Prehospital Intubations and Mortality: A Level 1 Trauma Center Perspective

Miguel A. Cobas, MD*

Maria Alejandra De la Peña, MD*

Ronald Manning, RN, MSPH†

Keith Candiotti, MD*

Albert J. Varon, MD*

BACKGROUND: Ryder Trauma Center is a Level 1 trauma center with approximately 3800 emergency admissions per year. In this study, we sought to determine the incidence of failed prehospital intubations (PHI), its correlation with hospital mortality, and possible risk factors associated with PHI.

METHODS: A prospective observational study was conducted evaluating trauma patients who had emergency prehospital airway management and were admitted during the period between August 2003 and June 2006. The PHI was considered a failure if the initial assessment determined improper placement of the endotracheal tube or if alternative airway management devices were used as a rescue measure after intubation was attempted.

RESULTS: One-thousand-three-hundred-twenty patients had emergency airway interventions performed by an anesthesiologist upon arrival at the trauma center. Of those, 203 had been initially intubated in the field by emergency medical services personnel, with 74 of 203 (36%) surviving to discharge. When evaluating the success of the intubation, 63 of 203 (31%) met the criteria for failed PHI, all of them requiring intubation, with only 18 of 63 (29%) surviving to discharge. These patients had rescue airway management provided either via Combitube® ($n = 28$), Laryngeal Mask Airway® ($n = 6$), or a cricothyroidotomy ($n = 4$). An additional 25 of 63 patients (12%) had unrecognized esophageal intubations discovered upon the initial airway assessment performed on arrival. We found no difference in mortality between those patients who were properly intubated and those who were not. Several other variables, including age, gender, weight, mechanism of injury, presence of facial injuries, and emergency medical services were not correlated with an increased incidence of failed intubations.

CONCLUSION: This prospective study showed a 31% incidence of failed PHI in a large metropolitan trauma center. We found no difference in mortality between patients who were properly intubated and those who were not, supporting the use of bag-valve-mask as an adequate method of airway management for critically ill trauma patients in whom intubation cannot be achieved promptly in the prehospital setting.

(Anesth Analg 2009;109:489–93)

Control of the airway is the first priority for the management of critically ill patients and is prioritized in established patient-management algorithms, such as Advanced Cardiac Life Support and Advanced Trauma Life Support. Although tracheal intubation is recommended as a definitive airway management, prehospital medical personnel perform this procedure infrequently in the United States and abroad,[1,2] and the effects of prehospital intubation (PHI) on patient mortality remain poorly defined.

There is a continuing debate regarding PHI and its effect on patient outcomes. Data in trauma patients are inconclusive. Several studies suggest that this procedure is beneficial, especially in patients with impending respiratory compromise.[3–6] Other recent trials suggest that there is an increased risk of adverse outcomes in trauma patients intubated in the field when compared with those managed with bag-valve-mask (BVM) ventilation followed by intubation in the emergency department. PHI may unnecessarily prolong the time spent at the scene,[7–9] and some of the controversy lies in the fact that multiple failed attempts before conversion to alternative devices for airway management increase the odds for complications, such as esophageal and bronchial intubation.[10] The placement of the airway devices also has been associated with complications,[11] including aspiration of gastric contents, laryngospasm, esophageal trauma, lacerations, and hematomas.[12]

The aim of this study was to determine the incidence of failed PHI and its correlation with hospital mortality

From the *Department of Anesthesiology, Perioperative Medicine, and Pain Management, and †DeWitt Daughtry Family Department of Surgery, Miller School of Medicine, University of Miami, Miami, Florida.

Accepted for publication February 25, 2009.

Address correspondence and reprint requests to Miguel Cobas, MD, Department of Anesthesiology, University of Miami, 1400 NW 12th Ave., Suite 3155, Miami, FL 33136. Address e-mail to mcobas@med.miami.edu.

DOI: 10.1213/ane.0b013e3181aa3063

in a Level 1 trauma center. We postulated that failure to intubate the trachea in the prehospital setting would translate into increased mortality when compared with those patients who were successfully intubated.

METHODS

After IRB approval, the Trauma Anesthesia Service at the Ryder Trauma Center/Jackson Memorial Hospital conducted this study between August 2003 and June 2006. This freestanding and certified Level 1 trauma center, with approximately 3800 emergency admissions per year, serves a population of more than three million people from the city of Miami and surrounding communities.

During the study period, trauma patients were initially treated in the prehospital setting by fire rescue personnel of various municipalities and with different experience levels; typically, the fire rescue personnel trained as paramedics perform an average of 1–3 tracheal intubations per year and must undergo periodic assessments of their training and ability in airway management and intubation skills.

Paramedics from the City of Miami Fire Rescue are trained to use BVM, endotracheal intubation (ETI), and Combitube®. The initial protocol for airway management is the use of BVM. ETI is indicated when the patient is unable to maintain adequate ventilation due to trauma, unconsciousness, decreased Glasgow coma scale (GCS) score, and respiratory or cardiac arrest. After two ETI attempts, placement of a Combitube is considered as a rescue airway measure. All procedures need to be confirmed by physical examination and end-tidal CO_2 assessment. On the other hand, the paramedic team from the Metro Dade County EMS uses only BVM and ETI for airway management. In both paramedic groups, when intubation is not possible ventilation is assisted with BVM ventilation. Cricothyroidotomy is an extreme measure for airway rescue and is indicated only in unconscious patients with complete airway obstruction.

For this study, members of the Department of Anesthesiology assessed the airways of patients at their admission to the trauma bay. We defined prehospital airway management as paramedics having had an active role in managing the patient's airway through a variety of approaches, including ETI, laryngeal mask airway (LMA®), and Combitube and/or cricothyroidotomy. We defined a failed PHI as the improper localization of an endotracheal tube (ETT) on arrival at the trauma center or the need to use alternative rescue devices for airway management after intubation attempts.

Additional demographic and outcome data of the patients were collected from the medical records department. All patients who had prehospital airway management had a data collection sheet completed by the anesthesia team on call.

Our primary end points were:

1. The incidence of improperly placed ETTs.
2. The incidence of hospital mortality in patients who had prehospital airway management but were not successfully intubated versus mortality in those who were properly intubated.

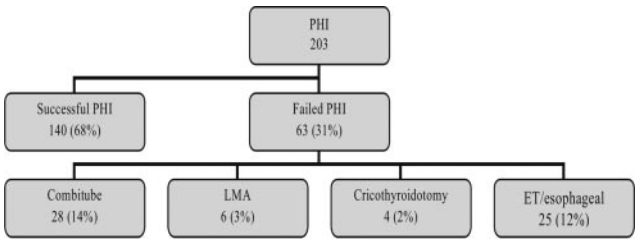

Figure 1. Prehospital airway management: success and failure diagram.

Our secondary end point was to determine the correlation of prospectively defined risk factors and their association with failed PHI.

Groups were compared using the χ^2 test for a difference in proportions and *t*-test for a difference in means. Data were analyzed using the NCSS 2004/PASS2005 statistical software package (NCSS Statistical Software, Kaysville, UT). A level of significance of $P \leq 0.05$ was used.

RESULTS

During the study period, 1320 patients had emergency airway interventions performed by an anesthesiologist upon arrival at the trauma center, and 1117 patients were intubated after arrival. Two-hundred three patients (15%) had prehospital airway management. Of those, 140 (69%) were successfully intubated in the field and 63 (31%) arrived either with an ETT in the esophagus or with an alternative airway device in place. Thirty-eight of the 63 failed field intubations had Combitube ($n = 28$, 14% of all the prehospital interventions), LMA ($n = 6$, 3%), or cricothyroidotomy ($n = 4$, 2%), defined as the insertion of an ETT or airway cannula through the cricothyroid membrane. The remaining 25 (12%) failed PHIs had unrecognized esophageal intubations, discovered upon initial airway assessment. All of these 63 patients were eventually intubated, with only 18 (29%) surviving to discharge (Fig. 1).

This study cohort was predominantly male (73%), with a mean age of 42 ± 20 years. The mean Injury Severity Score was 40 (±19). The mean GCS score, both in the field and upon hospital arrival, was 4. The majority of these patients were victims of blunt trauma (78%; Table 1).

Of the 203 patients with PHI, 129 patients (64%) died. When stratified by successful or failed ETT, the hospital mortality was 71% in the failed PHI group versus 60% in the successful PHI group, but this difference was not statistically significant ($P = 0.11$; Table 2). In subgroup analyses, those with a Combitube had the highest mortality ($n = 22$, 79%), followed by patients with esophageal intubations ($n = 17$, 68%),

Table 1. Prehospital Intubation: Demographics

	Successful intubation	Failed intubation	*P*
Age	40 ± 21	42.0 ± 20	0.95
Gender	105 (74%) M	43 (68%) M	0.37
	35 (26%) F	20 (32%) F	
Facial trauma	75 (54%)	33 (52%)	0.74
GCS on scene	4 ± 3	4 ± 3	0.27
GCS on admission to trauma center	4 ± 3	4 ± 2	0.5
Mechanism	29 (21%) penetrating	8 (13%) penetrating	0.39
	106 (76%) blunt	53 (84%) blunt	
	5 (3%) burns	2 (3%) burns	
ISS	40 ± 19	41 ± 18	0.52

GCS = Glasgow coma scale; ISS = injury severity score.

Table 2. Successful PHI Versus Failed PHI Groups and Relation with Mortality

	Live *N* (%)	Dead *N* (%)	Total
Successful PHI	56 (40)	84 (60)	140
Failed PHI	18 (29)	45 (71)	63
LMA	2 (33)	4 (66)	6
Combitube	6 (21)	22 (79)	28
Cricothyroidotomy	2 (50)	2 (50)	4
Esophageal intubation	8 (32)	17 (68)	25
	74	129	203

PHI = prehospital intubation; LMA = Laryngeal Mask Airway®.

LMA ($n = 4$, 67%), and finally cricothyroidotomy ($n = 2$, 50%). A total of 129 patients died; 67 of these died within 15 min and were considered dead on arrival (DOA), representing 52% of the dead patients. Of the group of patients who were successfully intubated in the field ($n = 140$), 37 (26%) were DOA. Of all the patients who had failed intubations ($n = 63$), 30 (48%) were DOA. This is a significant difference (Table 3).

One of our findings is the existence of a statistically significant relationship between type of transportation (air versus ground) and successful PHI. Of the 203 patients, 115 (57%) were transported by air, and within that group, 94 (82%) were properly intubated in the field, and 21(18%) were not. Of the 88 patients who were transported by ground, 46 (52%) were successfully intubated in the prehospital setting and 42 (48%) had a failed PHI ($P < 0.001$ compared with patients transported by air). When evaluating the relationship between mode of transportation and successful PHI, 94 of the 140 successfully intubated patients (67%) were transported by air and 46 of 140 (33%) by ground. Conversely, of the 63 patients with failed PHI, 21 (33%) were transported by air and 42 (67%) by ground.

DISCUSSION

Prehospital endotracheal airway control continues to be the main principle emphasized in the care of severely injured patients. Nevertheless, the timing, benefit, and relationship with outcome have not been fully determined. In fact, multiple studies, encompassing trauma and nontrauma patients[3,4,6,7,13–16] as well as adult and pediatric[8,9] populations, have demonstrated conflicting results. Most of the data in the literature rely on retrospective and descriptive studies, because randomization and standardization of the intervention is practically impossible to achieve.

The first parameter we identified in this study was the incidence of patients arriving at our facility without a properly placed ETT. At 31%, our incidence is within the range of other recent studies performed in the United States[8–10] but considerably higher than most of the data coming from Europe.[10,17,18] This difference may be attributed to many variables, including type of personnel, training, experience, and injury severity. In Europe, studies have reported successful prehospital ETI rates of 90%–100%.[1,7,10,17,19,20] In Europe, most prehospital ETI are performed by trained anesthesiologists and emergency room physicians, who perform this procedure in various settings.

Studies from the United States, where most of the emergency medical system is staffed by paramedics, have reported success rates ranging from 86% to 90%.[21–23] However, when ETI is performed by rescuers who do not often perform the procedure, the success rates have been as low as 50%.[24] It is important to consider that paramedics typically have an average of 6–10 ETIs during their training and routinely perform fewer than five ETIs per year when working in the field.[2]

The results obtained suggest that paramedics with less exposure to a difficult procedure, such as intubation, will likely have more difficulty performing it, increasing the incidence of failure. These findings pose an interesting dilemma: should we try to emphasize teaching and improve training to providers who rarely practice this procedure in the field or, on the contrary, place more restrictions on performing intubations in the prehospital setting? With this study, we have shown that the quality of airway management in the field has to be improved, and some of that improvement can be accomplished through better education and more frequent evaluations.

The significant difference we found in the success of PHI performed in connection with air (67%) and ground transport (33%; $P < 0.001$) may reflect the deployment to aerial units of paramedics with more

Table 3. Prehospital Intubation: Risk Factors

Distribution by intubation		Success	Failure	*P*
N	203	140 (69)	63 (31)	0.32
Age (yr)	42 ± 20	40 ± 21	42 ± 20	0.95
Height (cm)	171 ± 9	171 ± 9	170 ± 9	0.27
Weight (kg)	77 ± 18	78 ± 19	75 ± 17	0.24
	Gender			0.37
Male	148 (73)	105 (74)	43 (68)	
Female	55 (27)	35 (26)	20 (32)	
	Mechanism of injury			0.39
Blunt	159 (78)	106 (76)	53 (84)	
Penetrating	37 (18)	29 (21)	8 (13)	
Burn	7 (3)	5 (3)	2 (3)	
Facial trauma	108 (36)	75 (54)	33 (52)	0.74
Neck	15 (5)	8 (6)	7 (11)	0.19
Head	177 (59)	117 (84)	60 (95)	**0.045**
GCS prehospital	4 ± 3	4 ± 3	4 ± 3	0.27
GCS on arrival	4 ± 2	4 ± 3	4 ± 2	0.5
	ISS			
Mean	40 ± 19	40 ± 19	41 ± 18	0.52
0–15	15 (7)	14 (10)	1 (2)	0.075
16–25	38 (19)	24 (17)	14 (23)	
>25	150 (74)	103 (73)	47 (75)	
	Transport			**<0.001**
Air	115 (57)	94 (67)	21 (33)	
Ground	88 (43)	46 (33)	42 (67)	
	Mortality			0.11
Lived	74 (36)	56 (40)	18 (29)	
Died	129 (64)	84 (60)	45 (71)	
DOA	67 (52)	37 (26)	30 (48)	**0.005**
	Airway			
ETT	165 (80)	140 (100)	25 (40)	
LMA	6 (3)	NA	6 (10)	
Combitube	28 (14)	NA	28 (44)	
Cricothyroidotomy	4 (2)	NA	4 (6)	

The values given are in *N* (%).

Bold numbers signify statistical significance.

GCS = Glasgow coma scale; ISS = injury severity score; ETT = endotracheal tube; LMA = Laryngeal Mask Airway®; DOA = dead on arrival.

experience and skills, including intubation, because it is usually a promotion from the ground units. Although this study did not correlate intubation skills of individual paramedics, data from Germany, where air rescue crews perform ETI three times as frequently as ground crews,[1] support this. Therefore, clinical experience of those performing the intubation is invaluable and perhaps the most important piece of the PHI puzzle.

Another point worth mentioning is that only air rescue crews are authorized to use succinylcholine, which is a safety precaution due to the potentially catastrophic consequences of having an agitated patient inside the aircraft. Therefore, the low incidence of failed intubations by air compared with ground may also be due in part to the fact that airlifted patients had more checks and verifications than those transported by ground, because the former were potential candidates for paralysis and failure to identify proper intubation in this group would translate into death.

The second question we investigated was whether there is an increase in mortality in those patients who were not successfully intubated or in whom rescue airway devices were used. All of the patients who needed prehospital airway management were, as expected, very sick, with high-injury severity scores and low-GCS scores, and their overall mortality was more than 50%. The groups were comparable in their baseline characteristics, and there was no significant difference in mortality between them. The relative risk of death was 18% greater in the group of patients who were not properly intubated; however, the difference was not statistically significant.

The failed intubation group was composed of four subgroups such as unrecognized esophageal intubation, Combitube, LMA, and cricothyroidotomy. Unrecognized esophageal intubation is a clinical disaster with potentially devastating consequences. In this study, 25 (12% of all patients with field airway interventions) patients were found to have the ETT in the esophagus upon arrival at the trauma center, and 17 (68%) of these patients died. It is interesting to see that our incidence of esophageal intubation is consistent with the results of larger studies.[2,9] The percentage who survived must be explained by the existence of other means of oxygenation despite improper placement of the ETT, such as spontaneous ventilation or hypopharyngeal migration of the tube.

We found the highest mortality ($n = 22$, 79%) in the 28 patients who came with a Combitube. Different studies[11,12,25,26] have shown contradictory results with the use of Combitube, and as supraglottic devices like the LMA are becoming more popular, expertise in and the need for the Combitube has decreased in recent times, perhaps leading to more complications in an emergency situation. Patients who had a cricothyroidotomy performed in the prehospital setting had a mortality rate of 50%. With this procedure, complications, such as bleeding, barotrauma, and laryngotracheal injuries, may occur.[27]

The reasons for our findings have yet to be determined. There are plausible explanations: inability to intubate the patient may be associated with increased time spent at the scene, which in turn consumes valuable transportation time. Performing several attempts at intubation may be deleterious by creating hemodynamic disturbances while increasing the periods of hypoxia during attempts. Furthermore, mortality can be increased in patients with PHI when they are subject to repeated doses of sedative drugs used to facilitate ETI.

The limitations of this study include its observational and descriptive nature. The patients' airways were assessed upon arrival at the trauma center; the exact circumstances surrounding the interventions were not known. The study is also limited by the lack of reliable data on oxygenation and ventilation, which precludes any correlative analysis of these variables with the various forms of airway management described.

This prospective study showed a 31% incidence of failed PHI on arrival at a large metropolitan trauma center. We found no difference in mortality between those patients who were properly intubated and those who were not, supporting the use of BVM as an adequate method of airway management in critically ill trauma patients in whom intubation cannot be achieved promptly in the prehospital setting.

REFERENCES

1. Gries A, Zink W, Bernhard M, Messelken M, Schlechtriemen T. Realistic assessment of the physician-staffed emergency services in Germany. Anaesthesist 2006;55:1080–6
2. Johnston BD, Seitz SR, Wang HE. Limited opportunities for paramedic student endotracheal intubation training in the operating room. Acad Emerg Med 2006;13:1051–5
3. Bushby N, Fitzgerald M, Cameron P, Marasco S, Bystrzycki A, Rosenfeld JV, Bailey M. Prehospital intubation and chest decompression is associated with unexpected survival in major thoracic blunt trauma. Emerg Med Australas 2005;17:443–9
4. Davis D, Fisher R. Is there added benefit to prehospital intubation over noninvasive airway maneuvers? Acad Emerg Med 2005;12:163
5. Arbabi S, Jurkovich GJ, Wahl WL, Franklin GA, Hemmila MR, Taheri PA, Maier RV. A comparison of prehospital and hospital data in trauma patients. J Trauma 2004;56:1029–32
6. Winchell RJ, Hoyt DB. Endotracheal intubation in the field improves survival in patients with severe head injury. Arch Surg 1997;132:592–7
7. Murray JA, Demetriades D, Berne TV, Stratton SJ, Cryer HG, Bongard F, Fleming A, Gaspard D. Prehospital intubation in patients with severe head injury. J Trauma 2000;49:1065–70
8. Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, Poore PD, McCollough MD, Henderson DP, Pratt FD, Seidel JS. Effect of out of hospital pediatric endotracheal intubation on survival and neurological outcome. JAMA 2000;283:783–90
9. Cooper A, DiScala C, Foltin G, Tunik M, Markenson D, Welborn C. Prehospital endotracheal intubation for severe head injury in children: a reappraisal. Semin Pediatr Med 2001;10:3–6
10. Timmermann A, Russo SG, Eich C, Roessler M, Braun U, Rosenblatt WH, Quintel M. The out-of-hospital esophageal and endobronchial intubations performed by emergency physicians. Anesth Analgesia 2007;104:619–23
11. Calkins TR, Miller K, Langdorf MI. Success and complication rates with prehospital placement of an esophageal-tracheal combitube as a rescue airway. Prehosp Disaster Med 2006;21:97–100
12. Vezina MC, Trepanier CA, Nicole PC, Lessard MR. Complications associated with esophageal tracheal combitube in the prehospital setting. Can J Anaesth 2007;54:124–8
13. Davis DP, Peay J, Sise MJ, Vilke GM, Kennedy F, Eastman AB, Velky T, Hoyt DB. The impact of prehospital endotracheal intubation on outcome in moderate to severe traumatic brain injury. J Trauma 2005;58:933–9
14. Sloane C, Vilke GM, Chan TC, Hayden SR, Hoyt DB, Rosen P. Rapid sequence intubation in the field versus hospital in trauma patients. J Emerg Med 2000;19:259–64
15. Eckstein M, Chan L, Scheneir A, Palmer R. Effect of prehospital advanced life support on outcomes of major trauma patients. J Trauma 2000;48:643–8
16. Stockinger ZT, McSwain NE. Prehospital endotracheal intubation for trauma does not improve survival over bag-valve-mask ventilation. J Trauma 2004;56:531–6
17. Timmermann A, Eich C, Russo SG, Natge U, Brauer A, Rosenblatt WH, Braun U. Prehospital airway management: a prospective evaluation of anesthesia trained emergency physicians. Resuscitation 2006;70:179–85
18. Combes X, Jabre P, Jbeili C, Leroux B, Bastuji-Garin S, Margenet A, Adnet F, Dhonneur G. Prehospital standarization of medical airway management: incidence and risk factors of difficult airway. Acad Emerg Med 2006;13:828–34
19. Helm M, Hossfeld B, Schafer S, Hoitz J, Lampl L. Factors influencing emergency intubation in the pre-hospital setting. A multicenter study in German Helicopter Emergency Medical Service. Br J Anaesth 2006;96:67–71
20. Mackay CA, Terris J, Coats TJ. Prehospital rapid sequence intubation by emergency physicians: is it safe? Emerg Med J 2001;18:20–4
21. Rocca B, Crosby E, Maloney J, Bryson G. An assessment of paramedic performance during invasive airway management. Prehosp Emerg Care 2000;4:164–7
22. Wang HE, Sweeney TA, O'Connor RE, Rubinstein H. Failed prehospital intubations: an analysis of emergency department courses and outcomes Prehosp Emerg Care 2001;5:134–41
23. Hagberg C, Georgi R, Krier C. Complications of managing the airway. Best Pract Res Clin Anaesthesiol 2005;19:641–59
24. Stewart RD, Paris PM, Winter PM, Pelton GH, Cannon GM. Field endotracheal intubation by paramedical personnel. Success rates and complications. Chest 2005;3:341–5
25. Wirtz DD, Ortiz C, Newman DH, Zhitomirsky I. Unrecognized misplacement of endotracheal tubes by ground prehospital providers. Prehosp Emerg Care 2007;11:213–8
26. Davis DP, Valentine C, Ochs M, Vilke GM, Hoyt DB. The Combitube as a salvage airway device for paramedic rapid sequence intubation. Ann Emerg Med 2003;42:697–704
27. Scrase I, Woollard M. Needle vs. surgical cricothyroidotomy: a short cut to effective ventilation. Anesthesia 2006;61:962–74