Misplaced Endotracheal Tubes by Paramedics in an Urban Emergency Medical Services System

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Study objective: To determine the incidence of unrecognized, misplaced endotracheal tubes inserted by paramedics in a large urban, decentralized emergency medical services (EMS) system.

Methods: We conducted a prospective, observational study of patients intubated in the field by paramedics before emergency department arrival. During an 8-month period, emergency physicians assessed tube position at ED arrival using a combination of auscultation, end-tidal carbon dioxide ($ETCO_2$) monitoring, and direct laryngoscopy.

Results: A total of 108 intubated patients were studied. On arrival in the ED, 25% (27/108) of patients were found to have improperly placed endotracheal tubes. Of the misplaced tubes, 67% (18/27) were found to be in the esophagus, whereas in 33% (9/27), the tip of the tube was found to be in the hypopharynx, above the vocal cords. Of the patients with misplaced tubes noted in the hypopharynx, 33% (3/9) died while in the ED. For the patients found to have tubes in the hypopharynx, 56% (5/9) had evidence of $ETCO_2$ on ED arrival. For the patients found to have esophageal tube placement on ED arrival, 56% (10/18) died in the ED. Esophageal intubation was associated with an absence of expired CO_2 (17/18, 94%) on ED arrival. The singe patient in this subset with a recordable $ETCO_2$ had been nasotracheally intubated with the tip of the endotracheal tube noted in the esophagus while spontaneous respirations were present. On patient arrival to the ED, 63% (68/108) of the patients had direct laryngoscopy in addition to $ETCO_2$ determination. All patients had $ETCO_2$ evaluation performed on arrival. All patients in whom an absence of $ETCO_2$ was demonstrated on patient arrival underwent direct laryngoscopy. In cases in which direct laryngoscopy was not performed, the attending physician documented the $ETCO_2$ in conjunction with the presence of bilateral breath sounds.

Conclusion: The incidence of out-of-hospital, unrecognized, misplaced endotracheal tubes in our community is excessively high and may be reflective of the incidence occurring in other communities. Data from other communities are needed to clarify the scope of this alarming issue.

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INTRODUCTION

Placement of endotracheal tubes (ETTs) in the field by paramedics is a well-accepted out-of-hospital procedure used to obtain definitive airway control. Several studies have reported the incidence of unrecognized, misplaced endotracheal intubations in the field to be low, typically 1% to 5%[1-5] (Table 1). In the majority of these studies, verification of tube placement was performed in the field. It was our clinical impression before conducting our study that the incidence of patients with misplaced ETTs on arrival to our emergency department was substantially higher than that reported in the literature. To our knowledge, no study had investigated the actual incidence of misplaced ETTs on patient arrival to an ED.

The literature has addressed the utility of confirmatory devices to verify ETT position.[6-33] Although well accepted as the standard of care by anesthesiologists in the operating room,[10] the role of end-tidal carbon dioxide ($ETCO_2$) devices has not gained universal acceptance in the out-of-hospital setting.[6-9] The purpose of our study was to determine the incidence of unrecognized misplaced ETTs that had been inserted in the field, in an emergency medical services (EMS) community in which $ETCO_2$ monitoring was not consistently used.

Table 1.
Rate of misplaced endotracheal intubations in the field by paramedics as demonstrated in previous studies.

Author(s)	No. of Intubations (Misplaced/Total)	Misplaced Intubations (%)
Jenkins et al[1]	2/39	5.1
Bozeman et al[2]	1/100	1
Stewart et al[3]	3/779	0.4
Sayre et al[4]	3/103	2.9
Pointer[5]	5/383	1.3

MATERIALS AND METHODS

This study was conducted at an urban, Level I trauma center teaching hospital between May 1, 1997, and December 31, 1997. Our purpose was to assess the incidence of unrecognized, misplaced ETTs inserted by paramedics in an urban, decentralized EMS system. The institutional review committee determined that patient consent was unnecessary because of the observational and quality assurance nature of the project.

The county EMS system used a 2-tiered response with multiple providers (Table 2). Medical direction of the system was provided by a part-time county EMS medical director who was assisted by 2 associate medical directors. At the time of our study, the county medical director was a practicing community internist who had been an associate director for many years. The medical director's position was funded at a part-time (approximately 20 h/wk) level. The director had no direct line authority over paramedics operating in the system. Rather, their command structure derived from each individual agency. Protocols for care within the county were developed and approved by a physician advisory council with representatives from all the EDs and provider agencies. The small administrative staff worked for the Orange County government in the Department of Health and Family Services. Each provider agency operating within the county was responsible for its own educational and quality assessment activities. Paramedics received no specialized or additional airway training except that required for initial certification. There was no required retraining in endotracheal intubation, other than maintaining advanced cardiac life support certification, which required successful completion of the airway station, including intubation of a mannequin. Provider agencies were not required to track the number of intubations each paramedic performed per year, nor

Table 2.
Providers of EMS in Orange County, FL.

- Orange County Fire & Rescue Division
- 8 Municipal fire departments
- 4 Hospital ambulance services
- 1 Private ambulance service
- 3 Aeromedical services
- 1 Advanced life support stand-by service
- 1 Basic life support stand-by service
- 15 Nonemergency paratransit services
- 9 Hospital EDs

did they mandate any specific airway retraining requirement. At the time of the study, there were approximately 650 actively working paramedics among all the provider agencies servicing a population of approximately 850,000. Neither Orange County nor the provider agencies were able to determine the total number of intubations performed per year or the number performed per paramedic.

All ETTs placed by paramedics during the study period in patients transported to our ED were immediately evaluated by a senior emergency medicine resident and attending physician. A standardized form was completed by the physician indicating tube location and method of verification. All patients admitted to the ED and intubated by paramedics were included in the study. The department's research nurse monitored EMS logs on a daily basis to ensure that no potential subjects were excluded from the study. If a potential subject had been missed, a research sheet was completed by the physician within 48 hours.

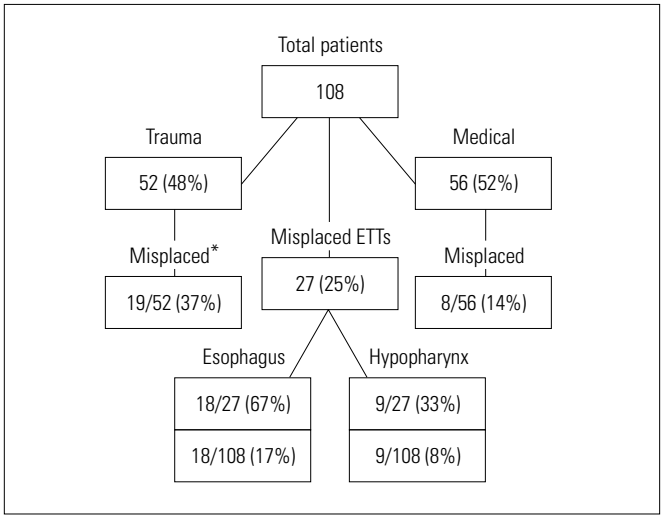
Evaluation of ETT placement was performed at the time of arrival to the department in the following manner. Without exception, each tube was evaluated for $ETCO_2$ with a semiquantitative colorimetric device or infrared CO_2 detector providing an expired CO_2 capnograph. Auscultation of the chest and epigastrium was immediately performed. If the tube was clearly misplaced (ie, epigastric sounds or vomitus via the endotracheal tube), it was removed and the intubation was considered "esophageal." If the tube was not obviously misplaced, an $ETCO_2$ monitoring device was attached to the tube and direct laryngoscopy was performed as appropriate at the discretion of the attending emergency physician. If the tube was visualized passing between the vocal cords, the intubation was considered "endotracheal." Alternatively, if both bilateral breath sounds and positive $ETCO_2$ waveform were present, and tube depth by marker was appropriate, tubes were deemed to be endotracheally placed by the attending physician. In all other cases, the tube was considered to be misplaced. Misplaced tubes were categorized as being in the hypopharynx if the tip of the tube was seen above the vocal cords, and esophageal if the tip of the tube was clearly in the esophagus.

RESULTS

The study patients included the 108 intubated patients who were brought by paramedics to the ED during the 8-month study period. On 2 occasions, study forms were completed the next day after review of the ED patient log by the research nurse revealed the absence of completed study forms. Direct laryngoscopy was used to evaluate 63% (68/108) of the tubes. In 43% (35/81) of the cases, tubes were deemed to be endotracheally placed by virtue of the presence of bilateral breath sounds, appropriate depth of placement by tube marker, and positive capnographic data, without direct laryngoscopy. Medical patients comprised 52% (56) of the group, whereas 48% (52) were trauma patients with cervical spine immobilization. The overall rate of improperly placed ETTs was 25% (27/108; Figure). Eleven (10%) of the 108 patients were 17 years or younger. Esophageal placement was present in 17% (18/108) and accounted for two thirds of the misplaced tubes. In 8% (9/108) of cases, the tip of the ETT was found to be in the hypopharynx, accounting for the remaining one third of misplaced tubes.

Trauma patients were significantly more likely to have misplaced ETTs than medical patients (37% versus 14%, $P<.01$). With one exception, all the patients found to have esophageal tube placement exhibited the absence of $ETCO_2$ on patient arrival. In the exception, the patient was found to be breathing spontaneously despite a nasotracheal tube placed in the esophagus. In the group of patients found to have tube placement in the hypopharynx, 44.4% (4/9) exhibited the absence of $ETCO_2$ on patient arrival. In the endotracheal group, 17.3% (19/81) showed the absence of $ETCO_2$ on patient arrival. In each of these cases, asystole was present, there was no pulse, and return of spon-

Figure.
Misplaced endotracheal tubes. *P<.01 *trauma versus medical.*



taneous circulation was never achieved despite appropriate tube placement verified laryngoscopically.

DISCUSSION

The incidence of unrecognized, misplaced endotracheal intubations in the present study is alarming, and substantially higher than in previously reported series. We believe there may be several explanations for this discrepancy. All of the previously published series[1-5] were conducted in EMS systems directed by academic EMS directors with tightly controlled oversight of paramedic training and practice. Evaluation occurred in the field with researchers present during the procedures. Eligible patients included only selected subsets of the total intubated populations. In the previous studies, the status of tube position at EDD arrival was not reported.

In an early study that fostered the proliferation of out-of-hospital endotracheal intubations, Stewart et al[3] demonstrated a greater than 90% success rate for field intubations in 779 patients. In 1.8% of cases, tubes were placed in an incorrect position. In 21% (3/14) of these episodes, the incorrect positioning of the tube went unrecognized. Only adult patients in cardiac arrest or in deep coma without gag reflex were included in this study. Patients in cervical immobilization devices and children were excluded from the study group. Pelucio et al[11] recently demonstrated an esophageal intubation rate of 6% before the application of an esophageal detection device in a study evaluating the accuracy of the esophageal detection device for field detection of esophageal intubations. Children were excluded from the study, as were adults in whom the paramedic was "uncertain" of the esophageal detection device reading. Our study, in contrast, included all patients intubated in the field without exclusions.

Endotracheal intubation is a psychomotor skill. Even under ideal conditions with the procedure performed by qualified anesthesiologists, it may be difficult to recognize esophageal intubations.[12] Adverse conditions in the field may make intubation even more difficult than in a hospital setting. Skill levels of various paramedic providers within a community may differ sharply.[20] Assessing tube position after intubation in this setting requires rigorous training and adherence to protocol.[11,16] Standard physical assessment techniques for verifying tube placement may be unreliable.[12,14,17] Auscultation over the chest can fail to detect esophageal placement in 15% of patients, and fogging of the tube has been shown to be present in 85% of esophageal intubations.[14]

$ETCO_2$ monitoring is routinely used by anesthesiologists to verify proper ETT position. Since 1990, the American Society of Anesthesiologists has considered this to be the standard of care in the operating room, and has now extended that standard to include all anesthetic practice irrespective of geographic location.[10] Although gaining acceptance among emergency physicians in recent years, $ETCO_2$ verification of tube placement has not yet become the standard of care in the ED.[18] Ironically, in the out-of-hospital setting, where reliable techniques to verify proper tube placement are needed most, use of $ETCO_2$ monitoring has been limited. There are, however, examples of EMS systems throughout the country in which routine use of $ETCO_2$ monitors for verification of tube placement has contributed to the virtual elimination of the problem of unrecognized, misplaced ETTs.[24]

The rate of unrecognized, misplaced ETTs found in our community is alarmingly high. There are several factors that may have contributed to this problem. Despite written protocols requiring the out-of-hospital use of $ETCO_2$ devices in our community, we anecdotally found their use to be sporadic. To avoid the Hawthorne effect, we chose not to query paramedics regarding verification techniques used in the field. Accordingly, we were unable to document the frequency of field $ETCO_2$ device use during the study period. This is certainly a limitation of the study. We believe that routine use of this technique, both at the time of intubation and as an ongoing monitor during transport, could potentially eliminate the problem of unrecognized misplaced ETT placement. An adequate continuous quality improvement system to identify individual paramedics in need of retraining and to identify the presence of this problem was not in effect during the study period.

Our data may differ from data in the EMS literature because this is one of the few studies undertaken in an EMS system not organized and run by academic emergency physicians with strong out-of-hospital care training and interest. No one is comfortable in reporting difficulty and poor performance in patient care activities. These data may be reflective of an unspoken, pervasive national problem in serious need of attention. Accordingly, we urge our colleagues across the country to review their experience in their own communities.

We have shared these data with the physicians, administrators, and politicians responsible for the EMS system in our community in an attempt to foster positive changes.

An immediate, aggressive educational program was undertaken by the county EMS staff with all of the provider agencies reviewing intubation techniques and techniques to confirm proper tube placement. An aggressive quality assurance program along with these efforts appears to have improved the immediate situation.

A follow-up study to document the improvement has been undertaken by the county with the cooperation of the provider agencies. The county board of supervisors has accepted the recommendations of the community advisory board that had been appointed, in part, in response to the concerns raised by our study. Increased funding for full-time, appropriately credentialed medical directors providing continuous on-call coverage, full-time education and continuous quality improvement officers, and an enhanced authority for the medical directors were among the approved recommendations in the process of being implemented.

Our study has several limitations. Because it was conducted in the ED, rather than in the field where the intubations occurred, we were unable to analyze the cause of improper tube placement. The consistency of the use of monitoring devices at the time of the procedure could not be confirmed. Further, it is possible that properly placed tubes were dislodged in transport. Functionally, whether the tubes were misplaced initially or dislodged en route to the hospital makes little difference to the patient.

A significant limitation of the study was the lack of uniformity of direct laryngoscopy on all tube verifications. All but 4 of the tubes deemed to be misplaced were confirmed by laryngoscopy. In each of these 4 cases, there was vomitus in the ETT and absent breath sounds on examination. The attending physician in each case promptly removed the tube and replaced it. In each of these cases, tube placement was deemed esophageal.

It is uniformly accepted that management of a patient's airway in the out-of-hospital setting is a critically important function of out-of-hospital providers. Substantial literature supports the fact that paramedics and basic emergency medical technicians can be trained to perform this function properly and successfully. Strong medical direction, a rational organizational structure, the use of $ETCO_2$ and other confirmatory devices for tube placement, as well as ongoing monitoring and a vigilant continuous quality improvement system may be critical elements to ensure that our citizens receive the high-quality out-of-hospital care they expect and deserve.

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