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Selected Topics: Prehospital Care

AN ANALYSIS OF ADVANCED PREHOSPITAL AIRWAY MANAGEMENT

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□ **Abstract—Considerable controversy persists regarding the optimal means and indications for airway management, the utility of paralytic agents to facilitate intubation, and the indications for advanced airway access techniques in the prehospital setting. To describe the use of intubation and advanced airway management in a system with extensive experience with both the use of paralytic agents and surgical airway techniques, a retrospective review was conducted of all prehospital airway procedures from January 1997 through November 1999. Data collected included demographics, airway management techniques, use of paralytic agents, and immediate outcome. The results showed there were 2700 patients intubated out of 50,118 patient encounters (5.4%). The indications for intubation included medical emergency in 82% of patients and traumatic injury in 18%. Fifty percent of patients were intubated with the use of succinylcholine. The overall oral intubation success rate was 98.4% and definitive airway access was achieved in all but 12 patients (0.6%), with 30 patients receiving surgical airway access (1%). The successful intubation rate for patients receiving paralytic agents was 97.8%. Previously published rates of prehospital surgical airway access range from 3.8 to 14.9% of patients. In this study, only 1.1% of patients required a surgical airway. We attribute this low rate to the use of paralytic agents. The availability of paralytic agents also allows expansion of the indications for prehospital airway control. © 2002 Elsevier Science Inc.**

□ **Keywords—endotracheal intubation; neuromuscular blocking agents; succinylcholine; prehospital; paramedic**

INTRODUCTION

Airway management is arguably the most critical intervention for prehospital providers. The advantages of definitive airway management include: airway protection, improved oxygenation and ventilation, provision of a route for drug administration, access for removal of foreign bodies and tracheal suctioning, and the ability to sense changes in lung compliance (1,2). Oral endotracheal intubation is widely considered the current standard for prehospital airway management. It is both successful and safe in the hands of appropriately trained prehospital personnel. Previous reports demonstrate successful prehospital intubation rates ranging from 75 to 96.6% and complication rates from 5 to 13% (2–10).

However, controversy persists regarding the role of prehospital intubation in certain patient groups, and the use of paralytic agents to facilitate intubation. A national survey in 1992 reported use of field paralytics by fewer than 1% of Advanced Life Support (ALS) systems surveyed (13). Previous reports of prehospital intubation success rates are limited, as the majority were conducted in systems that preclude the prehospital use of paralytic agents. The lack of paralytic agents limits the indications for oral intubation to patients either in cardiac arrest or those comatose with minimal or absent airway reflexes.

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Nasotracheal intubation is used in some systems for patients with spontaneous respirations, but has demonstrated a lower success rate than oral intubation, and is limited in the setting of head and neck trauma or patient combativeness (12). Several nonapneic patient populations will likely benefit from early airway intervention, including those with head injury, multisystem trauma, respiratory distress with hypoxia, drug overdose, anaphylaxis, burn injury with smoke inhalation, near drowning events, massive hemoptysis or hematemesis, and other unstable medical conditions. A recent report questions the benefit of prehospital intubation in pediatric patients. This study is limited, however, by both the inexperience of the paramedics involved and the absence of paralytic agents (11).

Furthermore, there remain patients with 'difficult airway access' who cannot be successfully orally or nasally intubated, with or without the use of paralytic agents. These patients require advanced airway access techniques, which in our system include needle cricothyrotomy, surgical cricothyrotomy, or retrograde intubation. These have not achieved widespread acceptance because of limited experience and concerns regarding potential complications. The national survey in 1992 reported that percutaneous surgical airways were permitted in 48% of urban Emergency Medical Services (EMS) systems and open surgical access allowed in only 2% (13).

The purpose of the current study was to review prehospital airway management in a system with extensive experience with the use of both paralytic agents and advanced surgical airway techniques. The paramedics in our city have been trained in the use of paralytic agents since 1970 and open surgical airway access since 1975. We sought to catalog the indications for prehospital intubation in this setting and to define the need for surgical airway access when paralytic agents are available.

MATERIALS AND METHODS

Prehospital records were retrospectively reviewed for all patients requiring intubation by the Seattle Fire Department Medic One program from January 1997 through November 1999, $n = 2700$. This time period corresponded to the establishment of a complete computerized database maintained by the Seattle Fire Department. Institutional Review Board approval was obtained from the University of Washington before study implementation. Records were selected from a database maintained by the Fire Department regarding all medic responses during this time period. The database was searched for all patients undergoing a prehospital airway procedure, as well as those receiving succinycholine without intubation, suggesting that intubation attempts were unsuccessful. Individual hospital records were also reviewed for the subset of patients who could not be intubated by the conventional oral endotracheal route and, thus, required prehospital surgical airway accesses. We refer to this subset as 'difficult airway' patients.

The paramedics of this program have been trained both in the use of paralytic agents and surgical airway access techniques, including surgical cricothyrotomy, and needle cricothyrotomy, for more than 20 years. Equipment and training for retrograde intubation has been available for 3 years. Retrograde intubation involves needle access to the airway from the anterior neck with subsequent retrograde passage of a wire through the needle and out the oropharynx to be used to guide the passage of an endotracheal tube (14).

All paramedics undergo yearly in-service training in these procedures and are under strict physician direction. Standard policy is that each of two paramedics makes two attempts at endotracheal intubation before proceeding to advanced airway techniques. The use of paralytic agents is at the discretion of the on-line physician providing medical control, but are generally used for all patients who are spontaneously breathing. The standard agent is succinylcholine administered as an IV dose of 1 to 2 mg/kg. Alert patients are premedicated with a combination of morphine and diazepam before the administration of succinylcholine. Nasotracheal intubation is discouraged in our system and thus rarely used.

Statistical analysis included the use of the χ^2 test for categorical data and the Student's t test for continuous data. Significance was defined as a $p \leq 0.05$.

RESULTS

Review of Prehospital Intubation Experience

There were 2700 patients intubated out of 50,118 paramedic patient encounters during this 3-year time period, for an intubation rate of 5.4%. Complete prehospital airway management data were available for 2614 patients. The mean age of the population was 57 years, range 0 to 104 years. There were 75 patients under the age of 18 (2.8%) and 54 under the age of 10 (2%). Sixty-two percent of the population was male, 38% female. The primary indications for intubation included: medical emergency in 82% of patients (2152/2614) and traumatic or burn injury in 18% (462/2614). A detailed summary of the injury or illness of the population can be found in Table 1. Thirty-six percent of patients (947/2614) were in cardiac arrest at the time of intubation. Immediate mortality was determined by status at the time

Table 1. Medical Condition Requiring Intubation

Injury/Illness	#Patients	%
Traumatic injury	450	17%
Burn/smoke inhalation	12	<1%
Cardiovascular emergency	1086	42%
Respiratory compromise/distress	293	11%
Neurologic event	393	15%
Abdominal/GI bleeding	32	1%
Endocrine (diabetic coma)	11	<1%
Pediatric (medical)	9	<1%
Psychiatric	17	<1%
Cardiac arrest: noncardiac origin	40	1.5%
Other medical event	60	2%
Unknown	72	3%

of medic release. This information was available for 2456 patients of whom 669 (27%) were dead at the time of medic release.

The overall oral intubation success rate was 98.4%. A summary of the airway management for this population is shown in Table 2. The successful oral endotracheal intubation rate for the subgroup of patients receiving paralytic agents was 97.8%. Surgical cricothyrotomy was used in 22 patients, needle cricothyrotomy in 6, and 2 patients had an initial needle cricothyrotomy that required conversion to an open technique. Three patients had attempts at retrograde intubation, all of which required conversion to an open cricothyrotomy. All patients who had attempted surgical airway access had definitive airway control achieved in the field. All patients requiring these advanced airway techniques were adults. All children (age $<$ 18 years) in this cohort were successfully intubated by the oral endotracheal route.

In total, there were 42 patients meeting the 'difficult airway' criteria, for an incidence of 1.6%. Definitive airway access was achieved in all but 12 patients (0.6%). These 12 patients received paralytics without achieving airway access. Of these, 5 were the result of medical emergencies, 3 were the result of traumatic injury, 2 overdoses, 1 burn injury, and 1 psychiatric disorder. All were transported to the hospital with bag-valve-mask ventilation and no attempt at surgical airway access. Two patients had received cardiopulmonary resuscitation (CPR) prior to paramedic arrival and these patients were both dead at the time of medic release. There were no other immediate deaths. The causes of death for these 2 patients were penetrating injury to the chest and hypertensive crisis with cerebellar hemorrhage. Neither death was judged to be airway related. Hospital records for Emergency Department (ED) airway management were available for 6 of the 12 patients. These six patients had oxygen saturation on hospital arrival ranging from 93 to 100% and all had successful airway access in the ED, five by oral intubation and one by surgical cricothyrotomy.

Table 2. Airway Management

Procedure	# Patients	%
Endotracheal intubation without succinylcholine	1308	50%
Endotracheal intubation with succinylcholine	1264	48.4%
Surgical cricothyrotomy	22	0.8%
Needle cricothyrotomy	6	0.3%
Both needle and surgical cricothyrotomy	2	0.08%
Received succinylcholine, airway access not obtained	12	0.6%

Fifty percent of patients were intubated with the use of succinylcholine. Comparison of those patients who received succinylcholine versus those who did not is shown in Table 3. Patients in the paralytic group were significantly younger and more likely to be female. The rate of paralytic use was 70% of intubations in trauma patients, 73% of intubations for overdose, and 40% for medical and cardiac emergencies. Seventy-three percent of the patients who did not receive succinylcholine were in cardiac arrest at the time of intubation, with an immediate mortality of 49%. Trauma patients accounted for 25% of those receiving succinylcholine, but only 17.5% of the entire population. Overall, 21% of the cohort received medication for sedation, which included a combination of morphine and diazepam. Of those receiving succinylcholine, 33% (410/1293) received sedation. Among those not receiving succinylcholine, 9.6% (127/1321) received sedating medications, which may have facilitated intubation.

There were 30 patients who had surgical airway access. The surgical airway access rate was 1.1% (30/2614). The mean age of this group was 62 $\pm$ 22 years, range 18 to 99 years. Seventy percent were male. The mechanisms of injury or illness for these patients are shown in Table 4. Twenty-five patients had a variety of medical emergencies, 10 of whom were in cardiac arrest. There were four trauma patients, of whom three were pedestrians struck by cars and one with a fall from significant height. Twelve of the 30 patients (40%) received paralytic agents. Immediate mortality was 11/30 patients (37%) as defined by status at the time of medic release.

DISCUSSION

Definitive control of the airway is a basic tenent of all resuscitation protocols for critically ill and injured patients. Both the ACLS and ATLS guidelines emphasize the importance of ensuring adequate ventilation and ox-

Table 3. Use of Paralytic Agents

	Succinylcholine	No succinylcholine	p
Demographics			
N	1293	1321	
Mean age (yrs)	54 ± 23	60 ± 21	<0.0001
%male	58%	66%	<0.0001
Cardiac arrest	7.6%	73%	<0.0001
Immediate mortality	3%	49%	<0.0001
Mechanism			
Trauma	321 (25%)	136 (10%)	
Overdose	225 (17%)	80 (6%)	
Medical	743 (58%)	1094 (84%)	
Unknown	4	11	

ygenation along with airway protection from aspiration. It follows that this standard of care should apply to the earliest care providers to encounter the patient, provided they have adequate training in airway management techniques. Our data, along with those of several previous studies, demonstrate that paramedics can perform the skills of advanced airway management with excellent results. Our study demonstrates successful oral endotracheal intubation in 98.4% of patients and definitive airway control in 99.4%. Factors that may contribute to this excellent success rate include: in depth paramedic training, strict physician control, the use of paralytic agents to facilitate intubation, and advanced airway access techniques.

Previous studies of prehospital intubation, without the use of paralytic agents, have demonstrated that the primary reasons for intubation failure were combativeness and masseter muscle spasm (2,10). Doran et al. reported an oral intubation success rate of 88%, with increasing level of consciousness directly correlated with decreasing success rates (10). Among those patients not in cardiac arrest, 23% of those who could not be intubated were a result of combativeness or trismus. The use of paralytic agents would likely have eliminated these problems. Similarly, in a report of all prehospital intubations for noncardiac arrest patients, the successful intubation rate was 75% with the leading cause for unsuccessful intubation reported to be altered level of consciousness resulting in combativeness (2).

Table 4. Mechanism of Injury or Illness for Patients Requiring Advanced Airway Access

Illness or Injury	# Patients
Medical	25
Cardiac arrest: presumed cardiac etiology	9
Cardiac arrest: noncardiac	1
Respiratory arrest	1
Suspected myocardial infection	4
Coma/decreased level of consciousness	2
Hypotension/shock	2
Seizure	1
Hypertensive crisis	1
Drug overdose	1
Other illness	2
Trauma	4
Pedestrian struck by car	3
Fall from height	1
Unknown	1

Our data are consistent with previous studies of prehospital paralytic use that have demonstrated successful intubation rates of 92 to 98% (9,15-17). Hedges et al. reported that the use of succinylcholine in 61% of patients not in cardiac arrest facilitated prehospital intubation. They found no difference in the incidence of aspiration between those patients who received paralytics and those who did not. No surgical airways were required in their series. Wayne et al. reported on 1,657 patients who had received prehospital succinycholine over a 20-year period with an aspiration rate of 13%. Ninety percent of the aspiration events occurred before the administration of paralytic agents. These two series are also notable, as they describe paralytic use by paramedics as opposed to flight nurses or physicians as was the case in most early reports (15,18-20). In a series of trauma patients reported by Syverud et al., 54% had failed intubation attempts before the administration of paralytic agents. The successful intubation rate with paralytic agents was 96% (15). In addition, a recent report demonstrated an increase in intubation success rates from 66.7% to 90.5% after the introduction of paralytic agents to an aeromedical program (21).

Several authors have proposed that blind nasotracheal intubation be considered as an alternative to oral endotracheal intubation for the awake patient, to avoid the need for paralytic agents (2,12,18,22). Several concerns have been raised, however, particularly regarding the use of this technique in trauma patients (19). These include: the frequent need to flex the neck for adequate tube placement, thus compromising cervical spine alignment; the risk of bleeding from the nasopharynx; increased risk

of vomiting leading to aspiration; greater risk of increasing intracranial hypertension; the risk of aggravating existing craniofacial injuries; and direct central nervous system (CNS) injury because of disruption of bony integrity. A recent study by Rhee and O'Malley comparing nasotracheal intubation to neuromuscular blockade-assisted oral intubation in trauma patients demonstrated no difference in the success rates between the two techniques. However, their success rates were lower than other series at 76 versus 79%, respectively (18). Another series of blind nasotracheal intubation also demonstrated low success rates of 66.7% for trauma and 72.2% for medical patients (12). Given the oral endotracheal intubation success rates of 97 to 98% with the use of paralytic agents, the rates of successful airway management using nasotracheal intubation appear unacceptably low (17).

Despite the frequent use of paralytic agents to facilitate emergent in-hospital intubations, and the previous reports of successful use in the field, there remains considerable controversy regarding their use in the prehospital setting. A primary concern has been that use of these agents in patients with difficult airway access would lead to loss of spontaneous ventilation in patients who may not be able to be successfully intubated using conventional techniques. This implies that paramedics trained in the use of paralytic agents also must be trained in bag-mask ventilation and the use of advanced airway access techniques, including surgical cricothyrotomy. Several previous studies, in systems that do not allow the use of paralytic agents, have demonstrated the successful use of these techniques in the prehospital setting (23-27). The rate of surgical airway access in these series ranges from 3.8 to 14.9% of all prehospital intubation attempts, prompting some authors to suggest that prehospital surgical airway access is too frequent (27,28). Our data suggest that the addition of paralytic agents to facilitate endotracheal intubation may actually decrease the need for surgical airway access. This is supported by the low rate of surgical airway access of 1.1% in our series. Fewer than 1% of patients receiving paralytic agents failed to have an airway established.

The role of prehospital intubation in pediatric and trauma patients has been questioned. A recently completed prospective, randomized trial of prehospital pediatric endotracheal intubation versus bag-valve-mask ventilation reported an intubation success rate of 57% with a 14% rate of tube dislodgement and a 2% rate of esophageal intubation. These authors demonstrated no difference in mortality, neurologic outcome, or aspiration rates between the groups and thus concluded that prehospital endotracheal intubation is not beneficial (11). The primary limitation to this study, however, is the inexperience of the care providers. The paramedics involved had no prior experience with the intubation of children and had only six hours of training before the onset of the study. Furthermore, this training involved skills sessions with mannequins alone, without operating room (OR) experience. Paralytic agents were also not used in this study.

A recent meta-analysis has also questioned the advantages of prehospital advanced life support (ALS) for the management of trauma patients (29). The primary concern is that ALS procedures prolong scene times, and thus, delay transport to definitive surgical therapy. These authors acknowledge, however, that prehospital intubation of trauma patients has been associated with 'decreased neurologic damage attributable to prevention of asphyxia and hypoxia.' Furthermore, a recent study of head injured patients demonstrated a significant reduction in mortality associated with prehospital intubation for all patients, from 36% to 26%, and for those with a Glasgow coma score (GCS) of 8 or less, mortality decreased from 57% to 36% (30). Furthermore, patients injured in rural areas, who require a prolonged transport time, may show a greater benefit from definitive airway control. One report of 12,417 trauma deaths in a rural state revealed a significantly lower per capita death rate among counties with ALS services versus counties with only BLS service (31).

The key elements involved in maintaining standards for airway management are ongoing training and medical supervision. A recent report of endotracheal intubation in a decentralized, urban EMS system without consistent medical control or specialized airway training and no requirements for maintenance of certification, demonstrated a dismal 25% rate of improperly placed endotracheal tubes (32). The paramedics in our program have had over 3000 h of advanced medical training. Airway management training includes initial didactic sessions coupled with mannequin experience. This is followed by OR intubations under the direction of an attending anesthesiologist and animal laboratory experience with needle and surgical cricothyrotomy. Ongoing training to maintain these skills is provided on a quarterly basis and access to the OR is maintained to update skills. Paramedics are required to perform a minimum of 12 intubations per year and to attend an animal laboratory for surgical airway access once every 2 years. If the minimum number of intubations is not met, then a return for OR training is mandatory. Recently, training also has been introduced for the technique of retrograde intubation. At the time of data collection for this study, experience with this technique was limited.

As a result of the extensive experience and high success rates in our system, we have a broad range of indications for prehospital intubation. These include: all major trauma cases with hemodynamic instability; neu-

rologic evidence of closed head injury with a GCS ≤ 8 or combativeness; near-drowning cases with respiratory distress or altered level of consciousness; burn or hazardous material exposure with airway compromise; medical emergencies with unstable hemodynamics; significant hemoptysis or hematemesis; significant respiratory distress secondary to chronic obstructive pulmonary disease or asthma; and drug or toxin overdose with decreased level of consciousness. Paramedics may intubate cardiac arrest patients before contacting medical control. They obtain on-line physician permission for all other intubations and the use of paralytic agents. Capnography is available in the medic unit to monitor end tidal carbon dioxide (CO_2) and confirm tube placement. Pharmacologic agents available to facilitate intubation include succinylcholine, pancuronium, morphine, and diazepam. The primary agent used for intubation is succinylcholine with the addition of morphine and diazepam for pain control and sedation. Pancuronium is only used when a longer acting agent is required for patient protection. IV lidocaine is administered before intubation for patients with suspected closed head injury to attenuate changes in intracranial pressure.

The major limitation to this study is the retrospective nature of the review. Evaluation of airway management was dependent on the documentation of the event, which may be incomplete. We do not have any record of the number of intubation attempts made per patient. Failure of the paramedic to indicate intubation attempts that may have been unsuccessful could lead to an underestimation of difficult airway problems. Scene times for the different techniques also were not available, so we cannot comment on any potential delay to definitive care. Because of the transportation of patients to 14 area hospitals, we were unable to obtain long term outcome data to include in this study. This limits our ability to assess safety, as some complications, such as unrecognized esophageal intubation, may be missed and we cannot determine the neurologic status of the survivors. As a result, we are currently enrolling patients in a prospective study to evaluate outcome and complication rates for those patients requiring advanced airway management techniques.

In summary, our data support the use of paralytic agents to facilitate oral endotracheal intubation in the prehospital setting. The use of paralytic agents is likely at least partially responsible for the low rate of surgical airway access, and allows oral intubation to be performed effectively in patients who are not in cardiac arrest or coma. This allows expansion of the indications for intubation to a larger number of critically ill or injured patients, who may benefit from airway protection and improved oxygenation and ventilation. Further prospective, randomized trials of the impact of prehospital intubation on outcome and the use of paralytic agents to facilitate intubation are clearly needed. These studies should be conducted in EMS systems with appropriately trained, experienced prehospital personnel who have an established record of proficiency with the procedure. Like any technical procedure, intubation and surgical airway access are skills that require judgment, experience, and practice. We believe this report represents the results of one urban ALS paramedic system that has had appropriate skills training, to demonstrate excellent results in the use of paralytic agents and surgical airway techniques to achieve definitive airway control.

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REFERENCES

1. Pepe PE, Copass MK, Joyce TH. Prehospital endotracheal intubation: rationale for training emergency medical personnel. Ann Emerg Med 1985;14:1085-92.
2. Krisanda TJ, Eitel DR, Hess D, et al. An analysis of invasive airway management in a suburban emergency medical services system. Prehospital Disaster Med 1992;7:121-6.
3. Stewart RD, Paris PM, Winter PM, Pelton GH, Cannon GM. Field endotracheal intubation by paramedical personnel. Success rates and complications. Chest 1984;85:341-5.
4. Jacobs LM, Berrizbeitia LD, Bennett B, Madigan C. Endotracheal intubation in the prehospital phase of emergency medical care. JAMA 1983;250:2175-7.
5. Pointer JE. Clinical characteristics of paramedics' performance of endotracheal intubation. J Emerg Med 1988;6:505-9.
6. Pointer JE. Clinical characteristics of paramedics' performance of pediatric endotracheal intubation. Am J Emerg Med 1989;7:364-6.
7. Losek JD, Bonadio WA, Walsh-Kelly C, et al. Prehospital pediatric endotracheal intubation performance review. Pediatr Emerg Care 1989;5:1-4.
8. DeLeo BC. Endotracheal intubation by rescue squad personnel. Heart Lung 1977;6:851-4.
9. Wayne MA, Friedland E. Prehospital use of succinylcholine: a 20-year review. Prehosp Emerg Care 1999;3:107-9.
10. Doran JV, Tortella BJ, Drivet WJ, Lavery RF. Factors influencing successful intubation in the prehospital setting. Prehospital Disaster Med 1995;10:259-64.
11. Gausche M, Lewis RJ, Stratton SJ, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. JAMA 2000;283:783-90.
12. O'Brien DJ, Danzl DF, Hooker EA, Daniel LM, Dolan MC. Prehospital blind nasotracheal intubation by paramedics. Ann Emerg Med 1989;18:612-7.
13. Lavery RF, Dora J, Tortella BJ, Cody RP. A survey of advanced life support practices in the United States. Prehospital Disaster Med 1992;7:144-50.
14. Lau HP, Yip KM, Liu CC. Rapid airway access by modified retrograde intubation. J Formos Med Assoc 1996;95:347-9.
15. Syverud SA, Borron SW, Storer DL, et al. Prehospital use of neuromuscular blocking agents in a helicopter ambulance program. Ann Emerg Med 1988;17:236-42.
16. Hedges JR, Dronen SC, Feero S, et al. Succinylcholine-assisted intubations in prehospital care. Ann Emerg Med 1988;17:469-72.
17. Sloane C, Vilke GM, Chan TC, et al. Rapid sequence intubation in the field versus hospital in trauma patients. J Emerg Med 2000; 19:259-64.

18. Rhee KJ, O'Malley RJ. Neuromuscular blockade-assisted oral intubation versus nasotracheal intubation in the prehospital care of injured patients. Ann Emerg Med 1994;23:37-42.
19. Ligier B, Buchman TG, Breslow MJ, Deutschman CS. The role of anesthetic induction agents and neuromuscular blockade in the endotracheal intubation of trauma victims. Surg Gynecol Obstet 1991;173:477-81.
20. Roberts DJ, Clinton JE, Ruiz E. Neuromuscular blockade for critical patients in the emergency department. Ann Emerg Med 1986;15:152-6.
21. Ma OJ, Atchley RB, Hatley T, et al. Intubation success rates improve for an air medical program after implementing the use of neuromuscular blocking agents. Am J Emerg Med 1998;16:125-7.
22. O'Brien DJ, Danzl DF, Sowers MB, Hooker EA. Airway management of aeromedically transported trauma patients. J Emerg Med 1988;6:49-54.
23. Jacobson LE, Gomez GA, Sobieray RJ, et al. Surgical cricothyroidotomy in trauma patients: analysis of its use by paramedics in the field. J Trauma 1996;41:15-20.
24. Miklus RM, Elliott C, Snow N. Surgical cricothyrotomy in the field: experience of a helicopter transport team. J Trauma 1989; 29:506-8.
25. Spaite DW, Joseph M. Prehospital cricothyrotomy: an investigation of indications, technique, complications, and patient outcome. Ann Emerg Med 1990;19:279-85.
26. Boyle MF, Hatton D, Sheets C. Surgical cricothyrotomy performed by air ambulance flight nurses: a 5-year experience. J Emerg Med 1993;11:41-5.
27. Fortune JB, Judkins DG, Scanzaroli D, McLeod KB, Johnson SB. Efficacy of prehospital surgical cricothyrotomy in trauma patients. J Trauma 1997;42:832-6:discussion 7-8.
28. Gerich TG, Schmidt U, Hubrich V, Lobenhoffer HP, Tscherne H. Prehospital airway management in the acutely injured patient: the role of surgical cricothyrotomy revisited. J Trauma 1998;45:312-4.
29. Liberman M, Mulder D, Sampalis J. Advanced or basic life support for trauma: meta-analysis and critical review of the literature. J Trauma 2000;49:584-99.
30. Winchell RJ, Hoyt DB. Endotracheal intubation in the field improves survival in patients with severe head injury. Trauma Research and Education Foundation of San Diego. Arch Surg 1997; 132:592-7.
31. Messick WJ, Rutledge R, Meyer AA. The association of advanced life support training and decreased per capita trauma death rates: an analysis of 12,417 trauma deaths. J Trauma 1992;33:850-5.
32. Katz SH, Falk JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. Ann Emerg Med 2001;37:32-7.