Title: Colorimetric Carbon Dioxide Detectors for Use in Intubated Patients: Clinical and Cost Effectiveness and Guidelines for Use

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Research question:

1. What is the clinical effectiveness of single use disposable colorimetric carbon dioxide detectors for the measurement of carbon dioxide levels and verification of endotracheal tube placement in intubated patients?

2. What is the cost effectiveness of single use disposable colorimetric carbon dioxide detectors for the measurement of carbon dioxide levels and verification of endotracheal tube placement in intubated patients?

3. What are the guidelines for use of single use disposable colorimetric carbon dioxide detectors in intubated patients?

Methods:

A limited literature search was conducted on key health technology assessment resources, including PubMed, the Cochrane Library (Issue 1, 2008), University of York Centre for Reviews and Dissemination (CRD) databases, ECRI, EuroScan, international HTA agencies, and a focused Internet search. Results include articles published between 2003 and May 2008, and are limited to English language publications only. No filters were applied to limit the retrieval by study type. Internet links are provided, where available.

The summary of findings is based only on information contained within the relevant abstracts.

Results:

HTIS reports are organized so that the higher quality evidence is presented first. Therefore, health technology assessment reports, systematic reviews and meta-analyses are presented first. These are followed by economic evaluations, randomized controlled trials (RCTs), observational studies, and evidence-based guidelines.
Four observational studies and four guidelines were identified pertaining to the clinical effectiveness of colorimetric carbon dioxide detectors for the measurement of carbon dioxide levels and verification of endotracheal tube placement in intubated patients. No relevant health technology assessments, systematic reviews, economic studies, or RCTs were identified. Additional information that may be of interest has been included in the Appendix.

**Overall summary of findings:**

**Observational studies**

Four observational studies were identified.

Singh *et al.* evaluated the NBP-75® quantitative handheld microstream capnometer.\(^1\) Children aged birth to 15.3 years (n=50) who were intubated during transport to hospital were prospectively enrolled into the study. The device successfully confirmed endotracheal tube (ETT) placement during transportation in all patients. There were no reports of false-negative readings, occlusion, or kinking of tubing. The majority of users confirmed the device was both a good size and easy to use and all users agreed the device was useful during transport. The authors concluded that the capnometer was useful in a pre-hospital setting and it provided critical quantitative and graphic real-time detection of end-tidal carbon dioxide (ETCO\(_2\)).

Bair *et al.* conducted a retrospective review of the emergency medical services (EMS) quality assurance database to examine the use of pre-hospital confirmation techniques used in cases where improper ETT placement was discovered upon hospital examination.\(^2\) During the 65 month study period, 1643 intubations were preformed, 35 (2\%) of which were deemed non-tracheal. Of the improper intubations, paramedics used multiple confirmatory techniques in 21 (60\%) patients. The most common techniques used were 'equal lung sounds' (91\%), followed by 'visualized cords' (52\%). In patients with pulses (20 of 35), per-protocol colorimetric ETCO\(_2\) was measured in 9 (45\%) patients. Overall, the authors concluded that more frequent use of multiple ETT placement confirmation techniques, including colorimetric ETCO\(_2\), may help reduce the occurrence of improperly positioned ETTs.

Jones *et al.* prospectively quantified the number of unrecognized improperly placed ETTs during pre-hospital treatment by paramedics.\(^3\) ETT placement was verified by emergency physicians using a combination of direct visualization, esophageal detector device, colorimetric ETCO\(_2\), and physical examination. During, the study period of 6 months, 208 pre-hospital intubations were performed, 12 (5.8\%) of which were placed outside of the trachea. A verification device, either an esophageal detector device or a colorimetric ETCO\(_2\) device, was used in 3 (25\%) of the improperly placed cases.

Rabitsch *et al.* evaluated the effectiveness and safety of the Colibri™ colorimetric breath indicator in 147 intubated patients who were under general anaesthesia, critically ill, undergoing pre-hospital transport, or patients under long-term ventilation receiving a second esophageal tube.\(^4\) The Colibri™ breath indicator was useful for all indications studied and showed no false negative results in the group with tubes inserted into the trachea and esophagus. The authors concluded that the Colibri™ indicator may be a useful tool for verifying the positioning of ETTs.
Guidelines

Four guidelines were identified. Brief summaries have been provided and links to the full guidelines are included in the reference list. It is recommended that the guidelines be viewed for more complete information on recommendations, benefits and harms.

The 2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care were identified in the search.\textsuperscript{5,6} In the section for monitoring and medications, the guidelines state that ETCO\textsubscript{2} monitoring is a safe and effective noninvasive indicator of cardiac output during CPR and in intubated patients, may be an early indicator of both ETT placement and return of spontaneous circulation.\textsuperscript{5} However, the utility of colorimetric carbon dioxide detectors is not specifically discussed. In the section describing adjuncts for airway control and ventilation, the guidelines recommend that both clinical assessment and ETCO\textsubscript{2} or esophageal devices should be used to verify ETT placement immediately after insertion and when the patient is moved.\textsuperscript{6} The guidelines also state that there is currently no conclusive evidence that identifies a single device as both sensitive and specific for ETT placement. Therefore, all confirmation devices should be considered adjuncts to other confirmation techniques. Additionally, the guidelines indicate that exhaled CO\textsubscript{2} detectors (waveform, colorimetry, or digital), are useful adjuncts in the initial verification of correct tube placement during cardiac arrest. Since many factors may cause false negative results, the guidelines recommend that if CO\textsubscript{2} is not detected, a second method should be used to confirm ETT placement, such as direct visualization or an esophageal detector device. Furthermore, these devices have not been adequately studied in advanced airways such as the Combitube\textregistered.

The 2003 American Association for Respiratory Care guidelines recommend that capnography should be used as an adjunct for determining that tracheal rather than esophageal intubation has taken place and states that colorimetric CO\textsubscript{2} detectors are adequate for this purpose.\textsuperscript{7}

Recommendations from a 2005 International Consensus Conference on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care state that in intubated pediatric patients with a perfusing cardiac rhythm (both in pre-hospital and hospital settings), verification of tube placement via colorimetric CO\textsubscript{2} detection is appropriate.\textsuperscript{8} Monitoring should be either continuous, or frequently intermittent during pre-, inter-, or intra-hospital transport. However, it is recommended that during cardiac arrest, if exhaled CO\textsubscript{2} is not detected, that tube position should be confirmed using direct laryngoscopy.
References summarized:

**Health technology assessments**
None identified

**Systematic reviews and meta-analyses**
None identified

**Economic analyses and cost information**
None identified

**Randomized controlled trials**
None identified

**Observational studies**


**Guidelines and recommendations**


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Appendix – Further information:

Observational studies


Review articles


Additional references


