# Endotracheal intubation in the field: con position

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Endotracheal intubation (ETI) is considered by most clinicians to be the definitive approach to airway control for most critically ill and injured patients, be they in the operating theatre, in the early phases of an intensive care unit hospitalization, or in the out-of-hospital setting (Pepe et al, 1985; American College of Surgeons Committee on Trauma, 1997; American Heart Association Emergency Cardiovascular Care Committee, 2000). The likely presence of significant physiological derangements (e.g. hypoxaemia, hypercarbia, hypoperfusion) and other clinical care imperatives (e.g. airway protection) have driven a strong philosophy that emergency medical services (EMS) personnel should attempt to provide a definitive airway as soon as possible in the out-of-hospital setting for cardiopulmonary arrest, severe trauma and other critical emergencies (Miller et al, 1978; Pepe et al, 1985; Fowler, 1988; Pepe et al, 1993; American College of Surgeons Committee on Trauma, 1997; American Heart Association Emergency Cardiovascular Care Committee, 2000).

Studies conducted in EMS systems with intensive medical direction, aggressive training programmes and on-scene supervision of EMS personnel have enjoyed extremely high rates of successful ETI for both children and adults (Copass et al, 1984; Stewart et al, 1984; Pepe et al, 1985; Durham et al, 1992; Sirbaugh et al, 1999). In most of these studies, successful intubation has been defined not only by accurate anatomical placement of the endotracheal tube, but also by absence of significant complications (Stewart et al, 1984; Pepe et al, 1985). With some exceptions, prehospital ETI is usually attempted in cardiopulmonary arrest cases and in the most severely injured trauma patients who generally have significant physiological impairment (unconscious), including the absence of a gag reflex (Pepe et al, 1985). As a result, the procedure can be relatively easy to perform when highly experienced intubators are involved. Accordingly, prehospital ETI is usually being attempted in patients with the highest risk of associated morbidity and mortality. Consequently, using univariate analysis, ETI will often be correlated with a poor outcome (Pepe and Eckstein, 1998; Eckstein et al, 2000). Nevertheless, in certain EMS systems, ETI has been correlated positively with survival, particularly in cases of post-traumatic circulatory arrest, suggesting a clear value in these worst-case scenarios (Copass et al, 1984; Durham et al, 1992).

Despite intuitive biases and these inferential studies indicating the positive effects of prehospital ETI (Copass et al, 1984; Durham et al, 1992; Sirbaugh et al, 1999), several studies have now suggested a detrimental effect or, at least, no significant outcome advantage to the procedure, including a controlled clinical trial in a paediatric population (Pepe and Eckstein, 1998; Gausche et al, 2000; Katz and Falk, 2001; Davis et al, 2003). In that controlled 33.5-month trial of 830 children aged 12 years or younger, neurological outcomes were insignificantly different for 92 of 404 (23%) receiving bag-valve mask (BVM) devices *vs* 85 of 416 (20%) receiving ETI (Gausche et al, 2000). Meanwhile, in another case-control study of

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severely head injured patients, those receiving ETI facilitated by rapid sequence induction had worse outcomes than those not receiving it despite the same degree of injury (Davis et al, 2003). In terms of post-traumatic circulatory arrest, although certain studies indicate a survival advantage to ETI (Copass et al, 1984; Durham et al, 1992), it has been associated in many other investigations with increased mortality (Pepe and Eckstein, 1998; Eckstein et al, 2000).

Based on this discussion, one could even argue that there is no strong scientific evidence for prehospital ETI, in terms of a proven survival advantage, despite the intuitive value of performing it in critically ill and injured patients. However, it is important that ETI itself may not be the problem, but rather the ensuing techniques of ventilatory support. In the following discussion, ETI utilization and outcomes will be reviewed, to better identify the settings in which prehospital ETI attempts should probably be discouraged.

## FACTORS THAT AFFECT SUCCESSFUL PREHOSPITAL ENDOTRACHEAL INTUBATION

It is clear that certain EMS systems have had extremely high rates of success with prehospital ETI placement (Copass et al, 1984; Stewart et al, 1984; Durham et al, 1992; Sirbaugh et al, 1999) while others have not (Gausche et al, 2000; Katz and Falk, 2001). Experience has demonstrated that several factors are strong determinants of success, including:

1. The quality and type of the initial training
2. The frequency of performance
3. On-scene supervision and follow-up of ETI performance (Stewart et al, 1984; Pepe et al, 1990, 1993; Pepe and Eckstein, 1998; Sirbaugh et al, 1999).

In contrast to the typical operating theatre experience, the skill of ETI performed in the emergency setting is fraught with challenges ranging from vomit-flooded airways and ground-level patient positions to problematic ambient lighting and oropharyngeal injuries. With a full stomach, relaxed oesophageal sphincter and inadvertent gastric insufflation from BVM or mouth-to-mouth ventilation, it is common to find the airway filled with vomit. Field suction is often less than adequate or delayed. In turn, this requires significant skill and experience to intubate rapidly without adjuncts.

In bright outdoor settings, the ambient light causes glare and constricts the rescuer's pupils. In these circumstances laryngeal visualization can be improved by placing a coat or blanket over the patient's and intubator's head, to create a makeshift darkroom for ETI, like an old-time photographer. Many of the techniques used by other practitioners in more traditional settings may not be as effective in the prehospital setting. In turn, a key to successful EMS intubation out-of-hospital is training and the experience of medical trainers and EMS medical directors. These experts not only understand these principles, but also are themselves experienced in such techniques in the out-of-hospital setting (Pepe et al, 1990).

Even if initial training is superb, the frequency of ETI performance is a critical factor in outcome. For example, studies have shown the success rates for ETI can be related to the deployment strategy of the EMS system (McManus et al, 1977; Stout et al, 2000). For example, some EMS systems use tiered ambulance deployments in which basic emergency medical technicians are routinely dispatched to the majority of incidents (which are predictably non-critical) and paramedics (who provide advanced life support techniques) are spared for the most critical calls. In such deployment configurations, fewer paramedics are needed on the system-wide roster and the individual experience of each paramedic, including frequency of ETI performance, can be enhanced dramatically. Consequently, this system configuration is correlated with improved success rates with ETI performance (McManus et al, 1977; Stout et al, 2000; Katz and Falk, 2001).

This issue of frequency of experience makes sense, particularly in EMS systems. While ETI skills may deteriorate a little with a break from practice, most prehospital personnel who have performed ETI 100 times or more may still be able to perform the technique well. However, getting to that threshold of experience requires a high exposure and practice level. For a 5-year 'veteran' paramedic to have achieved a successful ETI over 100 times, this would require successful performance of that procedure at least 20 times a year. If experience is shared with a partner, the implication is that this particular team would need to face 40 ETI situations a year on their particular ambulance and shift. With five to six full-time equivalent paramedics required to staff just one ambulance around the clock, that particular response unit would need to face 200–250 ETI cases a year. Considering that cardiac arrest, respiratory distress and major trauma cases requiring ETI constitute only 2–3% of all emergency responses, the ambulance in question would need to experience nearly 10 000 EMS incidents a year, a logistical-temporal impossibility. Therefore, unless alternate deployment strategies can be used (focusing a small cadre of relatively busy paramedics on the most critical cases), the difficulty in individual paramedics gaining enough hands-on ETI experience becomes clear.

Finally, even with appropriate initial training and tiered response systems affording a high frequency of performance, if the on-scene medics in training are not properly supervised, they may still develop habits. It is critical to continuously reinforce proper technique (e.g. sniffing position in those at low risk of neck injury) and to provide renewed coaching in the actual patient care setting, especially in terms of confirmation of tube placement and proper ventilatory techniques. In most EMS systems that provide high rates of ETI success, in-field medical directors, highly experienced EMS supervisors and well-coached veteran paramedics are the norm (Stewart et al, 1984; Pepe et al, 1990, 1993; Sirbaugh et al, 1999).

One of the main implications here is that, in the numerous EMS systems where many paramedics are simultaneously deployed to all emergency cases (and each of them are expected to be capable of rapidly providing ETI), worse outcomes and complications might be expected. In such circumstances, individuals are not only less likely to be experienced, but also less supervised by expert medical mentors because of sheer logistics (Stout et al, 2000). In the EMS system in which the clinical trial of paediatric intubation was conducted (Gausche et al, 2000), more than 2000 paramedics were trained to perform what resulted in being less than 150 annual paediatric intubations during the study period across a large geographical territory. This type of system configuration can make it more difficult for the individual paramedic to get very much exposure to paediatric intubation situations over his/her entire career, let alone any given study period, and it diminishes frequent exposure to medical mentors. Overall, this scenario provides a clear set-up for under-skilled attempts at ETI, be it for children or adults (Stout et al, 2000). Under these circumstances, a strong argument can be made against using ETI or even attempting prehospital ETI, especially in children and spontaneously breathing head-injured patients (Gausche et al, 2000; Davis et al, 2003).

## DETRIMENTAL EFFECTS OF VENTILATORY TECHNIQUES FOLLOWING INTUBATION

If paramedics are well-trained, highly-skilled, highly-experienced and highly-supervised performers of intubation for adults and children, ventilation techniques may still adversely affect outcome from ETI (Pepe et al, 2003; Aufderheide et al, 2004; Roppolo et al, 2004). Patients most in need of intubation (e.g. cardiac arrest, chronic lung disease and severe post-traumatic shock conditions) are the most vulnerable to the negative cardiovascular effects of positive pressure ventilation through the endotracheal tube. Traditionally, EMS personnel have a tendency to over-zealously ventilate such patients in the heat of the emergency (Pepe et al, 2003; Aufderheide et al, 2004; Roppolo et al, 2004). While such patients in deep shock do not require frequent breaths, they are often hyperventilated with excessive levels of assisted breathing, detrimental to outcome (Pepe et al, 2003; Aufderheide et al, 2004; Roppolo et al, 2004).

It is now speculated that low national survival rates for out-of-hospital cardiac arrest and the negative outcomes for several prehospital clinical trials may have been the result, at least in part, of uncontrolled ventilatory minute volumes (Roppolo et al, 2004). Not surprisingly, in the Davis et al study (2003) of severe traumatic brain injury in which emergency ETI was associated with worse outcomes, a key correlation with mortality was 'hyperventilation', defined as an arterial carbon dioxide tension $P\text{CO}_2$ <24 mmHg. Although one might suspect the adverse effects of respiratory alkalosis, such as myocardial depression, cerebral vasoconstriction and a left shift in the oxyhaemoglobin dissociation curve, it is most likely that the low arterial $P\text{CO}_2$ is a surrogate variable for overzealous positive pressure ventilation (Aufderheide et al, 2004).

As Aufderheide et al (2004) have shown, despite aggressive, targeted re-training on respiratory rates and delivery techniques, paramedics still overzealously ventilate patients in the adrenaline-charged environment of a critical emergency. It is possible that this scenario is exaggerated in children, considering that paramedics are taught that paediatric arrests are mostly hypoxaemic in nature. Proscribed respiratory rates are generally higher and emotions run even higher in children's critical emergencies than is adults' (Sirbaugh et al, 1999; American Heart Association Emergency Cardiovascular Care Committee, 2000; Gausche et al, 2000). This may further compound overzealous ventilation, whether intentional or not. In summary, clinical trials indicating worse outcomes with ETI may be confounded by detrimental effects of over-ventilation (Gausche et al, 2000; Roppolo et al, 2004).

## SHOULD ALL EMERGENCY MEDICAL SERVICES SYSTEMS ABANDON PREHOSPITAL ENDOTRACHEAL INTUBATION?

While much of the recent literature discourages out-of-hospital ETI, particularly in children and severe head injury patients, there remain communities that enjoy high success rates for ETI and exceptional patient outcomes. These EMS systems are typified by street-wise training, tiered paramedic ambulance response systems, patient care protocols involving controlled ventilatory rates for critical cases, intensive on-scene medical supervision and follow-up of ETI outcomes (Copass et al, 1984; Pepe et al, 1990; Durham et al, 1992; Sirbaugh et al, 1999). Therefore, ETI should not be discouraged in such appropriate settings. On the other hand, emergency ETI should be discouraged in those EMS systems unable to adequately train or provide frequent performance opportunities and follow-up to facilitate successful ETI.

## CONCLUSIONS

While ETI remains the gold standard for definitive airway management in emergency care circumstances, it may also be inappropriate in prehospital settings if there is an absence of:

1. Paramedic-sparing (skill-enhancing) deployment systems
2. Controlled (physiologically-appropriate) ventilatory techniques
3. Intensive medical supervision that provides street-wise training and follow-up, including expert, on-scene supervision of those EMS personnel providing ETI. HM

## KEY POINTS

- Endotracheal intubation (ETI) is a logical procedure to perform early in the prehospital management of the critically or injured patient.
- Nevertheless, while ETI may very well be life-saving in certain emergency medical services (EMS) systems, particularly in cases of severe trauma with circulatory arrest, ETI may also be detrimental in other EMS systems lacking certain characteristics that facilitate ETI.
- Successful placement and use of ETI is more likely to occur in EMS systems that provide 'street-wise' training, tiered EMS deployment systems and intensive, expert medical oversight, training and on-scene supervision of intubating EMS personnel.
- Even when paramedics are well trained in ETI in the unique environmental conditions of the out-of-hospital setting, inappropriate and overzealous ventilation techniques can still result in detrimental outcomes.
- Systems unable to adopt the appropriate characteristics that optimize ETI should either be discouraged from having it performed or should develop alternative mechanisms to better monitor and ensure routine success with placement and appropriate use.

## POINTS OF AGREEMENT

- Field endotracheal intubation may be life-saving in certain emergency medical services systems.
- Appropriate training, frequent practice and intensive, expert medical oversight lend themselves to more successful performance and use of the endotracheal tube in the out-of-hospital setting.
- Endotracheal intubation is the preferred method to provide airway control and to ensure adequate lung inflation (oxygenation) and appropriate clearance of carbon dioxide.
- The endotracheal tube is simply a tool that can be efficacious if used properly, but can also be detrimental, or even lethal without appropriate placement, verification, and ventilatory techniques.

## POINTS OF DISAGREEMENT

- None

*Conflict of interest: none*


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