Colourimetric capnometry to verify nasogastric tube placement in patients at risk of mal-placement

ORIGINAL ARTICLE

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ABSTRACT

Background. Nasogastric tubes (NGT) are frequently used in geriatric settings and verification of NGT placement is important for patient safety. This study aimed to ascertain the accuracy of carbon dioxide (CO₂) colourimeter in the verification of NGT and to estimate the reduction in patient waiting time for resumption of NGT feeding in the general care setting.

Methods. Doubtful NGT placements were obtained from patients in three medical extended wards in a public hospital in Hong Kong. Doubtful NGT placements were verified using both X-ray imaging and CO₂ colourimeter. The sensitivity and specificity of CO₂ colourimeter were evaluated using X-ray imaging as the gold standard. The patient waiting time for resumption of NGT feeding were estimated by recording the time required for completion of X-ray imaging verification.

Results. There were 26 patients in the study with a mean age of 74.07 years (SD = 16.33). Fifteen (57.7%) of them were male. The final sample consisted of 71 doubtful NGT placement and none of them was misplaced. The specificity of CO₂ colourimeter was 98.6%, while the sensitivity was unable to determine. The patient waiting time required for X-ray imaging verification ranged from 51 to 1095 minutes (mean = 380.75 min., SD = 179.51).

Conclusions. CO₂ colourimeter has high specificity in verification of doubtful NGT placement. Replacing X-ray imaging with CO₂ colourimetry verification may speed up resumption of NGT feeding.

Key words: Carbon dioxide; Colorimetry; Intubation, gastrointestinal; Sensitivity and specificity

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BACKGROUND

Nasogastric tubes (NGT) are frequently used in patients who are unable or unsafe to feed orally or have inadequate nutritional support. Nurses are responsible for insertion and management of the tubes. Tube misplacement into the lung is a complication with severe consequences.

The Joanna Brigg Institute recommends the use of various bedside methods individually or in combination to assess NGT placement.¹⁻³ However, the reliability of these methods to differentiate pulmonary from gastric placement is unacceptable.

These methods include observing patient's response such as coughing and choking, auscultating of air insufflated through the tube, and observing for bubbling when the tip end is immersed in water. Radiography is the gold standard for checking NGT placement, whereas pH checking of gastric aspirate is considered the second most reliable test. Nevertheless, both methods may not be applicable in all care settings. For example, a pH value of ≤ 5.5 suggests that the NGT is in the stomach. However, the pH value may be ≥ 6 when the patient is taking antacids and acid inhibitors or in some cases no gastric aspirate can be obtained from the tube. When these occur, radiography is recommended for

confirmation,³ but this is impractical or impossible in some institutions and community aged homes.

Radiographic confirmation of the NGT placement is not 100% reliable and may lead to misinterpretations by inexperienced personnel.⁴ Other problems include delayed feeding owing to the time required for taking radiographs and for interpretation and radiation exposure.

Colourimetric capnometry of carbon dioxide (CO₂) is reliable for detecting NGT insertion into the airway,⁵⁻¹⁰ with sensitivity of 88% to 100% and specificity of 99% to 100%.¹⁰ It is safe, easy to use, and efficient.⁷ However, it has lower sensitivity (80%) and specificity (86.5%) in the general adult ward setting.¹¹ This study aimed to determine the accuracy of colourimetric capnometry in verifying NGT placement in a general care setting.

METHODS

This study was approved by the Kowloon West Cluster Research Ethics Committee (KW/EX-18-108(127-04)). Written informed consent was obtained from each patient or the patient's guardian before data collection. Patients aged ≥ 18 years with an NGT insertion at three medical extended care wards of a general public hospital were invited to participate between December 2018 and May 2019. Patients were included when aspirates from NGT contained no gastric fluid, had pH of ≥ 6 , and were tan to off-white. Patients were excluded when they had gastric aspirate of pH ≤ 5.5 , were on continuous enteral feeding, had the NGT insertion for stomach lavage, washout, or gastric aspiration for bleeding monitoring, or were receiving any intensive medical intervention such as ventilator care and active resuscitation care.

Colourimetric capnometry of CO₂ was performed by nurses at bedside using the Easycap II adult CO₂ Detector. The NGT placement was checked through epigastric auscultation using the whoosh test. Supplement methods included checking coiling of the NGT inside the mouth, checking the NGT marking, and checking the patient's appearance and respiration pattern. The NGT was then connected by a syringe and flushed in 10 mL of air to clear any blockage. If the sound was clear, the syringe was removed, and the colourimetric capnometry was connected to the end of the NGT with a designated adaptor. The colour reading was checked after at least six breaths or 1 minute,¹³ as the ventilating

rate for normal adults is about 12 to 20 breaths per minute, with exhaled CO₂ of 35 to 45 mmHg.¹² A change of colour from purple to yellow or brown indicates the presence of an end-tidal CO₂ of >15 mmHg (**FIGURE**). The NGT placement was confirmed with radiography and by the on-call physician before resumption of feeding. In addition, the waiting time from NGT insertion to radiography, the waiting time from radiography to resumption of NGT feeding, and the total waiting time were recorded.

Sensitivity and specificity of colourimetric capnometry were calculated with reference to radiographic findings. A p value of <0.05 was considered statistically significant.

RESULTS

Of 40 eligible patients, 32 gave written informed consents. Of them, 26 (15 men and 11 women) aged 33 to 97 (mean, 74.07) years had 71 episodes of doubtful NGT placement (49 silicone tubes and 22 polyvinyl chloride tubes) owing to lack of aspirate after NGT insertion (**TABLE 1**). Epigastric auscultation was negative in five (7%) episodes. Most patients experienced only one insertion attempt, and a few experienced 2 to 3 insertion attempts. One patient experienced 10 insertion attempts because the NGT was coiled in the throat or regurgitated out by the patient.

Colourimeter indicated negative detection of CO₂ in 70 of 71 episodes, which were confirmed by radiography and by the on-call physician that the NGT end was underneath the diaphragm (suggesting

FIGURE. Three zones of end-tidal carbon dioxide levels in the colourimeter: A (range, 0.03% to $<0.5\%$) [<4 mmHg], B (range, 0.5% to $<2\%$) [4 to <15 mmHg], and C (range, 2% to 5%) [15 to 38 mmHg]

inside the stomach). Hence, the specificity of the colourimeter to confirm NGT placement was 98.6%, and the negative predictive value (accuracy to rule out tracheobronchial insertion) was 100%. However, as none of the episodes was true positive, the sensitivity and positive predictive value of the colourimeter were undetermined. The only episode with false-positive detection of CO₂ by the colourimeter occurred after 10 insertion attempts of the NGT. However, the NGT was confirmed to be in the gastro-intestinal tract by radiography.

The mean waiting time from NGT insertion to radiography was 223.82±159.82 (range, 27-795) minutes. The mean waiting time from radiography to resumption of NGT feeding was 158.20±93.88 (range, 11-367) minutes. Thus, the mean total waiting time was 380.75±179.51 (range, 51-1095) minutes. Of the 71 episodes, 78.9% needed to wait for >4 hours to resume NGT feeding (TABLE 2).

TABLE 1
Characteristics of patients (n=26)*

Age, y	74.07±16.33 (33-97)
≥65	23 (88.5)
<65	3 (11.5)
Sex	
Male	15 (57.7)
Female	11 (42.3)
Comorbidity	
Cerebrovascular accident	18 (69.2)
Hypertension	11 (42.3)
Diabetes mellitus	9 (34.6)
Dementia	6 (23.1)
Heart disease	4 (15.4)
Parkinson disease	3 (11.5)

* Data are presented as mean ± standard deviation (range) or no. (%) of patients

DISCUSSION

The high specificity of 98.6% indicated that colourimeter capnometry can be an alternative of radiography to confirm NGT placement.¹⁰ However, its sensitivity and positive predictive value was undetermined because none of the episodes was true positive, which may be related to the careful testing of the NGT placement by the epigastric auscultation whoosh test before colourimeter capnometry.⁷ Hence, a combination of epigastric auscultation with colourimetric capnometry to verify doubtful NGT placement is recommended.

The only false positive case may be due to trapping of CO₂ inside the NGT after repeated insertion attempts of the NGT owing to patient regurgitation. Hence, a sufficient time should be allowed to let out the trapped CO₂ before connecting to the colourimeter. The colour of the colourimeter reversed from yellow to purple when it is left in room air for 10 minutes. The device supports constant visual feedback within 2 hours; it can be re-used for CO₂ analysis in the same patient.

Although radiographic confirmation of NGT placement prior to patient feeding ensures patient safety, the waiting time until resumption of NGT feeding is too long. The processes involve seeking medical support to prescribe a request for radiography, waiting for radiographic investigation, and pending for physician interpretation of the results. Patients may be at risk of dehydration owing to delayed feeding. The waiting time may be longer if patients are living in the community, because patients have to wait for ambulance transportation to the accident and emergency department for radiographic examination and physician interpretation of the results of the NGT placement. Therefore, CO₂ colourimeter test together with

TABLE 2
Waiting time from nasogastric tube (NGT) insertion to resumption of NGT feeding in 71 episodes

Waiting time, hours	Waiting time from NGT insertion to radiography*	Waiting time from radiography to resumption of NGT feeding*	Overall waiting time*
	223.82±159.82 (27-795) minutes	158.20±93.88 (11-367) minutes	380.75±179.51 (51-1095) minutes
<1	5 (7.0)	5 (7.0)	1 (1.4)
1-4	35 (49.3)	50 (70.4)	14 (19.7)
>4-6	20 (28.2)	14 (19.7)	11 (15.5)
>6-8	8 (11.3)	2 (2.8)	31 (43.7)
>8	3 (4.2)	-	14 (19.7)

* Data are presented as mean ± standard deviation (range) or no. (%) of episodes

epigastric auscultation whoosh test may speed up resumption of NGT feeding and reduce healthcare manpower.

One set of CO₂ colourimeter costs HK\$137 and a reusable adaptor costs HK\$28. The colourimeter can be re-used by the same patient for NGT insertion. The overall costs of colourimetric capnometry is lower than those of radiographic examination, which involves manpower on transportation service, physician interpretation of the results, and nursing manpower on coordination. For patients living at home or residential care home, extra cost is incurred in admission for radiographic examination via the accident and emergency department.

The present study has limitations. It was conducted in three medical extended wards of a single hospital. The long waiting time may be biased by the restricted medical support and radiographic service and thus may not be generalised to other hospital settings. The sample size was small. Further studies with larger samples at different settings are warranted.

CONCLUSION

A combination of epigastric auscultation whoosh test and colourimeter capnometry is reliable to rule out NGT tracheal or bronchial insertion. Colourimeter capnometry is safe, easy to perform, and provides a clear-cut result, especially when radiographic examination is not accessible. It saves waiting time and money for radiographic examination and interpretation and minimise patient exposure to unnecessary radiation.

CONTRIBUTORS

All authors designed the study, acquired the data, analysed the data, drafted the manuscript, and critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

CONFLICTS OF INTEREST

All authors have disclosed no conflicts of interest.

FUNDING/SUPPORT

This study received support from Yan Chai Hospital

Medical Fund.

DATA AVAILABILITY

All data generated or analysed during the present study are available from the corresponding author on reasonable request.

ETHICS APPROVAL

The study was approved by Kowloon West Cluster Research Ethics Committee (Ref: KW/EX-18-108(127-04)). The patients were treated in accordance with the tenets of the Declaration of Helsinki. The patients provided written informed consent for all treatments and procedures.

ACKNOWLEDGEMENT

We thank all nurses who participated in this study.

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