

Paramedic Endotracheal Intubation

Henry E. Wang, MD, MS

Prehospital practitioners perform a range of critical life saving interventions such as delivery of cardiopulmonary resuscitation chest compressions, rescue defibrillation shocks, administration of intravenous fluids and drugs, and establishment of a patient airway. The equipment used in these interventions require special modifications to enable their portability and delivery in the field setting. For example, while in-hospital cardiac arrest equipment is often stored in large mobile “crash carts,” such devices would be impractical for prehospital use. Instead, paramedics use portable “jump bags” filled with medications as well as a lighter portable defibrillator/cardiac monitor.

One of the most important recent scientific findings is that medical procedures executed in the field setting may not perform equivalently to the same interventions carried out in the hospital. Thus, simply imitating in-hospital practices may not necessarily improve outcomes. In some cases these prehospital interventions may lead to worsened outcomes.

Paramedic Endotracheal Intubation

An excellent example of the challenges surrounding prehospital medical interventions is endotracheal intubation (ETI). Airway management is the process of establishing an open passage between the mouth and the lungs in order to deliver life-saving oxygen. Critically ill individuals such as those suffering from cardiac arrest or major trauma are often unconscious and cannot maintain an open airway on their own. Therefore, airway management is a fundamental priority in the care of the critically ill. Without an adequate supply of oxygen, vital organs (in particular, the brain) begin to die. Airway management may encompass a spectrum of basic methods (eg, mouth-to-mouth or bag-valve-mask ventilation) or more advanced techniques (eg, endotracheal intubation).^{1,2}

Endotracheal intubation (ETI) is the most prominent and invasive form of airway management. A plastic breathing tube is inserted through the mouth, between the vocal cords, and into the

trachea (windpipe). Endotracheal intubation provides a direct, patent conduit to the lungs to facilitate optimal and controlled delivery of oxygen.² The endotracheal tube also has an inflatable cuff designed to prevent the aspiration of stomach contents into the lungs. Endotracheal intubation is the standard method for airway management in the hospital setting including the operating room, emergency department, and intensive care unit.

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The History of Paramedic Endotracheal Intubation

Paramedics in the United States first performed field ETI over 20 years ago during an era of intense efforts to improve the out-of-hospital care of patients suffering from sudden cardiac arrest.³ Experts viewed delivery of oxygen as a fundamental component of cardiac arrest care, and most viewed ETI as the best way to deliver oxygen to the lungs in comatose individuals. Endotracheal intubation was widely performed on cardiac arrest patients in the hospital, and thus it seemed reasonable to train paramedics to act similarly on out-of-hospital patients. Prior to this time paramedics used older methods of airway management such as bag-valve-mask ventilation and the esophageal-obturator airway, neither of which was seen as adequate in this clinical context.⁴

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The first scientific reports of paramedic ETI originated from San Diego, Columbus (Ohio), Boston, and Pittsburgh.⁵⁻⁸ These groups of paramedics received intense preparation encompassing classroom and mannequin training as well as practice in the operating room on live patients. Anesthesiologists, viewed as the masters of ETI and airway management, played active training and mentoring roles in the pilot efforts. These studies garnered significant scientific attention and spurred efforts to generalize paramedic ETI throughout the United States.

Today, ETI is a standard of paramedic care. In Pennsylvania alone, paramedics perform ETI on over 11 000 out-of-hospital patients annually.⁹ Clinicians view ETI as one of the interventions that distinguishes paramedic care.¹⁰

Controversies Surrounding Paramedic Endotracheal Intubation

Is Paramedic ETI Life-Saving?

The intention of a resuscitation intervention is to improve patient survival or other health outcomes. Since its inception, most have assumed that paramedic ETI is beneficial: ETI provides a direct protected conduit to the lungs—how could it possibly be harmful? However, many recent studies suggest that paramedic ETI may in fact not improve survival or other outcomes. In some cases, the intervention may even worsen outcomes.

Multiple studies have examined the connection between paramedic ETI and patient outcomes.¹¹⁻¹⁸ The recurrent finding among these studies is that paramedic ETI does not improve survival and, in some cases, may actually increase mortality. These studies also have not identified any neurological benefit from the procedure. For example, Gausche et al performed a prospective pseudo-randomized controlled trial alternating ETI with bag-valve-mask ventilation of critically ill children; the authors found no difference in survival or neurological outcome.¹⁴ Davis et al evaluated out-of-hospital head injured patients intubated with the assistance of succinylcholine, a neuromuscular blocking agent.¹² The use of these drugs causes temporary paralysis of the patient to facilitate ETI and is normally reserved for physician use in the hospital.² Compared with historical matched controls that did not receive ETI, the experimental ETI group exhibited a higher adjusted odds of death.

We analyzed over 4000 head injured patients treated by paramedics in Pennsylvania over a 4-year period.¹⁶ We found that those intubated by paramedics had a 4 times higher adjusted odds of death than those intubated in the receiving hospital emergency department.

ETI Adverse Events and Errors

Some have attributed worsened outcomes to adverse events and errors occurring during out-of-hospital ETI. Clinically, this is plausible since ETI is an inherently difficult process requiring the coordination of numerous cognitive and manual steps. In addition, paramedics face other latent challenges when performing ETI such as the uncontrolled chaotic nature of the field environment. For example, it is not unusual for a paramedic

to provide airway management on a patient entrapped in the wreckage of a motor vehicle collision. Given these many factors, the occurrence of adverse events is not only possible but probable.

The most serious adverse event associated with ETI is inadvertent placement of the breathing tube in the esophagus. If not recognized and corrected, this error results in oxygen delivery to the stomach instead of the lungs. Katz and Falk presented the most prominent report of ETI adverse events, finding the endotracheal tube misplaced in 25 of 108 patients intubated by paramedics; in two-thirds of these cases, the tube was in the esophagus.¹⁹ Other studies using similar methods found lower—but not negligible—rates of tube misplacement.^{20,21}

Recent efforts have highlighted previously undefined ETI errors. Endotracheal intubation ideally should occur rapidly so that there is minimal disturbance to the patient's oxygen level or heart rate. Dunford et al examined a subset of 54 patients receiving succinylcholine-assisted paramedic ETI.²² The authors found that patient oxygen saturation and/or heart rate decreased significantly during ETI in over half of the patients. Of greater concern, the paramedics considered 84% of these ETI cases to be "easy." Thus, even when equipped with state-of-the-art monitoring equipment, paramedics were not aware of these adverse events.

When individual events are aggregated, the resulting ETI error rates may be higher than expected. We collected data on over 1900 ETI performed by paramedics across Pennsylvania, focusing on reports of three error events: (1) ETI tube misplacement or dislodgement; (2) multiple ETI attempts; and (3) failed ETI efforts.²³ We found that one or more of these errors occurred in 1 in 4.5 patients receiving ETI efforts.

ETI Training and Practice

Given the complexity of ETI, one would expect that paramedics receive substantial training and practice in the procedure. However, current ETI training standards and practices may not afford adequate baseline or maintenance experience.

For example, whereas resident physicians in emergency medicine and anesthesiology must perform 35-50 ETI prior to graduation, paramedic students are required to perform only 5 ETI.^{24,25} Examining a series of 7500 ETI performed by 800 paramedic students, we found that paramedic students perform a median of only 7 ETI (IQR: 4-12) during their training.²⁶ We also found that paramedics students required at least 15 to 20 ETI encounters to achieve adequate baseline proficiency. Emergency medicine residents typically spend 160 hours in the operating room learning ETI under the tutelage of anesthesiologists. However, in a survey of paramedic training program directors, we found that most paramedic students spend only 16 to 32 hours in the operating room learning ETI.²⁷

Paramedic clinical ETI experience also falls below expected levels. Using Pennsylvania statewide data for 2003, we found that paramedics perform a median of only one ETI annually.⁹ While the minimum annual number of procedures is not defined, the best air medical programs require that paramedics perform at least 12 ETI annually.²⁸

While some agencies provide additional training and experience

using mannequins or human simulators, the effectiveness of these training modalities remains unproven. Mannequins and human simulators do not accurately recreate the feel of live human flesh nor the heterogeneity in airway anatomy between different persons.²⁹ Studies linking mannequin and simulator training to paramedic ETI performance have significant limitations.^{30,31}

Is Change Possible?

We now recognize that efficacy demonstrated in small controlled settings may not necessarily translate to widespread success when replicated on a large scale. In the case of ETI, the original demonstrations of the technique involved relatively small teams of paramedics receiving intense training and monitoring.^{5,6,8,30} Few considered that many EMS agencies nationally would not have the resources necessary to ensure the same degrees of success. Today, our current systems of EMS care and education lack the resources to ensure success on a national scale.

There are, in fact, potential system level solutions. For example, one approach might involve substituting ETI with simpler alternate airway devices such as the Combitube or King LT airway.^{1,32,33} These newer devices are relatively easy to insert, work well in a variety of different clinical scenarios, are easier to master than ETI, and may not depend on live human practice for adequate training. In order to adhere to the most recent Advanced Cardiac Life Support guidelines, several individual paramedic agencies nationally have switched from ETI to alternate airway devices.³⁴

Facilitating change in ETI, however, comes accompanied by other challenges. One such challenge would be the workplace culture of EMS. Endotracheal intubation is a defining procedure of paramedic care.¹⁰ Taking ETI away from paramedics would be like taking scalpels away from surgeons—this proposition would likely face significant resistance. The optimal method for facilitating change in the face of these many challenges remains unknown. **NCMJ**

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