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[Diagnostic Test Accuracy Protocol]

Carbon dioxide detection for testing nasogastric tube placement in adults

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ABSTRACT

This is the protocol for a review and there is no abstract. The objectives are as follows:

To determine the diagnostic accuracy of capnometry and capnography for detecting correct NGT placement in adults compared to the reference standard.

BACKGROUND

Target condition being diagnosed

The insertion of a nasogastric tube (NGT) is the passage of a tube, appropriate for its intended purpose, via the nostril into the stomach (National Institute for Clinical Excellence 2006). NGTs are used within clinical practice for a variety of reasons including: decompression, following gastric surgery, patient assessment, administration of drugs, enteral feeding, and fluid administration. This is an extremely common clinical intervention, with an estimated one million tubes being purchased per annum in England and Wales alone (Hanna 2010). Although the majority of these tubes are inserted and used without incident, there is a recognised risk that the tube can be misplaced into the lungs, or move out of the stomach. Published reports of incidents have included oesophageal, peritoneal and intestinal placement, and NGTs placed within the brain (Burns 2001). Additionally, severe pulmonary complications, indeed deaths, have been reported as a direct result of NGT placement within the respiratory tract (Miller 2011). Between September 2005 and March 2010, 21 deaths and 79 cases of harm relating to feeding through misplaced NGTs were reported in the UK (National Patient Safety Agency 2011a).
Confirmation of NGT placement is required immediately following insertion and subsequently prior to each use, for example, administration of enteral feed or medication. Additionally, the tube should be checked following episodes of vomiting, retching or coughing spasms, after oropharyngeal suction has been required, every four hours during regular feeding or where there is a suggestion of tube displacement (American Association of Critical Care Nurses 2009). Any new or unexplained respiratory symptoms or a drop in oxygen saturation readings is a further indication for seeking repeated confirmation of NGT placement (Durai 2009).
There are various methods used to determine NGT position, including bedside assessment and observing for signs of respiratory distress. Air insufflated (blown) through the NGT in combination with epigastric ausculation (listening to the stomach with a stetho-

scope) for whooshing sounds has also been used (Fletcher 2011). Although these tests are widely known about, they are not officially recommended for use as standalone measures of NGT placement. Current guidelines from the American Association of Critical Care Nurses 2009 and National Patient Safety Agency 2011b recommend a combination of aspirate testing and radiological confirmation. In a small number of patients for whom the NGT has been placed under direct vision of an anaesthetist or surgeon, it is possible to forego chest x-ray confirmation (National Patient Safety Agency 2011b). Observing the characteristic of fluid aspirate can be used, with gastric secretions differing in colour and consistency to those obtained from tracheal, bronchial or intestinal secretions (Metheny 2001). In addition to this subjective approach, objective measures of aspirate pH can be used to assess NGT placement. A pH reading of between 1 to 5.5 is considered a reliable method for excluding placement in the pulmonary tree (National Patient Safety Agency 2011a). The ability to obtain gastric aspirate may not be achievable in up to 65% of patients (Hanna 2010). Concurrently, radiography or direct visualisation are considered the only reliable methods of confirming NGT placement (Elpern 2007; National Patient Safety Agency 2011b).

Index test(s)

The measurement of carbon dioxide (CO_2) in exhaled air is a widely used clinical observation and is a recognised standard of care during tracheal intubation or laryngeal mask airway (Ahrens 2003; The Intensive Care Society 2009). This can be achieved in one of two ways; capnography and colorimetric capnometry.

Capnography is the measurement of inspired and expired CO_2 using the absorption of infrared light by CO_2 molecules to estimate CO_2 concentrations. These measurements are then displayed against time to give a continual graphical trace. Detection of a CO_2 waveform is the test threshold for index test positivity for capnography. Colorimetric capnometry involves the detection of CO_2 using an adapted form of pH filter paper, impregnated with a dye which changes colour from purple to yellow in the presence of CO_2. The colour change is the index test threshold for test positivity for colorimetric capnometry. However, this method does not provide a continual reading and can only be used as a semi-measurement of the amount of CO_2 in the expired gas (Frakes 2001).

The monitoring of CO_2 emanating from an NGT inadvertently passed into the airways would utilise this phenomenon in a reverse manner, confirming tracheobronchial placement rather than the intended alimentary tract (Thomas 1998), provided that there is circulation to deliver CO_2 to the lungs and an absence of complete bronchospasm preventing gas exchange (The Intensive Care Society 2009). CO_2 monitoring for this clinical application has indeed been suggested, and has been a concept acknowledged in the literature for over 20 years (Mercurio 1985).

Alternative bedside methods for detecting NGT placement have been suggested in the literature (e.g. measurement of gastric enzymes by Metheny 1997 or an electromagnetic technique as evaluated by Kearns 2001), however CO_2 monitoring is the only currently available technique identified as a potential viable alternative to the reference standard appearing in clinical guidelines (The Intensive Care Society 2009). We have therefore chosen to focus on the detection of CO_2 only to keep the Review manageable and maximise clinical relevance of the comparison.

Clinical pathway

The measurement of CO_2 in exhaled air is a recognised and mandatory standard of care for confirming and monitoring endotracheal tube or airway placement under general anaesthesia. Additionally, it is also a mandated form of monitoring for patients undergoing moderate and deep sedation (Weaver 2011). The monitoring of CO_2 from an NGT has been suggested as a replacement for the current reference standard of chest radiography.

Rationale

Several studies have examined the accuracy of colorimetric capnometry in predicting gastric placement of NGTs. Very high levels of specificity and sensitivity were reported against a reference standard radiograph control (Araujo-Preza 2002; Thomas 1998) or air insufflation and epigastric auscultation (Elpern 2007; Meyer 2009). Similar results have been reported with capnography when using a radiograph control (Kindopp 2001), and when both capnography and colorimetric capnometry were compared against both radiograph and epigastric auscultation controls (Burns 2006).

Several narrative reviews examining various techniques for verification of NGT placement comment on the use of CO_2 detection. Some authors comment that the use of CO_2 detection shows promise (Ackerman 2006) with suggestions that this approach may result in cost savings (Roberts 2007). Further narrative reviews conclude that radiographic confirmation remains the most reliable method of confirming gastric NGT placement (Bourgault 2009; Metheny 2001; Simons 2012).

Both capnography and capnometry were evaluated in a recent meta-analysis by Chau 2011, which concluded that there was

strong evidence available to support their use to confirm NGT position, with a sensitivity ranging from 0.88 to 1.00 and specificity of 0.95 to 1.00. However, this work was limited both by language and publication status and no searching of the grey literature.

A systematic review of CO_2 detection for testing NGT placement in adults is required; to identify and critically evaluate the current evidence base and to establish the diagnostic test accuracy of this new application of an existing clinical technology.

OBJECTIVES

To determine the diagnostic accuracy of capnometry and capnography for detecting correct NGT placement in adults compared to the reference standard.

METHODS

Criteria for considering studies for this review

Types of studies

We will include studies which compare the diagnostic accuracy of CO_2 detection for correct NGT placement with the reference standard, and those which evaluate the diagnostic accuracy of CO_2 detection for differentiating between respiratory and gastrointestinal tube placement. We will include both prospective and retrospective studies. CO_2 detection may be assessed by either capnometry or capnography.

Participants

Adult patients (as defined by the trialists) who are undergoing NGT placement in any care setting for any reason. If no definition is available, we will assume the participants are adults unless identified as children in the studies.

Index tests

The index test evaluated in this review is CO_2 detection by either capnometry or capnography against the reference standard.

Target conditions

We will include studies if the aim of the diagnostic test was to confirm correct NGT placement.

Reference standards

The reference standard is either radiographic or direct visualisation of NGT placement.

Search methods for identification of studies

Electronic searches

We will search the following databases:

1. Cochrane Register of Diagnostic Accuracy Tests (latest issue);
2. CENTRAL (*The Cochran e Library*, latest issue) (Appendix 1);
3. MEDLINE (Appendix 2);
4. EMBASE (Appendix 3);
5. Medion database.

Searching other resources

We will not limit the search by language or publication status.
We will contact manufacturers of colorimetric capnometers (for example, Easycap and Easycap II Nellcor-Puritan Bennet) and capnographs (for example, Ohmeda 5250 RGM monitor division of British Oxygen Company) that have been used within trials to identify any published, unpublished or ongoing studies which meet the inclusion criteria.
We will review available conference proceedings from the British Association for Parenteral and Enteral Nutrition (BAPEN), European Society of Parenteral and Enteral Nutrition (ESPEN), American Society of Parenteral and Enteral Nutrition (ASPEN), Australian Society of Parenteral and Enteral Nutrition (AUSPEN), South African Society of Parenteral and Enteral Nutrition (SASPEN) and the Latin American Federation for Parenteral and Enteral Nutrition (FELANPE) online for relevant studies. Where appropriate, we will contact the authors of abstracts to identify further studies deemed worthy of review.
We will screen reference lists within relevant trials to identify any further potential papers worthy of review.

Data collection and analysis

Selection of studies

We will undertake the systematic review using the methods outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011) and the *Cochrane Handbook for Reviews of Diagnostic Interventions* (Deeks 2010). Two authors (AH and FS) will independently examine the titles and abstracts identified

by the search strategy to remove any duplicate records and obviously irrelevant reports. We will retrieve and evaluate the full text versions of potentially relevant studies identified by at least one author. Two authors (AH and FS) will independently assess each study to determine if they meet the eligibility criteria outlined above in the section Criteria for considering studies for this review. We will resolve any disagreements by discussion between the authors (AH and FS), with a further author (KP) acting as arbiter. We will provide details of both included and excluded studies in the respective tables of the review.

Data extraction and management

AH and FS will extract data independently utilising a standardised data extraction form (Appendix 4). We will resolve any disagreements by discussion between the authors (AH and FS), with a further author (KP) acting as arbiter. The data extraction form will include the following:

- author, year of publication and journal/source of study;
- study design;
- total study population;
- total number of ventilated and spontaneously breathing participants;
- total number of small and large bore feeding tubes;
- reference standard (either radiographic, direct visualisation or endoscopic confirmation of NGT placement);
- performance of reference standard (negative or positive confirmation of stomach placement);
- index test (either capnography or colorimetric capnometry);
- performance of index test (negative or positive confirmation of stomach placement);
- QUADAS-2 items (i.e. the recognised quality assessment tool for diagnostic test accuracy studies);
- data for 2 x 2 tables.

We will use the statistical package within Review Manager software (RevMan 5.2), using double data entry with two authors (AH and FS) to control and correct data entry errors.

Assessment of methodological quality

We will assess the risk of bias of included studies using QUADAS-2 tool for assessing risk of bias and applicability as outlined by Whiting 2011 and recommended by the Cochrane Diagnostic Test Accuracy Group (Wisniewski 2012). We will record this on a study quality assessment form (Appendix 5). The qualities assessed are described in detail in Appendix 6.

For each item in the quality assessment, a description of how the study addressed the issue will be included and a judgement entered of "low", "high" or "unclear" for an overall risk of bias for each domain and "low", "high" and "unclear" overall concern for domains one, two and three. We will include an Assessment of methodological quality table which will detail all of the judgements made for all included studies in the review. Assessment of methodological quality will be carried out by the two authors (AH and FS), independently . We will resolve any disagreements by discussion between the author, with a further author acting as arbiter (KP).

Statistical analysis and data synthesis

We will extract data of diagnostic performance from each primary study and construct 2 x 2 tables of true positive cases, false positive cases, true negative cases and false negative cases. We anticipate that data will be binary categorisation for all studies due to the nature of the diagnosis under investigation (either gastric placement, or not). Therefore, no threshold for positivity is required.

We will calculate sensitivity and specificity with a 95% confidence interval (CI) for each study. We will present the individual study results graphically using forest plots and the receiver operating characteristic (ROC) space.

We will use the bivariate random-effects approach as described by Reitsma 2005 for the meta-analysis of the pairs of sensitivity and specificity. The bivariate approach preserves the two-dimensional nature of the data by analysing pairs of sensitivity and specificity jointly, incorporating any correlation that might exist between the two measures using a random-effects model. Explanatory variables may also be added to the bivariate model to investigate how these variables affect sensitivity and specificity separately. Study level covariates exploring the effects of mechanical ventilation, size of tube and conscious level will be added to the analysis. We will categorise these covariates as:

1. mechanical ventilation: ventilated or not;
2. tube size: small bore (up to 14 Fr), large bore (16 Fr and above);
3. conscious level: impaired or not.

The bivariate mean estimates of sensitivity and specificity will also be presented graphically along with their corresponding 95% confidence ellipses.

We will use the Proc NLMIXED procedure available within the statistical software package, SAS Inc., to carry out the bivariate random-effects analyses.

Investigations of heterogeneity

Heterogeneity in test accuracy is likely to arise due to differences in study characteristics. We will investigate this firstly using exploratory analysis and visual inspection of forest plots of sensitivities and specificities, and secondly through visual inspection of the pairs of sensitivity and 1-specificity for each study, plotted in 'ROC space'. Study characteristics to be compared include the 'test type' (i.e. capnography or capnometry) and also:

1. whether the patients are mechanically ventilated or not;
2. whether the bore of the feeding tube is small (up to 14 Fr) or large (16 Fr and above);

3. whether the patients' conscious level is impaired or not.

Subject to an adequate sample size of at least 10 included studies, heterogeneity will be further investigated by adding study level covariates to the hierarchical model to identify factors associated with diagnostic test accuracy. The aforementioned binary categorical covariates will be considered for inclusion in the model.

Sensitivity analyses

We will use sensitivity analysis to restrict studies with an appropriate spectrum of patients, superior form of index test (capnography) and reference test (chest x-ray or direct visualisation) and studies at low risk of verification bias (i.e. with predetermined criteria for chest x-ray interpretation). These covariates will be incorporated in the bivariate model to examine the effect of potential sources of bias across subgroups of studies.

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* *Indicates the major publication for the study*

APPENDICES

Appendix 1. CENTRAL search strategy

1. Intubation, Gastrointestinal/
2. Enteral Nutrition/
3. ((nasal or nose or nasoenteral or nasogastric) adj2 (cannula or tube or intubation)).tw.
4. Feeding tube.tw.
5. Ryles tube.tw.
6. Fine bore tube.tw.
7. or/1-6
8. capnography/
9. (capnography or capnogram).tw.
10. capnometry.tw.
11. (carbon dioxide adj (detect* or monitor*)).tw.
12. or/8-11
13. 7 and 12

Appendix 2. MEDLINE search strategy

1. Intubation, Gastrointestinal/
2. Enteral Nutrition/
3. ((nasal or nose or nasoenteral or nasogastric) adj2 (cannula or tube or intubation)).tw.
4. Feeding tube.tw.
5. Ryles tube.tw.
6. Fine bore tube.tw.
7. or/1-6
8. capnography/
9. (capnography or capnogram).tw.
10. capnometry.tw.
11. (carbon dioxide adj (detect* or monitor*)).tw.
12. or/8-11
13. 7 and 12

Appendix 3. EMBASE search strategy

1. nasogastric tube/
2. ((nasal or nose or nasoenteral or nasogastric) adj2 (cannula or tube and intubation)).tw.
3. fine bore tube.tw.
4. enteric feeding/
5. feeding apparatus/
6. feeding tube.tw.
7. Ryles tube.tw.
8. or/1-7
9. capnography/
10. (capnography or capnogram).tw.
11. capnometry.tw.
12. (carbon dioxide adj (detect* or monitor*)).tw.
13. or/9-12
14. 8 and 13

Appendix 4. Data extraction form

Source

Study ID	Report ID	Review author name

First author	Full reference

Study eligibility

Type of study Does the study compare: - CO_2 against ref. standard* for respiratory NGT placement OR - CO_2 against ref. standard for respiratory/gastric NGT placement		Yes	Unclear	No
		Next question	*Next question*	**Exclude**
Participants Were the participants having ***naso*** gastric tube placement?		Yes	Unclear	No
		Next question	*Next question*	**Exclude**
Were the participants: - defined as adult by trialists OR - ***not*** identified as paediatric		Yes	Unclear	No

(*Continued*)

	Next question	*Next question*	**Exclude**
Index tests Did the study evaluate CO_2 detection by capnometry against ref. standard?	Yes	Unclear	No
	Next question	*Next question*	*Next question*
Did the study evaluate CO_2 detection by capnography against ref. standard?	Yes	Unclear	No
	Next question	*Next question*	**Exclude**
Target conditions Was the aim of the diagnostic test to confirm NGT placement?	Yes	Unclear	No
	Next question	*Next question*	**Exclude**
Outcomes Did the study **record**+ performance of reference standard?	Yes	Unclear	No
	Next question	*Next question*	*Next question*
Did the study **record** performance of index test?	Yes	Unclear	No
	Include	Include (subject to clarification of "unclear" points)	**Exclude**
Final decision	**Include**	**Unclear**	**Exclude**

* reference standard is either radiographic, direct visualisation or endoscopic confirmation of NGT placement
+ remember we are looking for **recording** of outcomes, not *reporting*

If the study is to be excluded, record the reason and details to add to "Table of excluded studies":

General information

Authors	
Contact address	
Country of study	
Language of publication	

Any other published versions/reports of this trial?
All references to a trial need to be linked under one Study ID both on this form (p1) and in RevMan.

Code	Authors	Full reference	Linked Study ID on p1? (tick)	Linked Study ID in RevMan? (tick)
A				
B				
C				

(*Continued)*

Add other additional lines/codes as required

Participants		
Age (mean, median, range)		
Sex (numbers/%)		
Trial characteristics		
Study design		
Single/multicentre?		
Country/countries		
Definition used of participant eligibility		
Total study population		
Total number of ventilated patients		
Total number of spontaneously breathing patients		
Total number of small bore feeding tubes		
Total number of large bore feeding tubes		
Aim of diagnostic test (e.g. NGT placement in stomach or exclusion of respiratory placement)		

(*Continued)*

Reference standard used (either radiographic, direct visualisation or endoscopic confirmation)		
Detail reference standard process (if available)		
Index test (either capnography or colorimetric capnometry)		
Detail index test process Include: - Time between reference test and index test - CO_2 detector details (make, model)		
Comparison: capnometry and capnography for detecting correct NGT placement in adults compared to the reference standard		
Test outcome (CO_2 detection) **NGT placement (reference standard result)** **Totals** **Gastric** **Not** **Gastric** **Not** **Totals:**		
Comparison: capnometry and capnography for detecting respiratory tube placement		
Test outcome (CO_2 detection) NGT Placement(reference standard result) Totals		

(*Continued*)

Respiratory Gastric Respiratory Gastric Totals:	
Comparison: capnometry and capnography for detecting correct gastric tube placement	
Test outcome (CO_2 detection) NGT placement (reference standard result) Totals Respiratory Gastric Respiratory Gastric Totals:	
Any additional information:	

Appendix 5. Study quality assessment form

Trial characteristics - QUADAS-2 items
Phase 1: State the review question

Patients (setting, intended use of index test, presentation, prior testing):
Index test (s):
Reference standard and target condition:

Phase 2: Draw a flow diagram for the primary study
Phase 3: Risk of bias and applicability judgements

Domain 1: Patient selection	
A. Risk of bias	
Described methods of patient selection:	
Was a consecutive or random sample of patients enrolled?	Yes/No/Unclear
Was a case-control design avoided?	Yes/No/Unclear
Did the study avoid inappropriate exclusions? - Did the study avoid excluding difficult to pass NGT patients?	Yes/No/Unclear
Could the selection of patients have introduced bias?	**Risk: LOW/HIGH/UNCLEAR**
B. Concerns regarding applicability	
Describe included patients (prior testing, presentation, intended use of index test and setting):	
Is there concern that the included patients do not match the review question?	**Risk: LOW/HIGH/UNCLEAR**

Domain 2: Index test (capnometry/capnography)	
A. Risk of bias	
Describe the index test and how it was conducted and interpreted:	
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes/No/Unclear
If a threshold was used, was it pre-specified?	Yes/No/Unclear

(*Continued*)

Could the conduct or interpretation of the index test have introduced bias?	**Risk: LOW/HIGH/UNCLEAR**
B. Concerns regarding applicability	
Is there concern that the index test, its conduct, or interpretation differ from the review question?	**Risk: LOW/HIGH/UNCLEAR**

Domain 3: Reference standard (chest x-ray/direct visualisation)	
A. Risk of bias	
Describe the reference standard and how it was conducted and interpreted:	
Is the reference standard likely to correctly classify the target condition? - Were currently acceptable methods for determining NGT placement used?	Yes/No/Unclear
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes/No/Unclear
Could the conduct or interpretation of the reference standard have introduced bias?	**Risk: LOW/HIGH/UNCLEAR**
B. Concerns regarding applicability	
Is there concern that the target condition as defined by the reference does not match the review question? - Consider the use of chest x-ray interpretation criteria, or physician judgement alone	**Risk: LOW/HIGH/UNCLEAR**

Domain 4: Flow and timing	
A. Risk of bias	
Describe any patient who did not receive the index test(s) and/or reference standard or who were excluded from the 2x2 table (refer to flow diagram): Describe the time interval and any intervention between index tests and reference standard:	
Was there an appropriate interval between index tests and reference standard? - We have set arbitrary 4 hours for this review	Yes/No/Unclear
Did all patients receive the reference standard?	Yes/No/Unclear
Did patient receive the same reference standard?	
Were all patients included in the analysis? - Consider withdrawals and withdrawals who were likely to impact on study results - Also consider the exclusion of "difficult" patients	
Could the patient flow have introduced bias?	**Risk: LOW/HIGH/UNCLEAR**

Appendix 6. Study quality assessment details

- Domain 1: Patient selection

Risk of bias: Could the selection of patients introduced bias?
Signalling question 1: Was a consecutive or random sample of patients enrolled?
Signalling question 2: Was a case-control design avoided?
Signalling question 3: Did the study avoid inappropriate exclusions?
Certain conditions may make the passage of an NGT more difficult, such as anatomical variation of the larynx and pharynx and altered physiology of swallowing (Der Kureghian 2011). We will classify studies where patients who are difficult to pass an NGT in are excluded as "yes", those who did not as "no" and "unclear" where this information is unclear.
Applicability: Are there concerns that the included patients and the setting do not match the review question?
The inclusion criteria for this review outlines studies for inclusion in which the patients are considered to require an NGT passed for any reason. Therefore, we anticipate that all the studies in the review will be judged as "low" concern.

- Domain 2: Index test

Risk of bias: Could the conduct or interpretation of the index test have introduced bias?

Signalling question 1: Were the index test results interpreted without knowledge of the results of the reference standard?
Signalling question 2: If a threshold was used, was it pre-specified?
We will classify the study as "yes" if the index test results were interpreted without knowledge of the reference standard, "no" if the index tests were interpreted with knowledge of the reference standard results and "unclear" if this information is not clear.
Applicability: Are there concerns that the index test, its conduct or interpretation differ from the review question?
The detection of carbon dioxode by capnometry or capnography for determining NGT placement is an inclusion criteria for this review, so we anticipate that all studies will be classified as "low" concern.

- Domain 3: Reference standard

Risk of bias: Could the reference standard, its conduct or its interpretation have introduced bias?
Signalling question 1: Is the reference standard likely to correctly classify the target condition?
Signaling question 2: Were the reference standard results interpreted without knowledge of the results of the index test?
We will classify the studies as "yes" if the criteria for correct NGT placement were the currently acceptable standards of placement verification (outlined in Reference standards), "no" if the criteria for verification of placement were by any other method and "unclear" if this information is not clear.
We will classify the study as "yes" if the reference test results were interpreted without knowledge of the index test, "no" if the reference standard was interpreted with knowledge of the index test results and "unclear" if this information is not clear.
Applicability: Are there concerns that the target condition as defined by the reference standard does not match the question?
The target condition is the confirmation of NGT placement in the stomach, which may be improved by the use of pre-specified diagnostic criteria for chest x-ray interpretation (Lamont 2011). The threshold at which an x-ray is interpreted as positive (i.e. NGT in the stomach) may, therefore, be different dependent on whether the interpretation was based on individual clinician's interpretation or according to clear diagnostic criteria. We will classify those studies which used clear diagnostic criteria for chest x-ray interpretation as "low" concern, for those who did not or where the interpretation was based on individual clinician's interpretation as "high" concern, and "unclear" concern if this information is not clear.

- Domain 4: Flow and timing

Risk of bias: Could the patient flow have introduced bias?
Signalling question 1: Was there an appropriate interval between the index test and reference standard?
Signalling question 2: Did all patients receive the same reference standard?
Signalling question 3: Were all patients included in the analysis?
If an NGT is correctly inserted and initial gastric placement is confirmed, continual assessment is still required as any routine activity (e.g. vomiting, coughing, retching) can cause tube displacement (Simons 2012). Therefore, any delay in testing may influence results. However, we have set an arbitrary time delay between tests in line with the American Association of Critical Care Nurses 2009 who recommend tube location to be checked at four hourly intervals. We will classify the study as "yes" if the delay is less than four hours, "no" if the delay is four hours or more and "unclear if the information is unclear.
We will classify the study as "yes" if all patients had the same reference standard, "no" if the reference standard was different and "unclear" if this information is unclear.
Uninterpretable results may be present (e.g. unclear chest x-ray, blocked NGT preventing gas flow required for capnography/capnometry). Additionally, withdrawals from the study may be present. We will classify the study as "yes" if uninterpretable results were reported and the study had no withdrawals or the withdrawals were unlikely to affect the results, "no" if uninterpretable results were not reported or there were withdrawals that were likely to affect the results, or both, and "unclear" if this information is not clear.

CONTRIBUTIONS OF AUTHORS

Conceiving the review: Agi Holland (AH) and Fiona Smith (FS)

Designing the review: AH, FS and Kay Penny (KP)

Co-ordinating the review: AH

Data collection for the review: AH and FS

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Screening search results: AH, FS and KP

Organising retrieval of papers: AH and FS

Screening retrieved papers against inclusion criteria: AH, FS and KP

Appraising the quality of the papers: AH, FS and KP

Extracting data from papers: AH, FS and KP

Writing to authors of papers for additional information: FS

Providing additional data about papers: AH

Obtaining and screening data on unpublished papers: AH and FS

Entering data into RevMan 5.1: AH and FS

Analysis of data: AH, FS and KP

Interpretation of data: AH, FS and KP

Providing a clinical perspective: AH and FS

Writing the review: AH, FS and KP

Securing funding for the review: AH and FS

Performing various work that was the foundation of the current study: AH and FS

DECLARATIONS OF INTEREST

None known.

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