

VERIFICATION OF ENDOTRACHEAL TUBE PLACEMENT FOLLOWING INTUBATION

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Verification of endotracheal tube placement is of vital importance since unrecognized esophageal intubation can prove rapidly fatal. Since unrecognized esophageal tube placement is so clearly detrimental, many methods and devices have been explored in an attempt to eliminate this dreaded complication. Verification of placement in the out-of-hospital setting is not always straightforward since the procedure is typically performed under adverse conditions, and is often performed on patients in cardiac arrest. While there are numerous methods and devices utilized for verifying endotracheal tube placement, none have been shown to be 100% reliable. Even the universally

taught clinical signs of esophageal intubation are often misleading.

Given the efficacy of devices such as the electronic end-tidal carbon dioxide (ETCO₂) detector in the operating suite, the American Society of Anesthesiology has included ETCO₂ detection in their "Standards for Basic Intra-operative Monitoring."¹ This action, combined with the ready availability of inexpensive devices, has established ETCO₂ detection as the standard of care for endotracheal intubation in the hospital.²

The purpose of this paper is to state the position of the National Association of EMS Physicians on the use of adjuncts to verify endotracheal tube placement. The paper reviews current methods for out-of-hospital endotracheal intubation and uses an evidence-based appraisal of the medical literature to support the recommendations. Methods are presented and discussed in the temporal order used by field providers during patient care.

METHODS OF VERIFICATION

The methods of endotracheal tube placement verification are listed in Table 1. Direct visualization is usually used before all other methods. By visualizing the tube as it is passed through the cords, the thinking is that the operator can be reasonably assured that the tube has been placed in the trachea. Visualization

of cuff inflation distal to the cords is thought to offer additional evidence of proper placement.³ Problems arise if the cords are not visible or if the tube becomes dislodged either before or after it has been secured. Inadvertent esophageal intubation has been reported in cases where the operator "visualized" tube passage through the cords and was almost certain of endotracheal placement.⁴ For this reason, direct visualization cannot be relied on as the sole method for verifying placement.

It is essential that the operator hold on to the tube with strict attention to maintaining the proper depth of insertion until the tube can be secured. Neck flexion has been associated with 3–5 cm of endotracheal tube movement, which can result in tube dislodgment.⁵ Some EMS agencies attempt to address this problem by providing long-board immobilization of intubated patients. Regardless of whether or not immobilization is used, personnel should periodically reverify tube placement, especially after patient movement.

Esophageal Detector Device

The esophageal detector device (EDD), consisting of either a self-inflating bulb or a 60-mL syringe, has become a widely used method of verification.⁶ The technique relies on the fact that the trachea is rigid and permits free aspiration of air from

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the pulmonary dead space. Conversely, aspiration from the esophagus causes collapse of the esophageal wall and delayed or absent reinflation. To take full advantage of anatomic differences, the EDD should be used immediately after tube placement, prior to delivering the first breath. If ventilation is performed prior to aspiration, rapid reinflation may occur regardless of tube location.⁶

When used in the operating room, the EDD appears to be highly sensitive and specific in distinguishing tracheal from esophageal tube placement.⁷ This finding has also been confirmed in a randomized trial using a cadaver model.⁸ The EDD appears to be reliable when used in the operating room for detecting tube placement in children and in patients with nasogastric tubes in place.⁹ The EDD appears less reliable in confirming appropriate tube placement when used by paramedics, with only a 50% accuracy in detecting esophageal placement.¹⁰

Therefore, the optimal use of the EDD is as an adjunct to other methods. The information obtained is highly dependent on the experience of the observer.¹¹ If the esophageal detector device indicates esophageal placement, the endotracheal tube should be removed and reinserted under direct visualization, unless the EDD information can be overruled by other techniques.

Observational Methods

Reliability of the widely taught observation of chest movement with bag ventilation as a means of verifying correct placement has been called into question. In theory, there should be chest excursion with ventilation. However, obesity and lung disease may impede chest excursion, while esophageal intubation may produce some degree of chest movement.¹¹⁻¹⁵ Auscultation of breath sounds in both axillae may result in misdiagnosis of up to 15% of all esophageal intubations.¹⁶

Air passage through the esophagus may produce audible sounds that can be mistaken for breath sounds. Auscultation of epigastric sounds may improve accuracy, since in theory, air movement into the stomach should occur with esophageal intubation and ventilation. This technique is not 100% reliable, since gastric distention is a gradual phenomenon, and may be due to previous bag-valve-mask ventilation, regardless of tube placement.^{17, 18}

Another technique is to note the presence of exhaled tidal volumes. This is based on the recoil of the lung producing passive exhalation following forced inhalation.¹⁹ Reservoir bag compliance is theoretically related to the degree of lung resistance, and is taught as a means of verifying placement.²⁰ However, this is highly variable and respirator bag compliance with either esophageal or endotracheal tube insertion is inconsistent.^{12, 13, 16, 19, 20}

A variety of endotracheal tube cuff maneuvers have been purported to help determine tube placement. During cuff deflation, if high-pitch sounds are heard, the tube may be thought to be in the trachea, while low-pitch sounds may indicate esophageal intubation. Owing to its unreliability, this technique cannot be recommended.¹² Another endotracheal tube cuff maneuver is to palpate the endotracheal tube cuff in the neck by compressing the external air reservoir. In theory, compression of the reservoir results in tube cuff hyperinflation, which can be palpated through the neck. This technique has been used to ascertain proper tube insertion depth but is unreliable in distinguishing esophageal from endotracheal tube placement.²⁰

In theory, tube condensation with exhalation and clearing with ventilation might be used to verify placement; however, the presence or absence of this is extremely unreliable. One dramatic observation that mandates immediate tube removal is when gastric contents are observed in the endotracheal tube. One

TABLE 1. Methods Used to Confirm Endotracheal Tube Placement

Observed
Direct visualization
Observation of chest movement
Auscultation of breath sounds
Absence of epigastric sounds with respiration
Presence of an exhaled tidal volume
Reservoir bag compliance
Endotracheal cuff maneuvers
Absence of air escape
Tube condensation with exhalation
Absence of gastric contents within the tube
Measured
Pulse oximetry
End-tidal carbon dioxide measurement
Esophageal detector device

should be cautioned that this, too, may be unreliable, since gastric contents may be in the tracheal from previous aspiration.²¹

Pulse Oximetry

Pulse oximetry may be used if there is a perfusing rhythm. Following intubation, prolonged high saturation is a reliable indicator of endotracheal intubation, whereas a gradual drop might indicate esophageal intubation. A delayed drop following esophageal intubation may be seen with vigorous preoxygenation. Even with esophageal intubation, adequate oxygen saturation persists for up to 5 minutes despite the absence of lung ventilation.^{12, 16, 22} Pulse oximetry requires adequate peripheral perfusion, and is of limited utility in shock, hypovolemia, and other conditions characterized by peripheral vasoconstriction.

End-tidal Carbon Dioxide Detection

In patients with a perfusing rhythm, ET_{CO}₂ detection is the most reliable method for verifying tube placement.²³ This measurement is highly accurate in verifying tube placement in patients with a perfusing rhythm. The technique is less reliable in low-perfusion states such as cardiac ar-

rest. During cardiac arrest, endotracheal tube placement may result in a "falsely" low ETCO_2 reading due to the minimal blood return to the lungs, resulting in an unacceptably high false-negative rate. If a high ETCO_2 reading is seen, endotracheal placement is assured.²⁴ The basic methods of ETCO_2 detection include qualitative colorimetric and quantitative digital measurements. The digital quantitative method yields much more information than the basic colorimetric device in terms of physiologic status and arterial CO_2 saturation; however, the colorimetric method appears to be adequate in verifying tube placement.

Please note that the colorimetric devices simply measure the presence of CO_2 , whereas quantitative methods generate a waveform that can be correlated with the respiratory cycle. The threshold for detection of exhaled CO_2 is approximately 15 mm Hg for the colorimetric capnometer, whereas a detectable waveform may be seen at much lower levels of exhaled CO_2 with capnography.²⁵ The four-phase capnography waveform should include the respiratory baseline, expiratory upstroke, expiratory plateau, and inspiratory downstroke. The presence of this waveform, no matter how small, provides compelling evidence of endotracheal placement.

RECOMMENDATIONS

NAEMSP recommends adoption of the following:

- No single technique is 100% reliable under all circumstances.
- EMS providers should receive training to use specific methods for the verification of endotracheal tube placement in conjunction with advanced airway training.
- Each EMS system should implement endotracheal tube placement verification protocols and use ongoing performance improvement to assure compliance.
- Clinical observation, as a sole

means of verifying endotracheal tube placement, is not uniformly reliable. EMS services performing endotracheal intubation should be issued equipment for confirming proper tube placement.

- In the patient with a perfusing rhythm, end-tidal CO_2 detection is the best method for verification. In the absence of a perfusing rhythm, capnography may be extremely helpful, and may be superior to colorimetric methods.
- The esophageal detector device may be unreliable in certain clinical setting and should be used as an adjunct to other confirmatory methods.
- Tube verification should be performed by the EMT based on accepted standards of practice while taking into account whether the patient has a perfusing rhythm. Verification methods should include a combination of clinical signs and the use of adjunctive devices such as the presence of exhaled carbon dioxide and esophageal detection devices.
- Once placement has been confirmed, the endotracheal tube should be secured.
- Confirmation of tube placement is a dynamic process requiring ongoing patient assessment.
- Reconfirmation should be performed any time the patient is moved, or if tube dislodgment is suspected.

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