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Airway Insertion First Pass Success and Patient Outcomes in Adult Out-of-Hospital Cardiac Arrest: The Pragmatic Airway Resuscitation Trial

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Abstract

OBJECTIVE: While emphasized in clinical practice, the association between advanced airway insertion first-pass success (FPS) and patient outcomes is incompletely understood. We sought to determine the association of airway insertion FPS with adult out-of-hospital cardiac arrest (OHCA) outcomes in the Pragmatic Airway Resuscitation Trial (PART).

METHODS: We performed a secondary analysis of PART, a multicenter clinical trial comparing LT and ETI upon adult OHCA outcomes. We defined FPS as successful LT insertion or ETI on the first attempt as reported by EMS personnel. We examined the outcomes return of spontaneous circulation (ROSC), 72-hour survival, hospital survival, and hospital survival with favorable neurologic status (Modified Rankin Scale ≤3). Using multivariable GEE (generalized estimating equations), we determined the association between FPS and OHCA outcomes, adjusting for age, sex, witnessed arrest, bystander CPR, initial rhythm, and initial airway type.

RESULTS: Of 3,004 patients enrolled in the trial, 1,423 received LT, 1,227 received ETI, 354 received bag-valve-mask ventilation only. FPS was: LT 86.2% and ETI 46.7%. FPS was associated with increased ROSC (aOR 1.23; 95%CI: 1.07–1.41)), but not 72-hour survival (1.22; 0.94–1.58), hospital survival (0.90; 0.68–1.19) or hospital survival with favorable neurologic status (0.66; 0.37–1.19).

CONCLUSION: In adult OHCA, airway insertion FPS was associated with increased ROSC but not other OHCA outcomes. The influence of airway insertion FPS upon OHCA outcomes is unclear.

Keywords

cardiopulmonary arrest; airway management; intubation (intratracheal); emergency medical services

INTRODUCTION

Advanced airway techniques such as endotracheal intubation (ETI) and supraglottic airway (SGA) insertion are often used in the resuscitation of critically ill patients. Clinical guidelines emphasize the importance of first-pass success (FPS) when performing ETI.[1, 2] Studies of Emergency Department ETI have associated multiple intubations with increased rates of adverse events including hypoxemia, regurgitation, bradycardia and cardiac arrest.[3–6]

The Pragmatic Airway Resuscitation Trial (PART) was a cluster randomized clinical trial evaluating the effect of different airway management strategies (initial King laryngeal tube (LT) vs initial ETI).[7] PART found that 72-hour survival, ROSC, hospital survival, and hospital survival with good neurologic status were better with a strategy of initial-LT than initial-ETI. An important secondary observation of the trial was the difference in FPS between the intervention groups: 86.2% for LT compared with 46.7% for ETI. While prior studies highlight the frequency of multiple ETI attempts in OHCA, the relationship between FPS and OHCA outcomes is less well understood.[8]

In this study we sought to determine the association between FPS and OHCA outcomes in PART.

METHODS

Design and Setting

We conducted a secondary *post hoc* analysis of data from PART. The Institutional Review Boards of the participating institutions approved the parent PART study under federal rules for conduct of emergency research under Exception from Informed Consent (21 CFR 50.24).

The trial methods for PART were previously reported.[7, 9] The trial included 27 EMS agencies associated with Birmingham (Alabama), Dallas-Fort Worth, Milwaukee, Pittsburgh and Portland sites of the Resuscitation Outcomes Consortium. Agency annual 911 responses ranged from 1,200 to 125,000. The agencies operated a range of care configurations, including advanced life support (ALS) units only (n=4 agencies), basic life support (BLS) unit only (n=3), and both ALS and BLS units (n=19). Population settings included urban (n=2 agencies), suburban (n=7), rural (n=1), combined urban/suburban (n=14), and combined urban/suburban/rural (n=3). BLS personnel used LT in 18 agencies.

Patient selection

For this analysis, we included all subjects enrolled in the parent PART. Specific inclusion criteria for the trial included adult OHCA ≥18 years (or per local interpretation) requiring advanced airway management or bag-valve-mask (BVM) ventilation. Key exclusion criteria included patients <18 years, pregnant women, prisoners, traumatic cardiac arrest, and the initial presence of a non-study advanced EMS unit. The trial enrolled patients from December 1, 2015 through November 4, 2017.

Interventions and Exposures

The parent PART used cluster randomization with crossover. The 27 EMS agencies were organized by 13 randomization clusters and alternated airway intervention assignments at 3–5 month intervals. All other aspects of airway management and resuscitation care followed local protocol.

The primary exposure in this analysis was first-pass airway insertion success (FPS). EMS personnel reported the number of attempts and outcomes for each airway device used on the patient case. For ETI, an airway attempt was defined as a single insertion of the laryngoscope blade into the patient's mouth. For LT, an airway insertion attempt consisted of passage of the tube past the patient's teeth. We defined FPS as cases with successful airway placement and one reported attempt. Airway placement success for each attempt was based upon EMS personnel reports. We did not use independent techniques to confirm first or subsequent airway insertion success.

Outcomes

As defined by the parent trial, the present analysis focused on the primary outcome of 72-hour survival after the index arrest. The parent PART used this outcome because of its pragmatic focus and limited resources. Key secondary outcomes of the parent trial and current analysis were a) return of spontaneous circulation (ROSC – defined as the presence of palpable pulses upon ED arrival), b) hospital survival, and c) hospital survival with favorable neurologic status (Modified Rankin Score ≤ 3). EMS personnel reported all out-of-hospital endpoints. Study personnel ascertained other endpoints through the review of hospital records.

Data Analysis

We determined the association between FPS and OHCA outcome on an as-treated basis, including only patients who received LT or ETI attempts, and excluding those who received BVM (or other airway techniques) only. We fit a generalized estimating equations model (GEE) with FPS as the primary independent variable and 72-hour survival as the primary outcome. Consistent with the parent trial, we used GEE to account for clustering by the 13 randomization clusters defined for the trial. We adjusted the model by airway type (LT vs. ETI), age, sex, witnessed arrest, bystander CPR, initial ECG rhythm. We did not adjust for trial randomization assignment (initial-LT vs initial-ETI) because of the high likelihood of collinearity with airway type. We repeated the analysis modeling ROSC, hospital survival and hospital survival with favorable neurologic status as dependent variables. Since FPS may have varied by airway type, we separately tested the [FPS X airway type (LT vs. ETI)] multiplicative interactions.

We conducted all analyses using SAS 9.4 (SAS, Cary, North Carolina).

RESULTS

The parent trial enrolled 3,004 patients, including 1,352 randomized to receive initial-LT and 1,298 initial-ETI. (Figure 1) We excluded 354 patients who received only BVM ventilation as well as 5 LT and 3 ETI without outcomes, leaving 1,418 LT and 1,224 in the final analysis.

The number of insertion attempts was higher for ETI than LT. (Table 1) First-pass LT and ETI insertion success were 86.2% and 46.7%, respectively. LT and ETI overall airway success (initial + rescue airway attempts) were 98.2% and 94.5%. LT FPS was less likely among EMS witnessed arrests. (Table 2) In the ETI group, FPS was less likely among males but more likely among EMS witnessed arrests and those with a shockable rhythm.

Airway insertion FPS was not associated with 72-hour survival (adjusted OR 1.22; 95% CI: 0.94 – 1.58) (Table 3, Appendix). However, FPS was positively associated with ROSC (adjusted OR 1.23; 95% CI: 1.07 – 1.41). FPS was not associated with hospital survival to discharge (adjusted OR 0.90; 95% CI: 0.68 to 1.19) or hospital survival to discharge with favorable neurologic status (adjusted OR 0.66; 95% CI: 0.37 to 1.19). The [FPS X airway type] interaction was not significant for the outcomes of 72-hour survival (p=0.24), ROSC (p=0.86), hospital survival (p=0.08), or hospital survival with favorable neurologic status (p=0.14).

DISCUSSION

The present analysis provides important insights complementing the primary findings of PART. We observed that FPS was independently associated with slightly increased odds of ROSC. However, FPS was not associated with more definitive outcomes such as 72-hour survival, hospital survival, or hospital survival with favorable neurologic status. The [FPS X airway] multiplicative interactions were not statistically significant, suggesting that connection between FPS and ROSC was not strictly due to the type of airway used.

The findings of this secondary analysis are somewhat surprising given the wide differences in FPS rates observed between LT (86.2%) and ETI (46.7%). In the parent trial, LT was associated with statistically significant improvements in ROSC, 72-hour survival (the primary endpoint), hospital survival and hospital survival with favorable neurologic status. Many experts have pointed to this difference as a potential explanation for the outcome differences between LT and ETI.[10] However, our current findings contradict this assumption and point to other potential explanatory factors. For example, chest compression quality (fraction, rate, depth) and ventilation are linked to OHCA outcomes; our formal evaluations of chest compression and ventilation quality differences between and airway strategies in the PART trial are in progress.[11–14] Different airway strategies may have influenced drug administration, but we previously observed no difference in epinephrine timing between ETI and LT.[15]

Prior studies describe out-of-hospital ETI FPS rates ranging from 46.4% to 77.2%.[8, 16–18] In the Airways-2 trial (a clinical trial comparing OHCA intubation with i-gel insertion by EMS agencies in the United Kingdom), 79% of the intubations were completed in 2 or fewer attempts.[19] Assuming that the association between FPS and ROSC is clinically important, the best strategies for achieving FPS are not clear. ETI is inherently difficult and paramedics often struggle to gain adequate procedural experience; thus, it is not surprising that EMS personnel may require multiple attempts to achieve successful tracheal placement.[20] Using a review of CPR video recordings, Kim, et al. suggest that at least 137 ETI would be required for an operator to achieve the skill needed to intubate a cardiac arrest patient with a 90% FPS rate in less than 60 seconds; to achieve FPS in 30 seconds would require 243 ETI.[21] Driver, et al. demonstrated that use of the gum elastic bougie improved FPS in Emergency Department intubations, but the effect of bougie upon out-of-hospital FPS is unknown.[22]

Video laryngoscopy (VL) is associated with higher FPS, decreased duration, and shorter chest compression interruptions than DL in both in-hospital and out-of-hospital cardiac arrest.[23, 24] While many EMS practitioners and systems use supraglottic airway insertion to optimize first airway FPS, in this analysis the [FPS X Airway Type] interaction was not statistically significant, suggesting that any association between FPS and OHCA outcomes was not a function of the airway type.[25]

There are limitations to our study. EMS personnel in PART reported airway insertion success patterns. The FPS success rates observed in the trial are lower than those from prior reports.[26] If EMS personnel over-reported FPS, this may have amplified the observed associations with outcomes and mediating effects. We were not able to examine chest compression or ventilation patterns since CPR quality data which was collected for some of the PART subjects has not yet been analyzed. We did not have information on the airway management protocols, training protocols, or practice patterns across the participating agencies; the number and pattern of airway insertion attempts may have been influence by variations in local practice. We do not know whether EMS personnel were intubating during ongoing CPR or pauses, we do not have data on the skill levels of providers or number of providers on scene. We do not have information on the airway training practices of EMS agencies. FPS may be a proxy for EMS agency or practitioner skill. We did not adjust for variations in hospital based resuscitation care.

We observed associations between FPS and ROSC, but not 72-hour survival, hospital survival or hospital survival with good neurologic status. The parent PART was powered to detect differences in 72-hour survival. With a larger sample size we may have observed associations between FPS and 72-hour survival, hospital survival, or hospital survival with good neurologic status. However, given the opposing directions of the odds ratios between FPS and ROSC, 72-hour survival, hospital survival and hospital survival with favorable neurologic status, it is unlikely that a larger series would yield different results.

CONCLUSION

In conclusion, in adult OHCA patients enrolled in the PART trial, airway insertion FPS was associated with increased ROSC but not 72-hour survival, hospital survival or hospital survival with favorable neurologic status. The influence of airway insertion FPS upon OHCA outcomes is unclear.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Conflicts of Interest:

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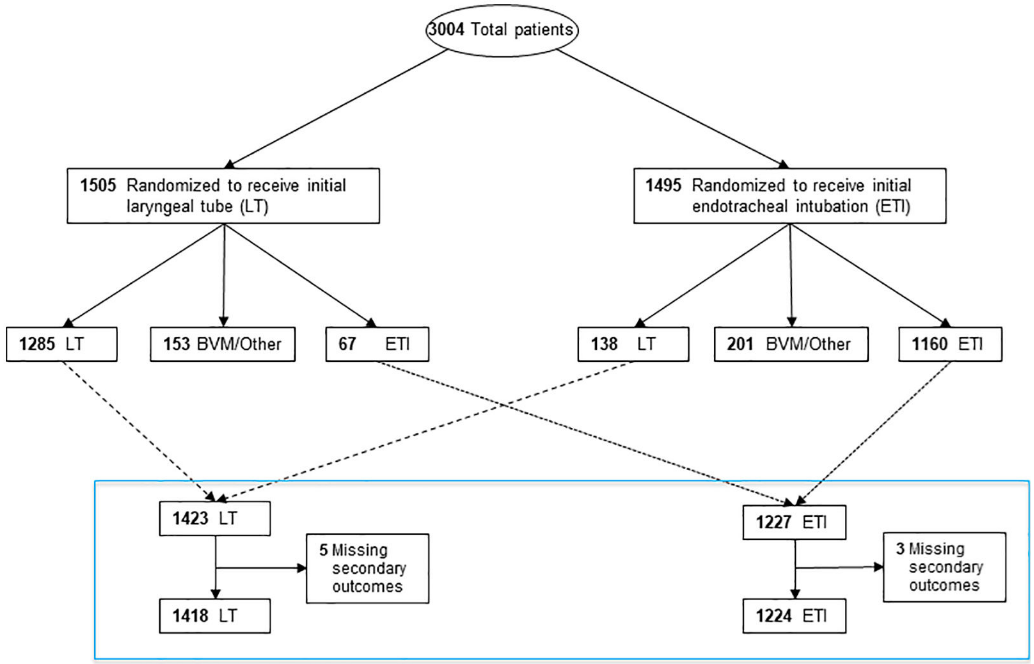

Fig. 1 –. As-treated analytic groups.

TABLE 1.

Airway insertion success and numbers of insertion attempts. Cases classified according to the first airway device (LT or ETI) used. Excludes cases where only bag-valve-mask or another airway was used.

Number of Attempts	Laryngeal Tube (n= 1,418)	Endotracheal Intubation (n=1,224)
1	1,328 (93.7%)	977 (79.8%)
2	83 (5.9%)	230 (18.8%)
3	5 (0.4%)	15 (1.2%)
4	2 (0.1%)	2 (0.2%)
First Pass Success *	86.2%	46.7%
Overall Airway Success †	98.2%	94.5%

*Successful airway placement with only one reported attempt

†Successful placement of any airway device (initial + rescue)

TABLE 2

Characteristics of the study population. FPS=First pass success.

Characteristic	Laryngeal Tube (n= 1,418)			Endotracheal Intubation (n=1,224)		
	FPS+ (*N* = 1222) N (col %)	FPS− (*N* = 196) N (col %)	Total N (col %)	FPS+ (*N* = 572) N (col %)	FPS− (*N* = 652) N (col %)	Total N (col %)
Age, years – median (IQR)	64 (53–75)	64 (52–78)	64 (53–76)	67 (57–77)	63 (52–73.5)	64 (53.5–76)
Male, n / N [%]	769 (62.9)	112 (57.1)	881 (62.1)	313 (54.7)	425 (65.2)	738 (60.3)
Witnessed arrest, n / N [%]						
EMS witnessed	122 (10.0)	30 (15.3)	152 (10.7)	71 (12.4)	65 (10.0)	136 (11.1)
Bystander witnessed	415 (34.0)	54 (27.6)	469 (33.1)	209 (36.5)	233 (35.7)	442 (36.1)
Not witnessed	685 (56.1)	112 (57.1)	797 (56.2)	292 (51.1)	354 (54.3)	646 (52.8)
Bystander chest compressions, n / N [%]						
Yes	569 (46.6)	90 (45.9)	659 (46.5)	271 (47.4)	308 (47.2)	579 (47.3)
No	477 (39.0)	68 (34.7)	545 (38.4)	216 (37.8)	255 (39.1)	471 (38.5)
Unknown	176 (14.4)	38 (19.4)	214 (15.1)	85 (14.9)	89 (13.7)	174 (14.2)
First rhythm						
Shockable	222 (18.2)	26 (13.3)	248 (17.5)	107 (18.7)	107 (16.4)	214 (17.5)
Non-shockable	989 (80.9)	168 (85.7)	1157 (81.6)	454 (79.4)	539 (82.7)	993 (81.1)
Missing	11 (0.9)	2 (1.5)	13 (0.9)	11 (19)	6 (0.9)	17 (1.4)
Randomization Assignment						
LT	1097 (89.8)	183 (93.4)	1280 (90.3)	35 (6.1)	32 (4.9)	67 (5.5)
ETI	125 (10.2)	13 (6.6)	138 (9.7)	537 (93.9)	620 (95.1)	1157 (94.5)
ROSC	445 (36.4)	61 (31.1)	506 (35.7)	208 (36.4)	200 (30.7)	408 (33.3)
72-hour Survival	194 (15.9)	28 (14.3)	222 (15.7)	88 (15.4)	77 (11.8)	165 (13.5)
Hospital Survival	86 (7.0)	19 (9.7)	105 (7.4)	40 (7.0)	35 (5.4)	75 (6.1)
Hospital Survival with Favorable Neurologic Status	47 (3.9)	13 (6.6)	60 (4.2)	20 (3.5)	21 (3.2)	41 (3.3)

TABLE 3

Analysis 1. Associations between first-pass airway insertion success and patient outcomes.

Outcome	Unadjusted OR (95% CI)	Adjusted* OR (95% CI)
72-hour Survival	**1.32 (1.02 – 1.71)**	1.22 (0.94 – 1.58)
ROSC	**1.29 (1.11 – 1.49)**	**1.23 (1.07 – 1.41)**
Hospital Survival	1.11 (0.92 – 1.33)	0.90 (0.68 – 1.19)
Hospital Survival with Favorable Neurologic Status	0.93 (0.61 – 1.41)	0.66 (0.37 – 1.19)

n=2,642 patients.

*OR adjusted for airway type, age, sex, witnessed arrest, bystander CPR and initial rhythm,.

Patients (n=2) with unknown sex were excluded from the analysis.