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Review

Use of end-tidal carbon dioxide detection to determine correct placement of nasogastric tube: A meta-analysis

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ABSTRACT

Objective: To review the diagnostic accuracy of end-tidal carbon dioxide detection in detecting inadvertent airway intubation and verifying correct placement of nasogastric tubes.
Design: We undertook a meta-analysis of diagnostic studies.
Study selection: All clinical trials that evaluated the diagnostic accuracy of the colorimetric capnometry or capnography in detecting inadvertent airway intubation and differentiating between respiratory and gastrointestinal tube placement in adults were included. Electronic databases including MEDLINE, CINAHL, EMBASE, All EBM Reviews, WanFang Data, China Journal Net, Chinese Medical Current Contents, and Index to Chinese Periodical Literature were searched from inception to July 2009.
Data extraction and quality assessment: Data were extracted using a form piloted prior to use. Two reviewers independently extracted data relating to purpose of the trial, sample, measurements used, index test results and reference standard. Methodological quality of eligible trials was assessed independently by two reviewers using a modified version of the Quality Assessment of Diagnostic Accuracy Studies for assessing studies of diagnostic accuracy. The accuracy of diagnostic tests is presented in terms of sensitivity, specificity, predictive values, and likelihood ratios.
Data synthesis: Nine clinical trials were eligible for inclusion in the meta-analysis. Eight trials were undertaken in intubated and mechanically ventilated patients and two trials also involved participants who were alert or awake. Eight involving a total of 456 nasogastric feeding tube placements investigated the diagnostic accuracy of either colorimetric capnometry or capnography to detect feeding tube placement. One trial involving 195 gastric tube insertions compared the diagnostic accuracy of simultaneous use of a colorimetric carbon dioxide detector and capnography to detect feeding tube placement. The use of colorimetric capnometry or capnography had a sensitivity ranging from 0.88 to 1.00, specificity 0.95 to 1.00, positive likelihood ratio 15.22 to 283.35, negative likelihood ratio 0.01 to 0.25. A summary receiver operator characteristics (SROC) curve was constructed and showed an area under the curve was 0.9959. Three trials reported significant cost savings using end-tidal carbon dioxide detectors.
Conclusions: There is evidence to support the use of capnography or colorimetric capnometry for the identification of nasogastric feeding tube placement in mechanically ventilated patients.

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What is already known about the topic?

- Inadvertent airway intubation during nasogastric tube insertion can be fatal.
- End-tidal carbon dioxide ($ETCO_2$) monitoring using colorimetric capnometry or capnography is sometimes used in mechanically ventilated patients to differentiate between respiratory and gastrointestinal placement of feeding tubes.
- There has been no systematic review on the effectiveness of $ETCO_2$ monitoring in determining correct placement of nasogastric tubes.

What this paper adds

- There is evidence to support the use of colorimetric capnometry or capnography for the identification of feeding tube placement in mechanically ventilated patients.
- Future trials should assess the potential beneficial impact of using $ETCO_2$ monitoring in clinical settings.
- More clinical trials are needed to determine the accuracy of $ETCO_2$ monitoring in non-intubated and non-mechanically ventilated patients.

1. Introduction

Nasogastric (NG) tubes are often used in the clinical management of patients requiring decompression, assessment, enteral feeding and medication administration. Respiratory (pulmonary aspiration) and tube-related (tube displacement/dislodgement, tube occlusion, nasopharyngeal trauma) complications are not uncommon (Leder and Suiter, 2008; Weinberg and Skewes, 2006; Wu et al., 2006).

Insertion of the NG tube requires skill and expertise. During initial tube insertion, misplacement includes brain, esophagus, peritoneum, intestine (Burns et al., 2001), and the respiratory tract (Sanaka et al., 2004). Inadvertent airway intubation during NG tube insertion can be fatal (Weinberg and Skewes, 2006). Displacement can occur with both large- and small-bore tubes, though small-bore tubes dislocate easily, often into the respiratory tract and with no external sign of displacement (Sanaka et al., 2004), and are prone to coiling (Swiech et al., 1994). Therefore, assessment of tube position is necessary to minimize the risks of tube-related complications and provide for optimal patient safety and comfort. A wide range of bedside methods such as observing for cough and choking, auscultation of air insufflated through the tube, aspiration of fluid (Rakel et al., 1994), visual inspection of the aspirates (Metheny et al., 1994), testing of aspirates for pH or concentrations of bilirubin, pepsin or trypsin (Metheny et al., 1997), observing for bubbling when the tip of the tube is held under water, testing the ability to speak, the use of magnetic detection (Tobin et al., 2000), spring gauge pressure manometer (Swiech et al., 1994), radiography, and end-tidal carbon dioxide ($ETCO_2$) monitoring using capnography or colorimetric capnometry (Howes et al., 2005; Kindopp et al., 2001) have been used to assess tube location. The objective of this systematic review was to investigate the diagnostic accuracy of $ETCO_2$ monitoring in detecting inadvertent airway intubation and verifying correct placement of NG tubes.

2. End-tidal carbon dioxide ($ETCO_2$) monitoring

End-tidal carbon dioxide ($ETCO_2$) monitoring using capnography or colorimetric capnometry is sometimes used in mechanically ventilated patients to differentiate between respiratory and gastrointestinal (GI) placement of feeding tubes (Frakes, 2001). Capnography comprises the continuous analysis and recording of carbon dioxide concentrations [CO_2] in respiratory gases. Capnographs use infrared technology to detect CO_2 and the result is expressed as partial pressure in millimetres of mercury. Flow waveform will also be displayed in capnographs showing the level of CO_2 detected. Although the terms capnography and capnometry are sometimes considered synonymous, capnometry suggests measurement without a continuous written record or waveform.

Colorimetric $ETCO_2$ devices use a phenol sulfonephthalein-impregnated pH-sensitive filter paper as an indicator and, in the presence of CO_2, will change from purple (indicating room air) to yellow (2–5% CO_2) (Jaffe, 2004; Nellcor Puritan Bennett, Inc., 2005).

2.1. Review questions

1. What is the diagnostic accuracy of $ETCO_2$ monitoring in correctly identifying tubes intentionally located in the airway?
2. What is the diagnostic accuracy of $ETCO_2$ monitoring in correctly differentiating between respiratory and GI tube placement?

2.2. PICO model

We used the PICO model to formulate the review question.

Population: All clinical trials that evaluated the diagnostic accuracy of the colorimetric capnometry or capnography in detecting inadvertent airway intubation and differentiating between respiratory and GI tube placement in adults.
Index tests: Colorimetric capnometry or capnography.
Comparison: Radiography, direct visualization or under direct endoscopic guidance, aspiration of stomach content, auscultation of air.
Outcome: The incidence of tube placement, the ability of the index test to identify correct placement of the NG tubes, the ability of the index test to identify respiratory placement of NG tubes.

3. Methods

3.1. Data sources and searches

Reports in English were considered in this review. Given that two of the reviewers were able to translate publications in the Chinese language, reports in Chinese