CLINICAL PRACTICE

An Evaluation of Out-of-hospital Advanced Airway Management in an Urban Setting

Christopher B. Colwell, MD, Kevin E. McVaney, MD, Jason S. Haukoos, MD, MS, David P. Wiebe, MD, Craig S. Gravitz, EMT-P, RN, Will W. Dunn, EMT-P, Tamara Bryan, EMT-P

Abstract

Objectives: To determine the success and complication rates associated with endotracheal intubation in an urban emergency medical services (EMS) system. **Methods:** This study evaluated consecutive airway interventions between March 2001 and May 2001 performed by paramedics from the Denver Health Paramedic Division in Denver, Colorado. Patients were identified and enrolled prospectively with the identification of all patients for whom intubation was attempted. A retrospective chart review of the emergency department (ED), intensive care unit, other hospital records, and the coroner's records was then conducted with the intent of identifying all complications related to attempted intubation, including the placement of each endotracheal tube. **Results:** A total of 278 patients were included in this study. Of these, 154 (55%) had an initial nasal intubation attempt, and 124 (45%) had an initial oral intubation attempt. Of the 278 patients for whom an intubation was attempted, 234 (84%, 95% CI = 77% to 88%) were reported by paramedics to be successfully intubated. Of 114 nasal intubations reported as successful by paramedics, two (2%; 95% CI = 0.2% to 6%) were found to be misplaced. Of the 120 oral intubations reported as successful by paramedics, one (1%; 95% CI = 0.02% to 5%) was found to be misplaced. Of the 278 patients, 22 (8%; 95% CI = 5% to 12%) had complications; three (1%; 95% CI = 0.2% to 3%) endotracheal tubes were incorrectly positioned, two (0.7%; 95% CI = 0.08% to 3%) of which were undetected esophageal intubations and one (0.4%; 95% CI = 0 to 2%) of which was in the posterior pharynx. **Conclusions:** Reasonable success and complication rates of endotracheal intubation in the out-of-hospital setting can be achieved in a busy, urban EMS system without the assistance of medications. **Keywords:** endotracheal intubation; urban; complications; prehospital care. ACADEMIC EMERGENCY MEDICINE 2005; 12:417–422.

There may be no out-of-hospital intervention other than defibrillation that is as critical to a patient's outcome as airway management. Placement of endotracheal tubes (ETTs) by paramedics in the out-of-hospital setting has been considered a standard of care for a long time, and a number of studies have shown this airway technique to be safe[1–3] and to improve survival in a variety of clinical settings.[4,5] A relatively recent increase in the attention focused on out-of-hospital interventions and the effect they have on patient outcomes has raised important issues and called into question some practices, such as endotracheal intubation, that many have considered standard out-of-hospital practice. Recent literature has questioned the safety and benefit of out-of-hospital intubation in certain patients, particularly the head-injured trauma patient.[6,7] Two studies also found rates of misplaced ETTs that ranged from unacceptable (25%)[8] to concerning but more in line with earlier literature (5.8%)[9] using hospital rather than field verification of proper placement. Before we determine the true impact of an out-of-hospital intervention on patient outcomes, we need to know whether, and in what settings, the intervention can be performed. The purpose of this study was to determine the success and complication rates associated with endotracheal intubation in an urban emergency medical services (EMS) system.

From the Department of Emergency Medicine, Denver Health Medical Center (CBC, KEM, JSH, DPW), Denver, CO; the Paramedic Division, Denver Health Medical Center (CBC, KEM, CSG, WWD, TB), Denver, CO; and the Department of Preventive Medicine and Biometrics, University of Colorado Health Sciences Center (JSH), Denver, CO.

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Address for correspondence and reprints: Christopher B. Colwell, MD, Department of Emergency Medicine, Denver Health Medical Center, 777 Bannock Street, Mail Code 0108, Denver, CO 80204. Fax: 303-436-7541; e-mail: christopher.colwell@dhha.org.

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METHODS

Study Design. This study was conducted in two phases. The first phase was a prospective evaluation of consecutive airway interventions between March 2001 and May 2001 performed by paramedics from the Denver Health Paramedic Division in Denver, Colorado. The second phase was a retrospective evaluation of all patients included in the first phase for whom intubation was attempted, with the intent of identifying all complications related to attempted intubation, including the placement of each ETT. This

study was approved by the Colorado Multiple Institutional Review Board and all institutional review boards for participating hospitals, and was granted a waiver of informed consent for the duration of the study.

Study Setting and Population. This study was performed in the City and County of Denver, Colorado. The approximate census of Denver County is 550,000 and the approximate service area is 150 square miles. The Denver Health Paramedic Division is the sole provider of 9-1-1 ambulance transport for the City and County of Denver. Patients of all ages in whom at least one intubation attempt was performed were included in the study.

The Denver Health Paramedic Division is a division of Denver Health Medical Center, which provides centralized, online medical control by an emergency medicine attending or senior emergency medicine resident physician. The paramedics operate under protocols that allow them to intubate using blind nasotracheal or orotracheal intubation without the use of pharmacologic adjuncts. Paramedics intubate without base contact for life-threatening airway emergencies. The protocols allow the paramedics to leave patients who are pronounced dead in the field under the care of the Denver coroner. All ETTs are left in place in patients who are pronounced dead in the field and verification of the placement is performed by the coroner or medical examiner at the time of autopsy or prior to release to the funeral home when no autopsy is performed. The chief paramedic and a medical director oversee all paramedic operations. The Denver Fire Department co-responds and provides basic life support (BLS) for approximately 70% of the annual EMS calls. The Denver Health Paramedic Division is a third-service, hospital-based advanced life support system that employs approximately 140 paramedics and staffs a minimum of seven and a maximum of 15 ambulances with dual paramedics working four ten-hour or five eight-hour shifts weekly. Policy requires that paramedics work no more than 16 hours maximum and must have a minimum of six hours between shifts. Ambulances are deployed using a dynamic dispersal system to maintain consistent coverage 24 hours a day. Paramedics are subjected to a rigorous field instruction program at the time of hire. This program includes additional training in blind nasotracheal and orotracheal intubation. Paramedics average 10 to 12 intubations per year. Other than the initial field training program, paramedics receive no special airway training other than that required for state certification. They are also required to be current with the American Heart Association's Advanced Cardiac Life Support (ACLS) curriculum.[10] Approximately 40% of all patients transported within Denver County are returned to Denver Health Medical Center, an academic, Level 1 trauma center with an approximate annual census of 65,000 patients. All other transported patients are transported to one of 10 other 9-1-1 participating metro-area hospitals.

Study Protocol. During the three-month study period, the paramedics completed a data-collection instrument for every patient encounter. Indications to perform endotracheal intubation were left to the discretion of the paramedic, based on clinical judgment. An intubation attempt was defined as a single pass of an ETT into the oral or nasal cavity. All paramedics were trained as to this definition prior to beginning the study. Close oversight was maintained during the study in order to minimize reporting biases. Billing records were reviewed and cross-checked with reported paramedic intubation attempts. Additional confirmation included a review of a random sample of emergent transports to verify inclusion of all patients with an intubation attempt.

Measures. During the first phase, paramedics completed a closed-response data-collection instrument immediately or soon after each patient encounter. In all cases in which airway management was required, data were collected on the type of intubation (nasal versus oral), the number of attempts, methods of confirmation, and management of failed airways. Appropriateness of the intubation beyond paramedic judgment was not specifically assessed.

Methods of confirmation of tube placement by paramedics included end-tidal capnography plus at least one of the following: 1) direct visualization of the tube passing through the vocal cords; 2) auscultation of lung sounds; 3) absence of sounds over the epigastrium; 4) normal oxygen saturation; or 5) observed clinical improvement.

During the second phase, records were obtained and reviewed from all 11 receiving hospitals, as well as the Denver Office of the Coroner. Reviewers (CBC and KEM) were blinded to all collected data during phase one. All emergency department (ED) and intensive care unit (ICU) records, including nursing documentation, hospital discharge summaries, and autopsy reports, were reviewed using a standardized data-collection instrument. All radiograph reports were reviewed for confirmation of tube placement. Variables collected included confirmation of ETT placement, extubation or reintubation in the ED, methods of ETT confirmation, and complications of ETT placement. The method of ETT placement confirmation was left to the discretion of the receiving emergency medicine attending physician. If the emergency physician (EP) removed the ETT in the ED, it was considered an esophageal intubation for the purposes of this study unless it was clearly stated that the ETT had been removed for another reason. Complications were defined by an a priori consensus process as

broken teeth, esophageal intubation, hypopharyngeal intubation, epistaxis, pharyngeal laceration, and right mainstem intubation, as well as any problem attributed by the hospital health care team to the out-of-hospital intubation attempt.

Several assumptions were made for the purposes of this study. First, if the endotracheal tube was not changed or removed during the patient's course in the ED or ICU, the tube was assumed to be in proper position. In patients who died, it was assumed that the ETT was misplaced if either the EP or the coroner (in cases where the patient was pronounced dead in the field and taken directly to the morgue) determined the ETT was not in place.

Second, if a complication potentially attributable to the intubation or intubation attempt was not identified by the EP or documented in the ED record or in any medical record associated with the hospitalization, then a complication related to the field intubation or intubation attempt was assumed not to have existed. In addition to looking for any problem attributed to the intubation in the medical record, we also specifically looked for episodes of epistaxis, posterior pharyngeal lacerations, gastrointestinal hemorrhage, use of consultants (e.g., an otolaryngologist) and why they were involved with the patient, subcutaneous air, pneumothorax, or upper airway infections.

Data Analysis. Descriptive analyses were performed for all variables. Values for continuous variables are reported as medians with interquartile ranges (IQRs), and values for categorical variables are reported as proportions with 95% confidence intervals (95% CIs). All data were entered into an electronic database (Microsoft Access, Microsoft Corporation, Redmond, WA) and statistical analyses were performed using Stata Version 8 (Stata Corporation, College Station, TX). The unit of analysis was the patient unless specifically stated otherwise.

RESULTS

During the three-month study period, 12,709 patients were evaluated. Of these, a total of 300 (2%) patients had at least one intubation attempt as documented by paramedics. Of the 300 patients, 22 (7%) were excluded from data analysis due to missing hospital or coroner's data, resulting in 278 (93%) total included patients for whom ETT confirmation and complications were assessed. Twenty-five (9%) of the 278 patients were pronounced dead in the field and turned over to the Denver coroner. The number of unavailable records was proportionate across all 11 receiving hospitals and the Denver coroner (data not shown).

Of the 278 patients, 154 (55%) had an initial nasal intubation attempt and 124 (45%) had an initial oral intubation attempt. Of the 154 initial nasal intubation attempts, 114 (74%, 95% CI = 66% to 81%) were successful and 40 (26%, 95% CI = 19% to 34%) were unsuccessful. Of the 40 nasal intubations that were unsuccessful, 26 (70%) were managed with BLS maneuvers, and in 14 (30%) cases, oral intubation was attempted. Of these 14 cases in which oral intubation was attempted after failing nasal intubation, nine (64%, 95% CI = 35% to 87%) were successful. The remaining cases ($n = 5$) were managed with BLS maneuvers (Figure 1).

Of the 124 initial oral intubation attempts, 120 (97%, 95% CI = 92% to 99%) were successful, and four (3%, 95% CI = 1% to 8%) were unsuccessful and managed with BLS maneuvers (Figure 1).

Two (2%; 95% CI = 0.2% to 6%) of the 114 nasal intubations reported as successful by paramedics were found to have misplaced ETTs (Table 1). One was found to be in the hypopharynx on a lateral cervical spine radiograph approximately 60 minutes after the patient arrived at the hospital. This patient was discharged home on his second hospital day with the diagnoses of alcohol abuse and respiratory arrest. The EP immediately deemed the second ETT unacceptable. It was removed and the patient was intubated using a rapid sequence technique. The EP did not record the method used to determine tube misplacement.

The EP thought that one (0.8%, 95% CI = 0.02% to 5%) of the 120 oral intubations reported as successful by paramedics was incorrectly placed. The tube was removed and the patient was intubated using a rapid sequence technique. The treating physician documented no method for determining tube misplacement. This gives an undetected esophageal intubation rate of two in 278 attempts (0.7%, 95% CI = 0.09% to 3%) and an overall malposition rate of three in 278 attempts (1%, 95% CI = 0.2% to 3%) (Table 2).

Thirty-six (13%, 95% CI = 9% to 18%) of the 278 patients who had at least one intubation attempt arrived at the hospital unintubated. Of these, 25 (69%) were treated with bag–valve–mask techniques, and 11 (31%) were determined to no longer require advanced airway management and were treated with supplemental oxygen only.

Eighteen (12%; 95% CI = 7% to 18%) of the 154 patients with an attempted nasal intubation experienced an episode of epistaxis. Of these, 13 (73%) were mild (defined as epistaxis requiring no specific intervention), two (11%) were moderate (defined as epistaxis requiring intervention by the EP without further consultation), and three (17%) were severe (defined as epistaxis requiring management by a consultant). Of the three patients with severe epistaxis, one had a posterior pharyngeal laceration that required repair, one required nasal packing in the ICU, and the other had undiagnosed leukemia with thrombocytopenia that required transfusion. Another patient experienced nasal trauma likely related to the

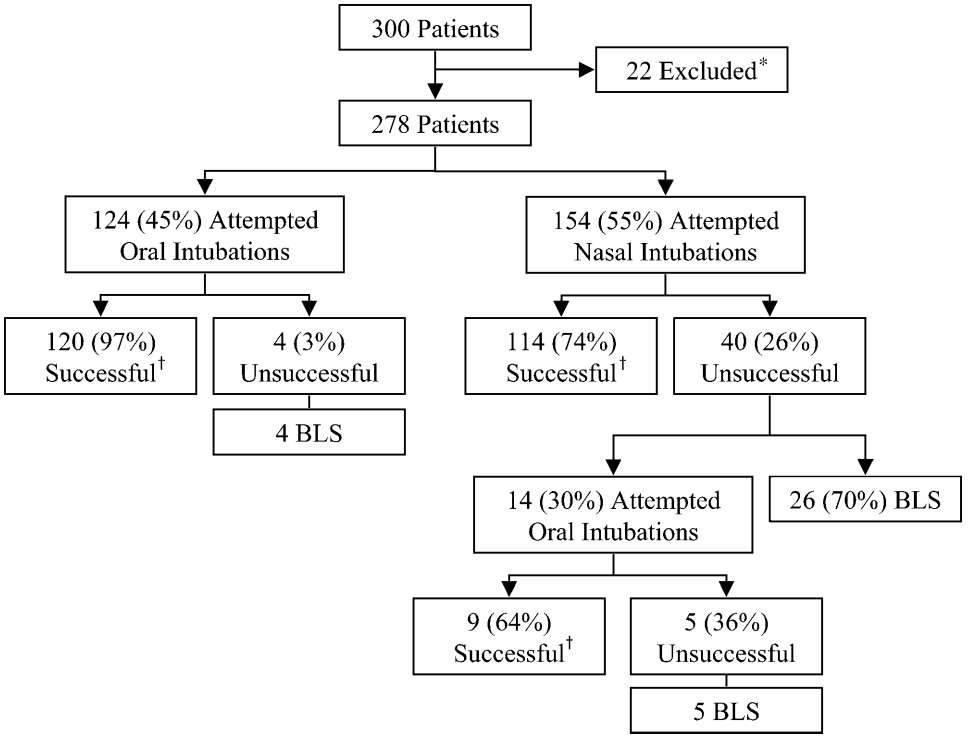

Figure 1. Overall approaches to advanced airway management and their success and failure rates. (*Excluded due to unavailable hospital or coroner records; †Success defined by paramedic reporting.) BLS = basic life support.

intubation attempt and was unable to eat until the third hospital day.

No complications were identified in the 124 patients who had an initial oral intubation attempt. Of the 154 patients who had an initial nasal intubation, 21 (14%, 95% CI = 9% to 20%) had a complication, including misplacement of the ETT. Thus, 22 (8%, 95% CI = 5% to 12%) of the 278 patients for whom complete documentation was obtained had a complication, including misplacement of the ETT.

DISCUSSION

Airway intervention is a critical component of out-of-hospital medical care. Intubation is a widely practiced method used for definitive airway control. Published literature has documented a wide range of experiences with out-of-hospital endotracheal intubation. Stewart et al. found endotracheal intubation to be a field procedure that is safe and can be skillfully performed by paramedics, with a <1% unrecognized esophageal intubation rate.[1] O'Brien et al. found blind nasotracheal intubation to be a safe initial out-of-hospital airway approach with acceptable success and complication rates,[11] and Gray et al. found out-of-hospital personnel to be able to perform the skills of intubation successfully.[12] More recently, however, Katz and Falk found a 25% rate of misplaced ETT tubes, two-thirds of which were located in the esophagus.[8] Several studies have also questioned the effect of out-of-hospital intubation on patient outcomes, particularly in the head-injured patient.[6,7,13] Given the discrepancy in the literature and the potential impact on patient care, a clear understanding of success and complication rates related to airway management is crucial to effectively establish protocols for EMS systems. We present the success and complications rates of intubation in a high-volume, urban 9-1-1 system. We have included both

TABLE 1. Misplaced Orotracheal Intubations

	Oral Attempt† (*n* = 124)	(95% CI)	Oral Success‡ (*n* = 120)	(95% CI)
Unrecognized esophageal intubation	1 (0.8%)	(0.02, 4)	1 (0.8%)	(0.02, 5)
Unrecognized hypopharyngeal intubation	0 (0%)	(0, 3)	0 (0%)	(0, 3)
Right mainstem intubation	0 (0%)	(0, 3)	16 (13%)	(8, 21)
Total*	1 (0.8%)	(0.02, 4)	1 (0.8%)	(0.02, 5)

*Defined as hypopharyngeal, esophageal, or potentially life-threatening endotracheal tube misplacement.
†Defined as attempt reported by paramedics.
‡Defined as success reported by paramedics.

TABLE 2. Misplaced Nasotracheal Intubations

	Nasal Attempt† (n = 154)	(95% CI)	Nasal Success‡ (n = 114)	(95% CI)
Unrecognized esophageal intubation	1 (0.6%)	(0.02, 4)	1 (0.9%)	(0.02, 5)
Unrecognized hypopharyngeal intubation	1 (0.6%)	(0.02, 4)	1 (0.6%)	(0.02, 4)
Right mainstem intubation	0 (0%)	(0, 3)	6 (5%)	(2, 11)
Total*	2 (1%)	(0.2, 5)	2 (2%)	(0.2, 6)

*Defined as hypopharyngeal, esophageal, or potentially life-threatening endotracheal tube misplacement.
†Defined as attempt reported by paramedics.
‡Defined as success reported by paramedics.

nasal and oral intubations as they are both used frequently for a variety of clinical situations in our system. Methods for determining attempt rates and success have included paramedic-initiated reporting and ride-along observers. Some studies have included EP evaluations for determining final position of out-of-hospital intubations. The purpose of this study was to try to answer some of the questions posed in the past, using prospective observational data, and then by following up with all the patients who had intubation attempts, in order to accurately estimate success and complication rates.

Previous studies have shown that unrecognized esophageal intubations may occur at an alarmingly high rate.[8] Of the patients who were intubated during the period of our study, only 1% were found to have misplaced ETTs. There may be a number of reasons for this dramatic difference in misplaced tubes found in our study. In the recent study that found high rates of esophageal intubation, multiple EMS agencies transported patients to a single ED, while our study evaluated a single, large agency, which transported patients to a number of different EDs. The agencies in this earlier study did not have uniform educational or retraining requirements and did not report the average number of intubations each paramedic performed annually. Given the number of intubated patients in that study (n = 108), it is possible that the high rate of misplaced tubes found was reflective of only a small number of the agencies and/or paramedics. Our paramedics average just over ten intubations per year, and it is also possible that the different results represent different levels of experience. Our study also evaluated a hospital-based EMS system organized and directed by academic EPs with strong out-of-hospital care training and interest. Our results may not be applicable to systems not managed by EPs with strong interest in out-of-hospital care.

A number of other studies have evaluated out-of-hospital endotracheal intubation. Gausche et al. found a 2% esophageal intubation rate, 14% dislodgement rate, and 18% right mainstem bronchus rate in out-of-hospital pediatric intubations.[14] Our rate of right mainstem bronchus intubation was 9%. This difference may be explained by the fact that the Gausche study looked at pediatric patients only, while a combination of pediatric and adult patients were included in our study. O'Brien et al., in a study looking at blind nasotracheal intubations, reported a 13% complication rate, including two unrecognized esophageal intubations and a piriform sinus laceration.[11] More recently, Wang et al. reported a success rate very similar to ours (86.8% vs. 87.0%) when they evaluated 45 EMS systems,[15] although due to poor response rates from some services involved in this study, it is not clear how many of those services are truly represented by that success rate.

Twelve percent of patients for whom an initial intubation attempt was made were not intubated on arrival to the hospital, according to the paramedic report. This does not include the unrecognized malpositioned ETTs (3/278), but represents the cases where the paramedic recognized that the patient was not successfully intubated by the time they arrived at the hospital. These included situations where the paramedic aborted attempts at intubation, either because he or she thought the patient's condition had changed and no longer required intubation or because the paramedic did not believe it was likely he or she would be able to achieve successful endotracheal intubation. This 12% also included situations in which the paramedic attempted to intubate the patient but recognized that the attempt was unsuccessful and removed the ETT. These patients were managed with BLS airway techniques that ranged from simple application of oxygen to bag–valve–mask ventilation depending on the patient's condition. These were reported as unsuccessful intubations, but not as complications unless there were complications related to the intubation attempt.

We found an overall complication rate of 8% related to intubations or intubation attempts, the large majority being epistaxis related to nasal intubation attempts. Previous studies have documented complication rates of intubation as high as 28%.[16] The majority of the complications did not appear to significantly affect clinical outcome, although some were quite serious, including the unrecognized misplaced ETTs, a tear in the posterior pharynx requiring surgery to repair, and a case of epistaxis significant enough to require a transfusion. In our study, oral intubation had significantly fewer complications than nasal intubation. We believe that our low ETT misplacement rate is directly tied to the successful use of

nasotracheal intubation in the nonmedicated out-of-hospital patient.

Our study did not evaluate final clinical outcomes or compare patients who were intubated with a similar group who were not. Future study should evaluate outcomes in adult patients who were intubated versus similar groups who were not to help address the question of when endotracheal intubation should be performed in the field. In addition to misplaced ETTs and complication rates related to intubation attempts, extended scene times to achieve or attempt intubation are an issue that may have an effect on patient outcomes. Although some research has occurred in this area, future research should attempt to define how airway management affects scene times and what effect this has on clinical outcomes.

LIMITATIONS

There were several limitations to our study. Due to the self-reporting aspect of our data collection, it is possible that a patient who had an intubation attempt but who was not intubated on arrival to the ED was not entered in the study. Close monitoring and a cross-check with billing information did not identify any patients for whom this occurred, although it is possible the cross-check did not identify every potentially eligible patient, as billing records reflect only what is documented on the paramedic report. The authors involved in recording follow-up information were not blinded to the purpose of the study, although they were blinded to the paramedic-reported results. There was no standardization of methods used to confirm proper ETT placement in the ED, thus possibly resulting in misclassification bias. Confirmation techniques were left to the discretion of the receiving health care team. The retrospective nature of the second phase of this study may have introduced selection or misclassification biases with respect to confirmation of ETT placement or reporting of complications related to intubation. Both selection and misclassification biases were minimized by the use of a standardized data-collection process and close oversight by study investigators.

CONCLUSIONS

Reasonable success and complication rates of endotracheal intubation in the out-of-hospital setting can be achieved in a busy, urban EMS system without the assistance of medications. It is still unclear, however, whether advanced out-of-hospital airway management significantly impacts clinical outcomes.

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