

# CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT

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Endotracheal intubation is a potential minefield for disaster. Errors in its performance can be associated with high morbidity and mortality for the patient and legal liability for the practitioner. Verification of Endo Tracheal Tube (ETT) placement is of vital importance since unrecognized esophageal intubation can prove rapidly fatal or result in hypoxic brain damage in survivors.

There are numerous methods and devices utilized for verifying endotracheal tube placement. However none has been shown to be 100% reliable. Even the universally taught clinical signs of esophageal intubation are often misleading. Verification of placement in the out of hospital setting is not always straight forward since the procedure is typically performed under adverse conditions after a cardiac arrest.

## **Verification methods**

Although direct visualization of ETT passing through vocal cords is generally considered to be a reliable indicator of tracheal intubation, such clinical anatomic observations are fallible and so additional means are required to ensure correct placement of tube within the trachea.

Traditional methods, such as chest auscultation, gastric auscultation, bag resistance, exhaled volume, visualization of condensation within ETT and Chest radiography, all are prone to failure as means of confirming tracheal intubation <sup>[1]</sup>.

## **Methods available to confirm ETT Placement**

### **I. Observational verification**

1. Direct visualization
2. Observation of chest movement
3. Five point auscultation
4. Presence of exhaled tidal volume
5. Reservoir bag compliance
6. Absence of air escape
7. Tube condensation with exhalation
8. Absence of gastric contents within the ETT

These methods are amenable to subjective variations.

### **II. Measured verifications**

1. End-tidal Carbon dioxide (ETCO<sub>2</sub>)
2. Esophageal Detector Device (EDD)
3. Pulse Oximeter

These methods are more objective type

### **III. Anatomical verification**

1. Chest radiograph
2. Lighted stylet

3. Ultra-sonography (USG)

4. Fibro optic Bronchoscope / Laryngoscope

**Merits and demerits of conventional verification methods**

METHODS OF VERIFICATION	DEMERITS
<p><b><u>Direct visualization</u></b> is usually used before all other methods and the visualization of cuff inflation distal to cords is thought to be offer additional evidences of proper placement <sup>[2]</sup></p>	<ul style="list-style-type: none"> <li>• Non visualization of cords</li> <li>• Dislodged tube (before / after securing)</li> <li>• Inadvertent esophageal intubation after direct vision intubation <sup>[3]</sup></li> </ul>
<p><b><u>Chest Movement</u></b> There should be adequate chest rise in a properly placed ETT with bag ventilation</p>	<ul style="list-style-type: none"> <li>• Obesity - decreased or absent chest excursion</li> <li>• Lung diseases - decreased or absent chest excursion</li> <li>• Esophageal intubation does produce some degree of chest movement <sup>[4,5]</sup></li> </ul>
<p><b><u>Auscultation – Axilla</u></b></p>	<p>Breath sounds may be heard in both axillae but may result in misdiagnosis in up to 15 % of all esophageal intubations. <sup>[6]</sup></p>
<p><b><u>Epigastic Auscultation</u></b> May prove accuracy</p>	<ul style="list-style-type: none"> <li>• Not 100% reliable</li> <li>• Gastric distention is gradual due to previous bag mask ventilation</li> </ul>
<p><b><u>Exhaled tidal volume and reservoir bag compliance</u></b></p>	<ul style="list-style-type: none"> <li>• Highly variable and respirator bag compliance with either esophageal or endotracheal tube insertions inconsistent <sup>[7,8]</sup></li> </ul>
<p><b><u>Endotracheal tube cuff maneuvers</u></b> Hearing high pitched sounds during cuff deflation in tracheal placements and palpation of ETT cuff in the neck by</p>	<ul style="list-style-type: none"> <li>• Techniques are unreliable in distinguishing tracheal from esophageal tube placements.</li> </ul>

compressing external reservoir.	
<b><u>Tube condensation</u></b>	<ul style="list-style-type: none"> <li>• Extremely unreliable</li> </ul>
<b><u>Gastric Content in tracheal tube</u></b>	<ul style="list-style-type: none"> <li>• Considered unreliable<sup>[9]</sup></li> </ul>

### **End tidal CO2 detection**

CO2 detection in exhaled air using devices (colorimetric CO2 detector, Capnograph - Digital or wave form) after six manual ventilations through ET tube is used to confirm tube placement. End tidal CO2 detection is highly reliable in identification of tracheal and esophageal intubation in patients with spontaneous circulation<sup>[10]</sup>.

Detection of exhaled CO2 is one of the several independent methods of confirming endotracheal tube position and it can be used as the initial method for detecting correct tube placement even in the victims of cardiac arrest (Class IIa)<sup>[11]</sup>. In cardiac arrest a CO2 level > 2 % should be considered definitive evidence of correct ETT placement, but the absence of such CO2 cannot be used reliably as an indicator of esophageal intubation.<sup>[37]</sup>

One meta analysis in adult (LOE 1)<sup>[13]</sup>, one prospective controlled cohort study (LOE 3)<sup>[14]</sup>, and several case series and reports (LOE 5)<sup>[15, 22]</sup>, indicate that CO2 detection (wave form, colorimetry, or digital) may be useful as an adjunct to confirm ET tube placement during cardiac arrest.

Sensitivity – (Percentage of correct ET tube Placement detected when CO2 is detected) –

**33 to 100 %**)

Specificity – (Percentage of in correct esophageal placement detected when no CO2 is detected)

– **97 to 100 %**

Positive predictive value (Probability of ET tube placement if CO2 is detected) **100 %**

Negative predictive value (Probability of esophageal placement if no CO2 is detected) **20-100%**

The threshold to detect exhaled CO2 is approximately 15 mmHg for the colorimetric capnometer, where as a detectable waveform may be seen at much lower levels of CO2 with capnography<sup>[23]</sup>. Capnography is the most reliable method for detecting tube position, independent of user's experience<sup>[24]</sup>. When exhaled CO2 is detected (Positive reading) in

Cardiac arrest, it is a reliable indicator of tube position in trachea. Consumption of large amount of carbonated liquids before cardiac arrest may cause false positive reading in esophageal intubation [25].

False negative reading (Failure to detect CO<sub>2</sub> when tube is in the trachea) may be due to

- 1) Low Blood flow and CO<sub>2</sub> delivery to lung (CPR)
- 2) Pulmonary embolism – decreased pulmonary blood flow
- 3) Contaminated detector – gastric content and acidic drugs like epinephrine when administered through trachea.
- 4) IV epinephrine will reduce elimination and detection of CO<sub>2</sub> [26]
- 5) Severe airway obstruction
- 6) Status Asthmatics
- 7) Pulmonary Edema

So if CO<sub>2</sub> is not detected, a second method should be used to confirm endotracheal tube placement, such as direct visualization or esophageal detection device [11]. Digital or waveform capnography is very useful to monitor tube position continuously.

### **Esophageal detector devices (EDD)**

**Principle** : This is based on the anatomical differences between the trachea and esophagus. Esophagus is a muscular structure with no support within its wall. Trachea is held patent by cartilaginous rings. Vigorous aspiration of air through ETT with deflated cuffs result in occlusion of ETT orifices by soft walls of the esophagus, where as aspiration is rapid and easy if the tube is in trachea.

The EDD consists of a bulb that is compressed and attached to ET tube or a syringe that is attached to ETT. The suction created by the EDD will collapse lumen of the esophagus and the bulb will not re expand. If the rescuer attempts to pull the barrel of the syringe, it will not be possible to pull the barrel, if tube is in esophagus.

Eight studies of at least fair quality evaluated the accuracy of EDD (LOE 3 <sup>[20, 28, 29]</sup>, LOE 5 <sup>[30]</sup>, LOE 7 [non cardiac arrest setting] <sup>[31-34]</sup>). EDD was highly sensitive for detection of esophageal intubation in 5 case series (LOE 5 <sup>[30]</sup>, LOE 7 <sup>[31-34]</sup>.) and it had poor specificity for tracheal tube placement in 2 studies (LOE 3 <sup>[20, 29]</sup> in Operation Theatre setting. EDD had poor sensitivity and specificity in children < 1 year of age (LOE 2) <sup>[35]</sup>

So EDD should be considered as just one of the several independent methods for confirmation of tube placement. EDD is more specific to confirm esophageal tube placement than Tracheal Tube placement. EDD is not accurate for continuous monitoring of ET Tube placement.

EDD will be misleading in the following situations.

- 1) Morbid obesity
- 2) Late pregnancy
- 3) Status Asthmaticus
- 4) Copious ET Secretions
- 5) Tracheal collapse

### **Pulse oximetry**

Oximetry is useful in detecting esophageal intubation. But it may not show a decreasing Oxygen (O<sub>2</sub>) saturation for several minutes after failed intubation because of the O<sub>2</sub> reserve (Pre oxygenation) created in the patient before intubation <sup>[36]</sup>. Oximetry may be misleading in spontaneously breathing patient who has had an inadvertent esophageal intubation. The catastrophe ensues if the patient is later paralyzed or heavily sedated in the mistaken belief that the tube is in the trachea.

### **Chest Radiography**

Although chest radiography is universally recommended after ETT placement, its primary purpose is to ensure its position below the cords and above the carina <sup>[37]</sup>. An antero-posterior film will not rule out an esophageal tube placement.

### **Other methods**

**Lighted stylet:** Is not accurate and there is as yet no evidence to support its use to confirm tracheal tube placement. Few studies show the usage of **USG**, to confirm tube placement <sup>[38-42]</sup> Bed side ultrasonographic images proved to be invaluable when the colorimetric end-tidal CO<sub>2</sub> detector yielded false negative or equivocal reading <sup>[43]</sup> but required more evidence to recommend it as a confirmation method for ET tube placement. In doubtful cases a **fiber-optic scope** can be passed through ETT to identify tracheal rings, a gold standard for confirmation of tracheal placement <sup>[37]</sup>.

### **International recommendation**

**1) Emergency Medicine Journal March 2001 <sup>[44]</sup>**

*Independent confirmation of correct tube placement by the use of devices that detect end-tidal CO<sub>2</sub> is mandatory for every endotracheal intubation performed in the emergency department and as part of the assessment of all patients who arrive at the emergency department already intubated.*

**2) American College of Emergency Physicians (ACEP) October 2001 <sup>[45, 46]</sup>**

*During intubation, direct visualization of the endotracheal tube passing through the vocal cords into the trachea constitutes firm evidence of correct tube placement, but should be verified with additional techniques.*

*End-tidal CO<sub>2</sub> detection, either qualitative, quantitative, or continuous, is the most accurate and easily available method to monitor correct endotracheal tube position in patients who have adequate tissue perfusion.*

**3) National Association of EMS Physicians (NAEMPS) – Position statement 1999 <sup>[47]</sup>**

*In the patient with a perfusing rhythm, end-tidal CO<sub>2</sub> detection is the best method for verification.*

**4) American Heart Association (AHA) Protocol for advanced cardiac life support. 2002 and 2005 <sup>[48]</sup>**

*Expired CO2 detectors are very reliable in patients with perfusing rhythm and are recommended to confirm tube position in these patients (Class IIa).*

**5) Association of Anesthetists of Great Britain and Ireland and American Society for Anesthesiologists (ASA) <sup>[12, 48]</sup>**

*Capnography is essential to the safe conduct of anesthesia*

*Continual monitoring for the presence of expired carbon dioxide shall be performed unless invalidated by the nature of the patient, procedure or equipment*

**6) NRP (Neonatal Resuscitation Protocol) Guidelines 2006. Consensuses on sciences;**

*Exhaled CO2 detection is reliable indicator of ETT placement in infants and it identifies esophageal intubation faster than clinical assessment. (Aziz J perinatol 1999, Bhende, Pediatrics 1995, Repetto, J Perinatol 2001, Roberts, Pediatric Pulmonl 1995)*

*NRP recommends using exhaled CO2 detection to confirm tracheal tube placement.*

An “eye opening” survey was conducted among Emergency Physicians and **NEAR** centers (Institutes committed to monitoring current airway practices) shows that, despite the recommendations issued by various National organizations that endorse continues monitoring of ET CO2 for confirming ET tube placement, it is *neither widely available nor consistently applied* <sup>[49]</sup>

### **Conclusion**

Confirmation of proper tracheal tube placement is as important as successful intubation. Exhaled CO2 detection is reliable and should be considered the standard for confirmation of tracheal placement of an ETT and for early detection of accidental esophageal intubation. Aspiration devices have at best a secondary role. The Emergency physician should make sure the availability of ET CO2 detection in ER and with EMS team when they are in the field. They should also ensure usage of confirmation devices by the concerned persons.



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