The Association Between Prehospital Endotracheal Intubation Attempts and Survival to Hospital Discharge Among Out-of-hospital Cardiac Arrest Patients

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Abstract

Objectives: The benefit of prehospital endotracheal intubation (ETI) among individuals experiencing out-of-hospital cardiac arrest (OOHCA) has not been fully examined. The objective of this study was to determine if prehospital ETI attempts were associated with return of spontaneous circulation (ROSC) and survival to discharge among individuals experiencing OOHCA.

Methods: This retrospective study included individuals who experienced a medical cardiac arrest between July 2006 and December 2008 and had resuscitation efforts initiated by paramedics from Mecklenburg County, North Carolina. Outcome variables were prehospital ROSC and survival to hospital discharge, while the primary independent variable was the number of prehospital ETI attempts.

Results: There were 1,142 cardiac arrests included in the analytic data set. Prehospital ROSC occurred in 299 individuals (26.2%). When controlling for initial arrest rhythm and other confounding variables, individuals with no ETI attempted were 2.33 (95% confidence interval [CI] = 1.63 to 3.33) times more likely to have ROSC compared to those with one successful ETI attempt. Of the 299 individuals with prehospital ROSC, 118 (39.5%) were subsequently discharged alive from the hospital. Individuals having no ETI were 5.46 (95% CI = 3.36 to 8.90) times more likely to be discharged from the hospital alive compared to individuals with one successful ETI attempt.

Conclusions: Results from these analyses suggest a negative association between prehospital ETI attempts and survival from OOHCA. In this study, the individuals most likely to have prehospital ROSC and survival to hospital discharge were those who did not have a reported ETI attempt. Further comparative research should assess the potential causes of the demonstrated associations.

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Sudden death from cardiac arrest in the out-of-hospital setting remains a leading cause of mortality worldwide.[1–4] Cardiovascular disease claims 2,400 lives each day, amounting to an annual death toll of over 875,000 in the United States. Nearly 295,000 of those deaths result from out-of-hospital cardiac arrest (OOHCA).[5] Over the past decade, the management of OOHCA has evolved from focusing on early advanced interventions, to focusing on the first links in the American Heart Association's (AHA) "Chain of Survival."[6] These changes have included emphasizing early recognition, with focus on improving bystander cardiopulmonary resuscitation (CPR) and public access defibrillation.[7,8] Emergency responders have also been encouraged to increase automated external defibrillator (AED) usage, minimize the interruption of chest compressions, and decrease the emphasis on advanced airway management.[9] Several studies have suggested that a shift to minimally interrupted cardiac resuscitation (MICR; or cardiocerebral resuscitation [CCR]) significantly improves OOHCA survival.[10–12] Despite these changes in resuscitation methods, survival rates generally remain poor.[13,14]

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To maximize the effects of MICR/CCR, further investigation of prehospital airway management in OOHCA patients should be conducted. Endotracheal intubation (ETI) has long been the "criterion standard" for the prehospital airway management of OOHCA patients. However, the efficacy of ETI as the standard for prehospital airway management has recently been challenged. Several studies have questioned the ability of paramedics to gain and maintain competency in the performance of ETI.[15,16] Yet many in the emergency medical services (EMS) community still believe that ETI should continue in the prehospital setting and consider it an essential paramedic skill.[17]

Out-of-hospital cardiac arrest patients comprise the majority of paramedic intubation attempts and also have the highest prehospital intubation success rates.[18] In the prehospital setting, the practice of early intubation still frequently occurs in OOHCA management.[18,19] This practice has continued despite the AHA's decreased emphasis on advanced airway management in cardiac arrest.[20,21] It has been recommended that intubation be delayed until after return of spontaneous circulation (ROSC) or at least three cycles of chest compressions have been completed during OOHCA resuscitation efforts.[11,12,19,22,23]

The performance of prehospital ETI has been shown to affect the overall management of OOHCA.[24–26] Studies suggest that the amount of time taken to perform ETI may lead to ineffective chest compressions with significant interruptions.[9,23,27] It has also been demonstrated that after ETI, unintentional hyperventilation increases intrathoracic pressures, resulting in decreased coronary and cerebral perfusion pressures.[28–30] Due to the potential complications of ETI during OOHCA, many have suggested that prehospital ETI in OOHCA should be limited or eliminated in favor of alternate airway devices.[23,27,31–33] In other patient populations, individuals managed with successful prehospital ETI have had worse patient outcomes than those managed by basic airway techniques.[16,26,27,34]

While ETI in the prehospital setting has been extensively studied, the benefit of prehospital ETI among OOHCA patients has not been fully examined. The objective of this study was to determine if prehospital ETI attempts performed on OOHCA patients were associated with ROSC and survival to hospital discharge.

METHODS

Study Design

This retrospective study used an existing registry of OOHCA within Mecklenburg County, North Carolina. This study was approved by the Carolinas Healthcare System and the Presbyterian Healthcare System Institutional Review Boards.

Study Setting and Population

The Mecklenburg EMS Agency (Medic) has tracked OOHCA using an Utstein-style cardiac arrest database since 2004. Cardiac arrests included in this study occurred during July 1, 2006, through December 31, 2008.

Individuals analyzed in this study were those who had nontraumatic cardiac arrest, defined as the absence of a pulse and lack of normal breathing, and had resuscitation efforts initiated by paramedics. Only adult (≥18 years) cardiac arrest patients were included in this analysis. Patients were excluded from the study if they were an interfacility transfer, drowning, or electrocution; had obvious signs of death (lividity, rigor mortis, etc.); or had a valid do not resuscitate order presented during resuscitation. Patients were also excluded if ETI was attempted, but the number of attempts until success or failure occurred was not reported.

Study Protocol

Medic is a third-service EMS agency serving a population of approximately 867,000 individuals in Mecklenburg County, with 630,400 of those individuals living in the City of Charlotte. Over the study period, average yearly call volume was 90,000, resulting in approximately 69,000 yearly patient transports. Patients may be transported to any of the seven area hospitals, including a single academic institution and a separate regional tertiary care facility. All ambulances are staffed with at least one paramedic and one basic emergency medical technician (EMT-B). First responders within the city and county are trained at the EMT-B level and have access to AEDs. Prehospital triage, treatment, and transport protocols are uniform within both the county and the city limits.

All data analyzed were collected after implementation of the 2005 AHA advanced cardiac life support guidelines. As such ETI was performed, depending on the algorithm, after 2 minutes of CPR, defibrillation (if indicated), and concurrently or after administration of epinephrine. Initiation of an ETI attempt was left to the discretion of the paramedic; no protocols were in place to dictate nonmedical contraindications to ETI, such as distance to hospital. Rapid sequence intubation was not available for any ETI attempt; however, paramedics were given the option to manage a failed ETI with either laryngeal mask airways or bag-valve mask ventilations. There were no substantial changes to the cardiac arrest protocol during the study period.

The main outcome variables for this analysis were sustained prehospital ROSC and survival to hospital discharge. Sustained prehospital ROSC was abstracted from EMS patient care report forms and defined as a return of pulses during the resuscitation that were still present at hospital arrival. Survival to hospital discharge was determined by reviewing hospital medical records. If discharge status or the medical record was unavailable or not located at the time of the analysis, the patient was conservatively classified as not surviving to hospital discharge. During the study period, neurologic status at time of discharge was not available.

The main independent variable of interest was the number of prehospital ETI attempts. According to Medic protocol, an ETI attempt was defined as performing an intubation procedure by inserting the laryngoscope into the mouth, past the anterior teeth. Patients were categorized as having a single successful ETI, a single unsuccessful ETI, a multiattempt successful ETI, a multiattempt unsuccessful ETI, or no

ETI attempt. The number of ETI attempts was abstracted from the prehospital report form, and multiple attempts were defined as more than one ETI attempt.

Other independent variables collected included demographics, initial cardiac arrest rhythm, witnessed arrest, presence of prearrival CPR, and discharge of an AED. The demographic variables collected were age (reported in years), sex (male or female), and race (nonwhite or white). Initial cardiac arrest rhythm, as documented by the paramedic, was categorized as shockable if either ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) was present or nonshockable for any other pulseless arrest rhythm. Each patient was classified as having an unwitnessed arrest, an arrest witnessed by family or bystander, or an arrest witnessed by first responders or EMS. Prearrival CPR and discharge of an AED were categorized as ''yes'' or ''no'' by the first arriving paramedic.

Data Analysis

Preliminary data analysis was conducted using descriptive statistics and univariate odds ratios (ORs). Descriptive analyses were performed to investigate potential associations between independent variables and the main outcome variables, ROSC, and survival to hospital discharge. Chi-square analyses and t-tests were used to determine initial significance where appropriate. Univariate ORs were calculated for each independent variable to assess its magnitude of effect on the outcome.

To further explore the relationships among independent variables and the two outcome variables, unconditional multivariable logistic regression was performed. There were two logistic regression models constructed separately for each outcome variable; however, the model building process was conducted identically for each outcome. Model building began with the variable ''ETI attempts'' as the initial independent variable in the model. An investigator-driven forward stepwise approach was then undertaken wherein other independent variables were added to the model one at a time. At each step, all remaining variables were assessed and the one with the lowest Wald p-value was added to the model. This process was repeated until variables failed to reach statistical significance at the 0.05 level.

Confounding was assessed by observing the effects of initially insignificant independent variables on the variable ETI attempts. A change in the OR of 10% in the ETI attempts variable was considered sufficient evidence to conclude confounding and the variable, regardless of its statistical significance, would remain in the model.[35] Upon completion of the main effects model, plausible interaction terms were created and effect modification was assessed. Only those interaction terms with a Wald p-value of ≤0.01 were added to the model. Model fit and discrimination was assessed using the Hosmer-Lemeshow goodness-of-fit test.[36] All data were abstracted from patient records and entered into Microsoft Excel (Redmond, WA). All statistical analyses were conducted using Stata v.10 (StataCorp, College Station, TX).

RESULTS

During the study period, there were 1,323 cardiac arrests in Mecklenburg County, North Carolina. After applying exclusion criteria, there were 1,142 (86.3%) patients included in the analytic data set. Figure 1 illustrates the number of individuals included in the study and categorization of the main independent variable of interest, prehospital ETI attempts. This figure further describes prehospital ETI attempts in relation to ROSC and survival to hospital discharge.

Table 1 includes the frequencies of independent variables for the total sample. The mean ± standard deviation age of study participants was 63.7 ± 16.8 years. A majority of individuals in the data set were male (697, 61.0%) and white (619, 54.2%). In this study, 302 individuals (26.5%) presented in VF/VT, and 146 of the arrests (12.8%) were witnessed by EMS or first responders.

There were 577 individuals (50.5%) who had successful ETI on the first attempt, and 292 (25.5%) received multiple ETI attempts, regardless of success. ETI was not performed on 203 individuals (17.8%). The occurrence of an ETI attempt was not associated with age, sex, race, presenting rhythm, or defibrillator usage. However, individuals experiencing OOHCA with prearrival CPR or witnessed by EMS or first responders were less likely to receive an intubation attempt.

Prehospital ROSC

Sustained prehospital ROSC was reported in 299 individuals (26.2%). Table 1 also presents frequencies of independent variables, unadjusted ORs, and 95% confidence intervals (CIs) for the occurrence of prehospital ROSC by each independent variable. In regard to ETI attempts, 45.3% of individuals with no ETI attempt had prehospital ROSC, while only 25.3% of individuals with one successful ETI attempt had ROSC. Initial analysis indicated that individuals with no ETI attempt were 2.44 (95% CI = 1.75 to 3.41) times more likely to experience prehospital ROSC than those individuals with one successful ETI attempt.

The final logistic regression model for prehospital ROSC included the variables initially presenting rhythm, witnessed arrest, sex, race, and ETI attempts (Table 2). This model demonstrated good fit (p = 0.82). Adjusted ORs, although attenuated, were similar to those found in the unadjusted analysis. Individuals who did not have ETI attempted were 2.33 (95% CI = 1.63 to 3.33) times more likely to have prehospital ROSC than those with one successful ETI attempt. This model controls for the other variables presented and indicates an OR of ROSC for those individuals with the lowest perceived likelihood of successful resuscitation. Also, regardless of success or failure, individuals who received more than one ETI attempt were less likely to have prehospital ROSC than those with one successful ETI attempt.

Discharge Status

Of the 299 individuals with prehospital ROSC, 118 (39.5%) were subsequently discharged alive from the hospital. There were 48 (16.0%) who had an unknown discharge status at the time of analysis and were

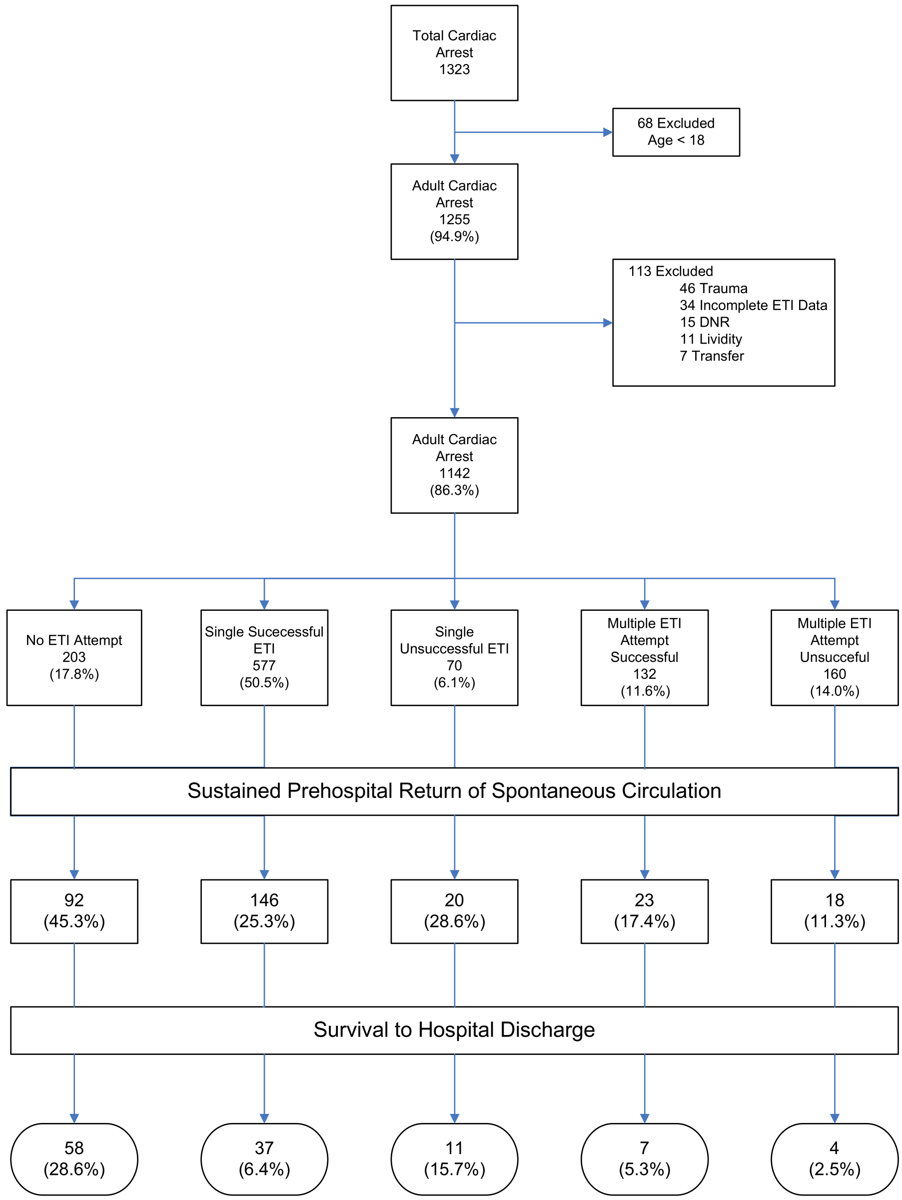

Figure 1. Exclusion criteria and categorization of ETI attempts by ROSC and survival to discharge. ETI = endotracheal intubation; ROSC = return of spontaneous circulation.

conservatively classified as not surviving to hospital discharge. Of those individuals with prehospital ROSC, 137 (45.8%) had an initial presenting rhythm of VF/VT, and 55 (18.3%) arrested in the presence of EMS or first responders. There were 146 individuals (48.8%) who had successful ETI on the first attempt, and 92 (30.8%) upon whom ETI was not performed.

Table 3 includes the frequencies of independent variables for individuals with prehospital ROSC by hospital discharge status and unadjusted ORs and 95% CIs for each independent variable. Similar associations were found among this cohort of individuals, compared to the entire study sample. Individuals with no ETI attempt were 4.96 (95% CI = 3.22 to 7.67) times more likely to be discharged from the hospital alive than those with one successful ETI attempt.

The final logistic regression model for discharge status displayed in Table 4 demonstrated good fit ($p = 0.89$). When controlling for the confounding variables presented in the model, those individuals with prehospital ROSC were 5.46 (95% CI = 3.36 to 8.90) times more likely to survive to discharge if they did not have a prehospital ETI attempt when compared to those with one successful ETI attempt.

DISCUSSION

Due to the multiple tasks that must be performed, the management of OOHCA remains one of the most complex scenes for an EMS professional. Early defibrillation and aggressive airway management, through ETI, have been two cornerstones of primary OOHCA interventions.[37] However, there is limited research exploring the effect that ETI attempts may have on OOHCA patients. In the prehospital setting, several studies have explored the efficacy of ETI in trauma and pediatric

Table 1
Descriptive Statistics and Unadjusted ORs or the Total Sample and by Sustained ROSC

Variable Name	Total Sample (Column %)	Non-ROSC OR (%)	ROSC OR (%)	Unadjusted OR (95% CI)
Presenting rhythm				
Non-VF/VT	840 (73.5)	678 (80.7)	162 (19.3)	Referent
VF/VT	302 (26.5)	165 (54.6)	137 (45.4)	3.47 (2.62–4.62)
Witnessed arrest				
No	390 (34.2)	325 (83.3)	65 (16.7)	Referent
Family/bystander	606 (53.0)	427 (70.5)	179 (29.5)	2.10 (1.52–2.88)
EMS/FR	146 (12.8)	91 (62.3)	55 (37.7)	3.02 (1.97–4.64)
Race				
Nonwhite	523 (45.8)	409 (78.2)	114 (21.8)	Referent
White	619 (54.2)	434 (70.1)	185 (29.9)	1.53 (1.17–2.00)
Sex				
Female	445 (39.0)	319 (71.7)	126 (28.3)	Referent
Male	697 (61.0)	524 (75.2)	173 (24.8)	0.84 (0.64–1.09)
Pre-arrival CPR				
No	298 (26.1)	219 (73.5)	79 (26.5)	Referent
Yes	844 (73.9)	624 (73.9)	220 (26.1)	0.98 (0.72–1.32)
Shock by AED				
No	953 (83.5)	737 (77.3)	216 (22.7)	Referent
Yes	189 (16.5)	106 (56.1)	83 (43.9)	2.67 (1.93–3.70)
Intubation				
One attempt with success	577 (50.5)	431 (74.7)	146 (25.3)	Referent
One attempt with failure	70 (6.1)	50 (71.4)	20 (28.6)	1.18 (0.68–2.05)
More than one attempt with success	132 (11.6)	109 (82.6)	23 (17.4)	0.62 (0.38–1.01)
More than one attempt with failure	160 (14.0)	142 (88.7)	18 (11.3)	0.37 (0.22–0.63)
No attempt	203 (17.8)	111 (54.7)	92 (45.3)	2.44 (1.75–3.41)

AED = automated external defibrillator; CPR = cardiopulmonary resuscitation; EMS/FR = emergency medical services/first responder; ROSC = return of spontaneous circulation; VF/VT = ventricular fibrillation/ventricular tachycardia.

Table 2
Logistic Regression Model for ROSC

Variable Name	OR (95% CI)
Presenting rhythm	
Non-VF/VT	Referent
VF/VT	3.25 (2.39–4.44)
Witnessed arrest	
No	Referent
Family/bystander	1.59 (1.13–2.25)
EMS/FR	2.08 (1.31–3.31)
Sex	
Female	Referent
Male	0.66 (0.49–0.89)
Race	
Nonwhite	Referent
White	1.39 (1.04–1.86)
Intubation	
One attempt with success	Referent
One attempt with failure	1.00 (0.56–1.80)
More than one attempt with success	0.60 (0.36–0.99)
More than one attempt with failure	0.40 (0.23–0.69)
No attempt	2.33 (1.63–3.33)

EMS/FR = emergency medical services/first responder; ROSC = return of spontaneous circulation; VF/VT = ventricular fibrillation/ventricular tachycardia.

patients.[38–42] These studies have suggested that prehospital ETI may lead to an increase in mortality in these specific patient populations, although their retrospective, nonrandomized designs do not permit evaluation of casuality. Results from the current study indicated that individuals experiencing OOHCA may be another subset of prehospital patients who experience increased mortality when receiving prehospital ETI.

It has been well documented that ETI is a complex psychomotor task and that prehospital providers have difficulty gaining and maintaining competency in this skill.[15] Prior research has indicated that prehospital ETI is a time-intensive task that may distract providers from performing important basic life support procedures during OOHCA.[16] It has been recommended that advanced airway procedures be delayed, with emphasis placed on minimally interrupted chest compressions. This strategy has been associated with improved resuscitation outcomes.[8–11] Research has also shown that hyperventilation can cause increased intrathoracic pressure, leading to decreased coronary and cerebral perfusion pressure among intubated OOHCA patients. The natural excitement inherent to OOHCA may prompt hyperventilation of the patient by prehospital personnel, especially when an endotracheal tube is appropriately placed.[28,29]

Orchestration and timing of procedures in OOHCA is typically the responsibility of the paramedic, who is also responsible for performing many critical and time-sensitive actions. Each procedure or task takes time, and performing each nearly simultaneously is difficult. Providing airway management for an OOHCA patient by means other than ETI may decrease the number of distractions that occur. Having a basic life support responder provide airway management with a bag-valve mask or alternative airway device may free the paramedic to supervise the overall resuscitation.

Table 3
Descriptive Statistics and Unadjusted ORs for Individuals With Sustained ROSC by Hospital Discharge Status

Variable Name	Not Discharged OR (%)	Discharged OR (%)	Unadjusted OR (95% CI)
Presenting rhythm			
Non-VF/VT	118 (72.8)	44 (27.2)	Referent
VF/VT	64 (46.7)	73 (53.3)	6.01 (4.06–8.91)
Witnessed arrest			
No	45 (69.2)	20 (30.8)	Referent
Family/bystander	107 (59.8)	72 (40.2)	2.73 (1.64–4.55)
EMS/FR	30 (54.5)	25 (45.4)	4.01 (2.16–7.44)
Race			
Nonwhite	67 (58.8)	47 (41.2)	Referent
White	115 (62.2)	70 (37.8)	1.39 (0.95–2.03)
Sex			
Female	80 (63.5)	46 (36.5)	Referent
Male	102 (59.0)	71 (41.0)	0.94 (0.64–1.37)
Prearrival CPR			
No	50 (63.3)	29 (36.7)	Referent
Yes	132 (60.0)	88 (40.0)	1.02 (0.66–1.56)
Shock by AED			
No	142 (65.7)	74 (34.3)	Referent
Yes	40 (48.2)	43 (51.8)	3.61 (2.41–5.41)
Intubation			
One attempt with success	109 (74.7)	37 (25.3)	Referent
One attempt with failure	9 (45.0)	11 (55.0)	2.31 (1.13–4.73)
More than one attempt with success	16 (69.6)	7 (30.4)	0.69 (0.31–1.58)
More than one attempt with failure	14 (77.8)	4 (22.2)	0.40 (0.15–1.03)
No attempt	34 (37.0)	58 (63.0)	4.96 (3.22–7.67)

AED = automated external defibrillator; CPR = cardiopulmonary resuscitation; EMS/FR = emergency medical services/first responder; ROSC = return of spontaneous circulation; VF/VT = ventricular fibrillation/ventricular tachycardia.

Table 4
Logistic Regression Model for Survival to Hospital Discharge

Variable Name	OR (95% CI)
Presenting rhythm	
Non-VF/VT	Referent
VF/VT	5.32 (3.41–8.31)
Witnessed arrest	
No	Referent
Family/bystander	1.81 (1.03–3.18)
EMS/FR	1.84 (0.91–3.69)
Sex	
Female	Referent
Male	0.59 (0.38–0.91)
Age	
5-year increase	0.90 (0.85–0.96)
Intubation	
One attempt with success	Referent
One attempt with failure	1.87 (0.87–4.02)
More than one attempt with success	0.68 (0.29–1.59)
More than one attempt with failure	0.40 (0.15–1.06)
No attempt	5.46 (3.36–8.90)

EMS/FR = emergency medical services/first responder; VF/VT = ventricular fibrillation/ventricular tachycardia.

The role of ETI in the prehospital setting has frequently been questioned. Further research should be conducted to better determine the effect ETI has on prehospital patients. While this study indicated that not performing ETI on OOHCA patients was associated with improved outcomes, causality of this association was not investigated. EMS systems interested in improving OOHCA care should further investigate their level of medical oversight, continuous quality improvement, and use of alternative airway devices. Further multicenter studies should be conducted to validate our results.

LIMITATIONS

This retrospective, single-center study contains several limitations involving the sample population and specific threats to the validity of the results. It is possible that the individuals with the highest likelihood of ROSC and survival to hospital discharge may have been those who received the timeliest care, experienced rapid ROSC, and were able to adequately manage their own airways. Only 28 patients had documented ROSC with adequate ventilations prior to EMS performing any advanced level interventions (other than defibrillation). Given the large ORs noted in the results, it appears unlikely that individuals with rapid response to treatments accounted for the entire noted measure of effect. Further, results are presented in the context of individuals with the poorest expected prognosis, e.g., unwitnessed arrest and initial rhythm other than VT/VF. No ETI attempt, even in this group, was associated with an increased likelihood for ROSC and survival compared to those with one successful ETI attempt.

It is possible that misclassification of the main exposure variable (ETI attempts) occurred, as this was a self-reported variable. This misclassification may be attributed to the paramedic's negative perception of multiple ETI attempts. It is unlikely that nonattempts or multiattempts were misreported. There was also no indication that exposure misclassification occurred to different degrees for each outcome. Most likely, nondifferential misclassification occurred, biasing results toward the null. Even if differential misclassification was present, estimated measures of effect were large enough that it was unlikely that bias accounted completely for these findings.

While this analysis was able to control for important confounders such as arrest rhythm, it may not be possible to generalize these results to all EMS systems. The definition of ETI attempt and multiple ETI attempt may differ in other systems. Finally, some outcome data from the hospitals were missing. Individuals with missing outcome data were conservatively coded as not surviving to discharge, which may have biased the results toward the null. A strength of this study was the use of an Utstein-style data collection template and limited changes in OOHCA protocols during the study period. Future research should be conducted to determine if these findings are applicable to other EMS systems.

CONCLUSIONS

Results from these analyses suggest that there is a negative association between prehospital endotracheal intubation attempts and survival from out-of-hospital cardiac arrest. In this study, the individuals most likely to have prehospital return of spontaneous circulation and survival to hospital discharge were those who did not have a reported endotracheal intubation attempt. Individuals experiencing out-of-hospital cardiac arrest may be another subset of prehospital patients who experience increased mortality when receiving prehospital endotracheal intubation. Further research should be conducted to better determine the effect endotracheal intubation has on prehospital patients.

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