest data from the Cardiac Arrest Registry to Enhance Survival (CARES) registry.

2.2. Data source

CARES is a multicenter registry of OHCA episodes from across the United States.[7] Currently, over 400 EMS agencies from 40 communities and 10 state-based registries contribute data to CARES. These agencies serve a total population base of 65 million people. Participating EMS agencies provide comprehensive clinical information on all treated OHCA, including patient demographics, circumstances of the event, EMS response and treatment, and outcomes. While the primary data entry method is an internet-based database, select agencies contribute to the central database via transfer of EMS electronic health record data. Local coordinators at each EMS agency contact receiving hospitals to determine patient outcomes. Data are cleaned and error-checked prior to consolidation with the master data set. CARES has collected OHCA in this fashion since its inception in 2004.

2.3. Selection of subjects

For this analysis we included adult (age ≥18 years), treated out-of-hospital cardiac arrests appearing in version 4 of the CARES registry. We excluded children <18 years old as well as those where age was not known or reported.

Airway management variables were optional in the CARES registry. Therefore we excluded cases where airway management data were not reported by the EMS agency. We also excluded the small number of cases (0.5%) where the type of advanced airway device was listed as "other." OHCA episodes in the analysis occurred during the calendar year 2011.

2.4. Outcomes and covariates

We examined four major outcomes: (1) sustained return of spontaneous circulation (ROSC), (2) survival to hospital admission, (3) survival to hospital discharge, and (4) survival to hospital discharge with good neurologic outcome. Sustained ROSC was reported by EMS personnel and consisted of restoration of pulses with circulation present for at least 20 min, or upon ED arrival. Survival to hospital admission consisted of patients who were alive upon admission to hospital or transfer to another facility from the ED. Hospital survival consisted of patients who were alive on hospital discharge. Patients made DNR after hospital admission were classified according to their final hospital vital status (alive or dead at the time of discharge from the hospital) and included in outcomes analyses. Survival to hospital discharge with good neurologic outcome consisted of patients with a cerebral performance category (CPC) score of 1 or 2 upon hospital discharge.

The primary exposure of interest was the ultimate method of prehospital airway management and included (1) endotracheal intubation (ETI), (2) supraglottic airway (SGA), and (3) no advanced airway. ETI included intubations accomplished by orotracheal or other technique. SGAs used by CARES agencies included King laryngeal tubes (King LT – King Systems, Inc., Noblesville, IN), esophageal-tracheal combitube (Combitube, Kendall-Sheridan Corporation, Mansfield, MA), and Laryngeal Mask Airway (LMA–LMA North America, San Diego, CA). Because CARES did not report unsuccessful airway insertions, all data reflect successful ETI or SGA insertion efforts; cases where ETI or SGA insertion were unsuccessful were classified as having received no advanced airway.

Covariates included in the analysis included age, sex, race/ethnicity, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, defibrillation by a public automated external defibrillator, initial ECG rhythm, arrest location, and response, treatment and transport times. CARES reported race and ethnicity as white, black, Hispanic and other. Initial ECG rhythm included shockable (ventricular fibrillation or tachycardia) and non-shockable (asystole or pulseless electrical activity). Arrest locations included home, public location, health institutions and other. First responder and ambulance response times consisted of time from dispatch to unit arrival on-scene. Scene-time consisted of elapsed time from arrival on scene to departure to hospital. Transport time consisted of elapsed time from scene departure to hospital arrival.

2.5. Analysis

Our data analytic approach closely paralleled strategies used by prior studies.[4,5] We compared the patient demographic, arrest characteristics and treatment times between patients receiving successful ETI, successful SGA or no advanced airway, using the chi-squared test, one-way ANOVA or one-way Kruskal–Wallis test as appropriate.

For the outcomes analyses, we performed two major comparisons: (1) ETI vs. SGA only, and (2) no advanced airway management vs. [ETI or SGA]. The former compares the comparative effectiveness of two different airway management strategies upon OHCA outcomes. The latter evaluates the relative effectiveness of any advanced airway technique (ETI or SGA) upon OHCA outcomes. Prior OHCA studies have made similar comparisons.[4,5]

A range of factors may influence EMS personnel selection of particular advanced airway device or strategy; for example, the witnessed nature of the cardiac arrest, the age of the patient or the provision of bystander CPR. Therefore, as done by Hasegawa et al., we defined propensity scores for the selection of ETI vs. SGA, as well as (ETI or SGA) vs. no advanced airway.[5] In the propensity score, we included clinical variables that could plausibly impact the airway device selection: age-decile, sex, race, initial rhythm, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, AED shock before EMS arrival, location type and ambulance response time. Because airway management practices may vary by EMS agency, we also incorporated EMS agency into the propensity score. Because of the large proportion of missing values, we did not include first responder response, scene or transport times in the propensity score calculation. We calculated propensity scores using the "pscore" module of Stata.

We fit a series of multivariable models testing the association between each outcome and airway strategy. We used random effects logistic regression to account for clustering by EMS agency. For each outcome, we fit (1) an unadjusted model, (2) a model adjusted for propensity score quartile, and (3) a model adjusted for propensity score quartile and clinical covariates (age decile, sex, race, initial rhythm, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, AED shock before EMS arrival, location type and ambulance response time). In the third model, we included both a propensity score and clinical covariates because the latter variables may also confound the relationship between airway type

Table 1
Airway management technique used on adult out-of-hospital cardiac arrests treated by EMS agencies in the CARES network. Supraglottic airway and endotracheal tube groups include successful advanced airway insertions only; failed insertion efforts were included in the subgroup "no successful advanced airway intervention".

Advanced management technique	N (%)
Supraglottic airway	3110 (29.3%)
Esophageal-tracheal combitube	309 (2.9%)
Laryngeal mask airway	55 (0.5%)
King laryngeal tube	2746 (25.8%)
Endotracheal intubation	5591 (52.6%)
No successful advanced airway intervention	1929 (18.2%)
Other[a]	61 (0.5%)

[a] Cases where the type of advanced airway was reported as "other" were excluded from further analysis.

and outcome. We repeated the analyses stratified by initial ECG rhythm (shockable vs. non-shockable).

To test the robustness of the results, we also repeated the analysis matching exposed and unexposed individuals by propensity score. Based upon the methodology of Nichol et al., we matched pairs using the logit of the propensity score, applying a caliper equal to 30% of the standard deviation of the logit.[8] We analyzed the propensity matched subsets using Generalized Estimating Equations to account for the matched pairs. Because matched pairs may have been selected between different EMS agencies, in these propensity-matched models we did not account for clustering by EMS agency. We performed all analyses using Stata v.12.2 (Stata, Inc, College Station, TX).

3. Results

During the study period there were 12,875 out-of-hospital cardiac arrests reported by CARES EMS agencies. We excluded 256 children <18 years old and 83 where age was unknown. We excluded an additional 1847 where the EMS agency did not provide airway management information. Of the remaining 10,691 adult OHCA patients, over 80% underwent successful insertion of an advanced airway device. (Table 1) Among patients receiving an advanced airway, approximately two-thirds received ETI and one-third received SGA. The King LT was the most commonly used SGA. Because of the very small number (61) of subjects who received an airway classified as "other," this group was excluded from further analysis. The airway data included in the analysis originated from 120 EMS agencies, with 1–1550 OHCA cases per agency.

Compared with those receiving SGA, patients receiving ETI were slightly older, more likely to be male, and less likely to receive defibrillation by a public AED. (Table 2) Compared with those receiving ETI or SGA, patients receiving no advanced airway interventions were more likely to experience an EMS-witnessed arrest, present with a shockable ECG rhythm, and to experience cardiac arrest in a public location or health institution. Among cases with times available, on-scene and transport to hospital times were slightly lower for those not receiving advanced airway interventions.

Termination of resuscitation occurred in approximately 30% of patients and was least frequent in the ETI group. (Table 3) Unadjusted outcomes were highest for patients who did not receive successful advanced airway placement. Compared with those receiving successful SGA placement, unadjusted outcomes were better with ETI.

Compared with SGA, ETI was independently associated with increased adjusted odds of sustained ROSC, survival to hospital admission, hospital survival, and good neurologic outcome, even after adjustment for a propensity score and clinical confounders (Table 4). When stratified by initial ECG rhythm, ETI remained independently associated with increased hospital survival and good neurologic outcome in the shockable but not the non-shockable subgroup. We observed similar results in the analysis of 1502 propensity-matched pairs (3004 patients).

Compared with those receiving ETI or SGA, patients receiving no advanced airway interventions exhibited higher adjusted odds of sustained ROSC, survival to hospital admission, hospital survival and neurologically-intact hospital survival. When stratified by initial ECG rhythm, the adjusted odds of survival remained higher among patients receiving no advanced airway interventions. The strengths of the associations were higher among patients presenting with a shockable rhythm than those presenting with a non-shockable rhythm. We observed similar results in the analysis of 1699 propensity-matched pairs (3398 patients) (Table 5).

4. Discussion

Our findings in this analysis of a large, multi-center US-based registry of OHCA are similar to those published previously and provide more support to the associations between prehospital airway management choices and ultimate neurologically-intact survival. OHCA in the CARES network receiving no advanced airway exhibited superior outcomes than those receiving ETI or SGA. When an advanced airway was used, ETI was associated with improved outcomes compared to SGA.

Many EMS practitioners consider SGA an attractive alternative to ETI because of their ease and speed of placement, the lessened risk of unrecognized esophageal intubation, the mitigated impact on chest compression continuity, and the decreased training requirements.[3,9] However, among OHCA patients receiving advanced airway insertion in the CARES network, we found that outcomes were better among those receiving ETI compared with those receiving SGA. These observations persisted even after accounting for a range of confounders and a propensity score. We also observed similar inferences in propensity-matched analyses.

Our findings are consistent with prior studies assessing airway management and cardiac arrest outcomes. A prior secondary analysis of 10,000 patients from the Resuscitation Outcomes Consortium (ROC) compared OHCA outcomes between patients receiving ETI and SGA.[4] The study suggested improved ROSC, 24-hour survival, and survival to hospital discharge with good neurologic function among patients receiving ETI compared with those receiving SGA.[4] While similar in many ways, there are key contrasts with our current CARES analysis. ROC is a specialized clinical trial network, and 150 EMS agencies from 10 regional centers participated in the ROC cardiac arrest studies, including large agencies in Canada. ROC agencies receive frequent specialized training such as emphasis on maintaining CPR continuity. In contrast, our analysis of CARES OHCA encompassing over 400 EMS agencies from more than 40 community-based sites and 10 statewide registries that may better reflect the heterogeneity of EMS practice in the US.[10] Because numerous factors may influence paramedics' selection of airway management interventions, in this CARES analysis we also conducted analyses using both propensity score adjustment and matching. Because paramedic practices and OHCA outcomes may vary regionally,[10] we accounted for clustering by EMS agency in the analytic models. We further explored the associations between airway management and outcome by stratifying our analysis by initial ECG rhythm and excluding cases with EMS witnessed cardiac arrest or where subjects were made DNR after hospital admission.

In this study we also observed that OHCA outcomes were markedly better among those who received no advanced airway interventions compared with those who received ETI or SGA. These results are consistent with Hasegawa et al.'s analysis of almost 650,000 OHCA from the all-Japan Utstein OHCA registry.[5] There are important differences in the patient and arrest demographics

Table 2
Characteristics of out-of-hospital cardiac arrest patients treated by EMS agencies in the CARES network. Cells reflect column percentages, except where noted. *P*-values based upon chi-square test.

Characteristics	No advanced airway (*n* = 1929)	Supraglottic airway (*n* = 3110)	Endotracheal intubation (*n* = 5591)	*P*-value
Patient demographics				
Age (mean, SD)	65.3 16.7)	63.9 (16.0)	66.1 (16.4)	<0.001*
Sex				
Male (%)	60.4	62.2	60.5	0.45
Female (%)	39.6	37.8	39.5	
Unknown (%)	0.0	0.0	0.02	
Race/Ethnicity				
White (%)	38.1	45.9	40.1	<0.001
Black (%)	25.3	27.6	21.4	
Hispanic (%)	5.8	3.2	5.3	
Other/Unknown (%)	30.8	23.3	33.3	
Arrest characteristics				
Bystander witnessed arrest				
No (%)	66.4	61.5	61.9	0.004
Yes (%)	33.6	38.5	38.1	
Unknown (%)	0.0	0.0	0.02	
EMS witnessed arrest				
No (%)	81.3	90.6	89.9	<0.001
Yes (%)	18.6	9.4	10.0	
Unknown (%)	0.1	0.0	0.04	
Bystander CPR				
No (%)	62.1	64.6	62.2	0.06
Yes (%)	38.0	35.4	37.8	
AED shock				
No (%)	91.6	90.8	94.2	<0.001
Yes (%)	8.5	9.2	5.8	
Initial rhythm				
Non-shockable (PEA, asystole) (%)	71.2	77.4	77.6	<0.001
Shockable (VF, VT) (%)	28.8	22.6	22.4	
Arrest location				
Home (%)	59.4	69.6	70.4	<0.001
Public location (%)	16.9	13.7	12.5	
Health institution (%)	22.7	16.1	16.5	
Other (%)	1.0	0.6	0.7	
Unknown (%)	0.0	0.0	0.02	
Treatment times				
First responder response time (ambulance dispatch to arrival on scene – median min, IQR)	5.0 (3.8–6.5)	4.8 (3.5–6.2)	4.9 (3.7–6.5)	0.003†
Unknown (%)	31.5	46.5	30.8	
Ambulance response time (ambulance dispatch to arrival on scene – median min, IQR)	6.0 (4.3–8.2)	6.1 (4.4–8.4)	6.0 (4.1–8.2)	0.04†
Unknown (%)	8.5	9.0	8.8	
On-scene time (ambulance arrival to departure from scene – median min, IQR)	19.2 (13.8–29.4)	23.7 (17.0–34.2)	23.0 (17.0–32.6)	<0.001†
Unknown (%)	42.0	40.0	32.7	
Transport time (departure from scene to hospital arrival – median min, IQR)	8.2 (5.0–13.0)	9.0 (6.0–13.0)	8.7 (5.7–12.8)	0.002†
Unknown (%)	48.1	49.4	35.6	

* From one-way ANOVA test.
† From one-way Kruskal–Wallis test.

between our cohort and Hasegawa's, where only 6% underwent ETI, 57% were managed with bag-valve-mask ventilation alone, and the overall neurologically intact survival rate was only 2.1%. CARES is limited to OHCA of presumed cardiac etiology, whereas 18% of OHCA in the Japanese cohort due to trauma, hanging, drowning, intoxication, or asphyxia, and an additional 27% were due to other non-cardiac causes such as cancer or respiratory or cerebrovascular diseases. Furthermore, advanced airway management skills are relatively new in Japan, unlike in the US, making generalizability difficult.

Although our findings of an association of improved outcomes with no advanced airway management are consistent with previous reports, we urge caution in the interpretation of those and the current findings. Confounding by indication is of major influence in studies of medical interventions.[11] Unlike the comparison of ETI vs. SGA, the observed survival differences between the airway and

Table 3
Unadjusted outcomes after out-of-hospital cardiac arrest in the CARES network. Cells reflect column percentages. *P*-values based upon chi-square test.

Outcome	No advanced airway (*n* = 1929)	Supraglottic airway (*n* = 3110)	Endotracheal intubation (*n* = 5591)	*P*-value
Field termination of resuscitation (%)	33.8	34.6	22.3	<0.001
Sustained ROSC (%)	36.5	25.5	33.8	<0.001
Survival to hospital admission (%)	33.4	21.4	26.6	<0.001
Survival to hospital discharge (%)	21.9	6.7	8.3	<0.001
Survival to hospital discharge with good neurologic outcome (%)	18.6	5.2	5.4	<0.001

Table 4
Associations between advanced airway type (endotracheal intubation vs. supraglottic airway) and out-of-hospital cardiac arrest outcomes. Analysis includes successful endotracheal intubation or supraglottic airway insertions only.

Outcome	All patients receiving ETI or SGA (n = 8701) OR (95% CI)	Initial shockable rhythm only[a] (n = 1956) OR (95% CI)	Initial non-shockable rhythm only[a] (n = 6745) OR (95% CI)	Excluding EMS witnessed (n = 7846) OR (95% CI)	Excluding subjects made DNR (n = 8360) OR (95% CI)
Sustained ROSC					
Unadjusted	1.43 (1.27–1.62)	1.71 (1.37–2.14)	1.33 (1.16–1.53)	1.46 (1.29–1.66)	
Adjusted for propensity score (quartile)[b]	1.37 (1.20–1.55)	1.75 (1.38–2.21)	1.24 (1.06–1.45)	1.39 (1.22–1.59)	
Adjusted for propensity score and confounders[c]	1.35 (1.19–1.54)	1.79 (1.41–2.28)	1.23 (1.05–1.43)	1.38 (1.20–1.58)	1.32 (1.15–1.51)
Propensity-matched, adjusted for confounders[d]	1.38 (1.16–1.64)	1.73 (1.24–2.43)	1.29 (1.05–1.58)	1.41 (1.19–1.67)	
Survival to hospital admission					
Unadjusted	1.34 (1.19–1.52)	1.55 (1.25–1.92)	1.23 (1.06–1.43)	1.39 (1.22–1.58)	
Adjusted for propensity score (quartile)[b]	1.34 (1.18–1.52)	1.69 (1.34–2.14)	1.21 (1.03–1.40)	1.38 (1.21–1.58)	
Adjusted for propensity score and confounders[c]	1.36 (1.19–1.55)	1.74 (1.37–2.21)	1.20 (1.03–1.41)	1.40 (1.22–1.61)	1.34 (1.16–1.55)
Propensity-matched, adjusted for confounders[d]	1.43 (1.19–1.71)	1.96 (1.40–2.75)	1.26 (1.01–1.57)	1.35 (1.13–1.61)	
Survival to hospital discharge					
Unadjusted	1.30 (1.07–1.58)	1.31 (1.03–1.66)	1.21 (0.89–1.64)	1.34 (1.09–1.65)	
Adjusted for propensity score (quartile)[b]	1.35 (1.10–1.67)	1.57 (1.19–2.07)	1.10 (0.80–1.51)	1.43 (1.14–1.78)	
Adjusted for propensity score and confounders[c]	1.41 (1.14–1.76)	1.63 (1.25–2.12)	1.12 (0.81–1.55)	1.49 (1.20–1.86)	1.44 (1.14–1.81)
Propensity-matched, adjusted for confounders[d]	1.72 (1.24–2.39)	2.14 (1.39–3.29)	1.27 (0.76–2.15)	1.38 (1.02–1.89)	
Survival to hospital discharge with good neurologic outcome					
Unadjusted	1.35 (1.06–1.70)	1.42 (1.06–1.92)	1.06 (0.72–1.57)	1.46 (1.13–1.89)	
Adjusted for propensity score (quartile)[b]	1.39 (1.09–1.79)	1.60 (1.16–2.21)	1.01 (0.67–1.52)	1.55 (1.17–2.04)	
Adjusted for propensity score and confounders[c]	1.44 (1.10–1.88)	1.68 (1.19–2.35)	0.98 (0.64–1.51)	1.62 (1.20–2.18)	1.51 (1.15–1.98)
Propensity-matched, adjusted for confounders[d]	1.66 (1.15–2.41)	1.94 (1.24–3.05)	1.28 (0.64–2.53)	1.42 (1.00–2.03)	

[a] Shockable rhythms included ventricular fibrillation and ventricular tachycardia. Non-shockable rhythms include pulseless electrical activity and asystole.
[b] Propensity score for advanced airway type (endotracheal intubation vs. supraglottic airway) based upon age decile, sex, race, initial rhythm, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, AED shock before EMS arrival, location type, ambulance response time, and EMS agency.
[c] Confounders include age decile, sex, race, initial rhythm, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, AED shock before EMS arrival, location type and ambulance response time.
[d] Propensity score-matched analyses based upon n = 1502 matched pairs (3004 patients).

Table 5
Associations between advanced airway strategy (no airway vs. [endotracheal intubation or. supraglottic airway]) and out-of-hospital cardiac arrest outcomes. Analysis includes successful endotracheal intubation or supraglottic airway insertions only.

Outcome	All patients (n = 10,630) OR (95% CI)	Initial shockable rhythm only[a] (n = 2512) OR (95% CI)	Initial non-shockable rhythm only[a] (n = 8118) OR (95% CI)	Excluding EMS witnessed (n = 9414) OR (95% CI)	Excluding subjects made DNR (n = 10,253) OR (95% CI)
Sustained ROSC					
Unadjusted	1.25 (1.12–1.39)	3.22 (1.60–3.98)	0.73 (0.63–0.84)	1.07 (0.95–1.21)	
Adjusted for propensity score (quartile)[b]	1.11 (0.99–1.24)	3.01 (2.41–3.75)	0.67 (0.58–0.78)	1.01 (0.89–1.14)	
Adjusted for propensity score and confounders[c]	1.07 (0.94–1.20)	2.74 (2.18–3.46)	0.68 (0.58–0.80)	0.99 (0.86–1.13)	1.14 (1.01–1.29)
Propensity-matched, adjusted for confounders[d]	1.01 (0.87–1.18)	2.72 (2.04–3.63)	0.64 (0.53–0.78)	1.13 (0.96–1.32)	
Survival to hospital admission					
Unadjusted	1.56 (1.40–1.75)	3.11 (2.53–3.81)	0.98 (0.84–1.14)	1.27 (1.12–1.44)	
Adjusted for propensity score (quartile)[b]	1.35 (1.20–1.52)	2.82 (2.27–3.49)	0.89 (0.76–1.05)	1.18 (1.03–1.34)	
Adjusted for propensity score and confounders[c]	1.31 (1.16–1.49)	2.59 (2.07–3.24)	0.92 (0.78–1.09)	1.16 (1.01–1.34)	1.45 (1.27–1.65)
Propensity-matched, adjusted for confounders[d]	1.45 (1.22–1.72)	2.79 (2.00–3.89)	1.02 (0.82–1.27)	1.48 (1.25–1.75)	
Survival to hospital discharge					
Unadjusted	3.67 (3.19–4.23)	4.74 (3.85–5.83)	2.54 (2.01–3.22)	3.09 (2.62–3.64)	
Adjusted for propensity score (quartile)[b]	2.96 (2.54–3.45)	4.24 (3.41–5.28)	2.07 (1.60–2.66)	2.74 (2.30–3.26)	
Adjusted for propensity score and confounders[c]	2.96 (2.50–3.51)	3.77 (2.98–4.75)	2.18 (1.68–2.84)	3.03 (2.48–3.69)	2.99 (2.51–3.56)
Propensity-matched, adjusted for confounders[d]	3.53 (2.67–4.66)	3.98 (2.70–5.88)	3.11 (1.96–4.92)	3.70 (2.79–4.91)	
Survival to hospital discharge with good neurologic outcome					
Unadjusted	5.19 (4.42–6.11)	6.33 (5.01–8.00)	4.11 (3.08–5.51)	4.33 (3.58–5.24)	
Adjusted for propensity score (quartile)[b]	4.13 (3.46–4.93)	5.61 (4.39–7.18)	3.18 (2.31–4.38)	3.85 (3.14–4.72)	
Adjusted for propensity score and confounders[c]	4.24 (3.46–5.20)	4.91 (3.78–6.41)	3.30 (2.36–4.63)	4.56 (3.59–5.79)	4.17 (3.39–5.12)
Propensity-matched, adjusted for confounders[d]	4.19 (3.09–5.70)	4.79 (3.39–6.77)	3.51 (2.06–6.00)	4.79 (3.61–6.35)	

[a] Shockable rhythms included ventricular fibrillation and ventricular tachycardia. Non-shockable rhythms include pulseless electrical activity and asystole.
[b] Propensity score for advanced airway type (endotracheal intubation vs. supraglottic airway) based upon age decile, sex, race, initial rhythm, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, AED shock before EMS arrival, location type, ambulance response time and EMS agency.
[c] Confounders include age decile, sex, race, initial rhythm, bystander witnessed arrest, EMS witnessed arrest, bystander CPR, AED shock before EMS arrival, location type and ambulance response time.
[d] Propensity score-matched analyses based upon n = 1699 matched pairs (3398 patients).

non-airway groups were very large, even after stratification by initial ECG rhythm, propensity score adjustment and propensity score matching. We believe that the large associations – despite the use of multivariable adjustment and propensity score matching – reflect the presence of unmeasured and immeasurable confounders. For example, the non-airway group may have included patients who regained airway reflexes, spontaneous respirations, or consciousness during EMS treatment. Patients with these findings would be expected to have superior outcomes compared with comatose individuals. We note that patients who did not receive an advanced airway were more likely to be found in a shockable cardiac rhythm, have their OHCA witnessed by EMS, or receive therapy from an AED. Other unmeasured confounders such as short distance to the hospital, provider procedural skill, perceived health status of the patient, and airway anatomic factors may have also influenced the decision to not insert an advanced airway. Additional study must integrate detailed information regarding the course of airway management such as the number and duration of attempts, rates of ventilation, and airway interventions carried out in the receiving ED.

Hypothesized reasons for the superiority of ETI over SGA include inadvertent exposure to hyperventilation and impairment of carotid blood flow.[12,13] Many EMS practitioners use SGA in a rescue capacity in the event of failed ETI, and thus SGA insertion may act as a surrogate for prolonged airway efforts.[14] CARES does not capture airway process data, and therefore we could not determine the impact of the number or duration of airway insertion attempts. A previous study found that the sequence leading to successful airway placement did not affect the observation of improved outcomes with ETI compared to SGA.[4] Of note, the survival differences between ETI and SGA were limited to patients with an initial shockable ECG rhythm. The latter observation is particularly important, potentially suggesting that patients in shockable rhythm may be particularly vulnerable to differences between the airway devices. We cannot ascertain from the current data whether these outcome differences are due to the physiology of ventricular fibrillation or whether the shockable rhythm state represents a surrogate for other factors.

While identifying outcome differences, practitioners should use caution when applying these results to clinical practice. The findings from this and other studies clearly indicate the need for additional prospective study of OHCA airway management. Given the influence of confounding by indication, prospective randomized assignment is necessary to adequately differentiate outcome differences between airway devices and techniques. Secondary measurements are also important to help identify the reasons underlying the observed outcomes including chest compression metrics (compression depth and density, interruptions in compressions), airway course (including number, duration and success of airway insertion attempts), and ventilation (rate and minute ventilation).

4.1. Study limitations

CARES is a voluntary registry. While the CARES network contains EMS agency representation from a range of communities, the network does not necessarily reflect contiguous areas within each region. While reporting compliance is high, there could be cardiac arrest cases inadvertently omitted from the CARES registry. The CARES data lack details of airway management such as the number and duration of airway insertion attempts. We also did not have information on failed airway insertion attempts, the proficiency or experience of providers, or post-airway ventilator practices. As such, we cannot perform an intention-to-treat analysis. There was no information on physiologic measures such as CPR chest compression continuity. There was also only limited in-hospital data such as the use of mild therapeutic hypothermia, percutaneous coronary intervention, and implantable cardioverter defibrillator placement after cardiac arrest. While we used multivariable and propensity score adjustment and matching techniques, unmeasured and unmeasurable confounders such as these may have influenced patient outcomes.

5. Conclusion

In the CARES network, survival was higher among OHCA receiving ETI than those receiving SGA. Survival was markedly higher among patients who received no advanced airway than those receiving endotracheal intubation or supraglottic airway placement.

Conflict of interest statement

All authors have no conflicts of interest to report.

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