Neuroanesthesia and Intensive Care

Capnography confirms correct feeding tube placement in intensive care unit patients

[La capnographie permet de confirmer la position appropriée de la sonde d'alimentation chez les patients de l'unité des soins intensifs]

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Purpose: To test the accuracy and potential time savings of capnography as compared with a two-step radiographic method in placing feeding tubes in critically ill patients.

Methods: One hundred feeding tube placements were studied in our tertiary care intensive care unit. All placements utilized a two-step radiographic method, but capnography was added to the procedure. The procedure was then completed or abandoned depending on radiographic interpretation.

Results: Radiography showed 11 feeding tubes projecting within the tracheobronchial tree. In all 11 of these placements, the capnography unit displayed a normal capnogram. Radiography revealed 86 tube placements in the midesophageal region. In all 86 of these placements, capnography displayed a "purging warning". In three placements, radiography indicated that the tube was coiled in the oropharynx. In these cases, the capnograph displayed one "no purging/no capnogram" result, and two "purging" warnings. If using capnography alone, an average of 72.5 min would be required to complete a feeding tube placement (which includes time for requisite "pre-feed radiograph"). The two-step radiological approach took an average of 169.4 min, a difference of 96.9 min (P <0.0001) between the two methods.

Conclusions: Capnography accurately identified all intratracheal feeding tube placements in this study. This study also shows that the use of capnography would significantly shorten the time needed for tube placement compared with a two-step radiologic method. Capnography should be considered for routine use when placing feeding tubes since it adds little time to the procedure and may improve patient safety.

Objectif : *Tester l'exactitude et le gain de temps potentiel associés à la capnographie comparée à la radiographie en deux étapes utilisées lors de la mise en place d'une sonde d'alimentation chez les patients gravement malades.*

Méthode : *Nous avons étudié 100 mises en place de sonde d'alimentation à notre unité de soins intensifs de centre tertiaire. La radiographie en deux temps, et la capnographie, ont été utilisées dans tous les cas. L'intervention a été complétée ou abandonnée selon l'interprétation radiographique.*

Résultats : *La radiographie a montré 11 sondes insérées dans la trachée. Dans ces 11 cas, la capnographie a affiché un capnogramme normal. La radiographie a révélé 86 mises en place au milieu de l'œsophage. Dans ces 86 cas, la capnographie a affiché un avertissement de "purge". Dans trois cas, la radiographie a indiqué que la sonde était enroulée dans l'oropharynx. La capnographie a alors affiché une "absence de purge/absence de capnogramme" et deux avertissements de "purge". L'utilisation d'une sonde d'alimentation, avec la capnographie seule, exige en moyenne 72,5 min incluant le temps requis pour "un radiogramme pré-alimentation"). La technique utilisant la radiographie en deux temps demande en moyenne 169,4 min. Il y a donc une différence de 96,9 min (P <0,0001) entre les deux méthodes.*

Conclusion : *La capnographie a permis de vérifier avec précision la position de toutes les sondes d'alimentation de la présente étude. L'usage de la capnographie, comparée à la radiographie en deux temps, a aussi réduit sensiblement le temps nécessaire à la mise en place de la sonde. La capnographie devrait faire partie de la mise en place courante des sondes, puisqu'elle prolonge de peu l'intervention et peut améliorer la sécurité du patient.*

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Presented at the annual meeting of the American Society of Anesthesiologists, San Francisco, California, October 17, 2000.
Supported in part by a grant from the Kingston General Hospital Research Fund.
Dr. Heyland is a career scientist with the Ontario Ministry of Health.

Accepted for publication February 23, 2001.
Revision accepted March 28, 2001.

A common way of administering medications and nutritional support in critically ill intensive care unit (ICU) patients is via a feeding tube placed either into the stomach or small bowel. A major risk with the procedure is accidental placement of the tube into the respiratory system, which can lead to pneumothorax, bronchopleural fistula, pneumonitis, or pneumonia.[1] In critically ill patients, such adverse events may result in disastrous consequences.

A recommendation found throughout the literature is to obtain a chest radiograph after placement of the feeding tube to ensure the tube is in the stomach or small bowel prior to feeding or administering medications.[1–10] Unfortunately, complications may have occurred by the time a radiograph is obtained with this approach. Feeding tubes are normally passed to a depth of 50–80 cm in order to reach the desired gastric or small bowel location. Should a feeding tube be passed into the respiratory system and advanced this far, bronchial perforation can easily occur.[9] Case reports of this scenario with subsequent pneumothorax are readily found in the literature.[4,5,7,10] Other techniques to determine if the tube tip is in the lung, stomach, or small bowel have been described. These include pH testing or visual inspection of tube aspirates, insufflation of air via the tube while auscultating over the epigastrium, listening for air movement at the tube's proximal end, observing for bubbling when the proximal tube end is held underwater, and utilizing pressure manometry attached to the tube.[2,6,11,12] All have proven fallible and the issue of diagnosing abnormal location too late can also occur with these techniques because they are employed after full tube placement. Further methods include utilizing fluoroscopy, endoscopy, and direct visualization of the tube passing into the esophagus.[1] These techniques are labour intensive, expensive, and add extra discomfort or radiation to the patient.

A technique involving two-step radiography has been described by Roubenoff and Ravich to localize the tip of the feeding tube as being in the esophagus or the large conducting system of the respiratory system midway through the procedure[5] (Figures 1 and 2). These authors state that this technique should be given consideration in all patients considered at high risk for respiratory feeding tube placement. Those at high risk include sedated patients, intubated patients, and patients with depressed airway reflexes.[5,10,13] By diagnosing transtracheal tube location while the tube is located in the large proximal conducting airways, the chance of pneumothorax due to bronchial disruption is virtually nonexistent. This technique is currently encouraged in our ICU because of past adverse outcomes with feeding tube placements. While improving patient safety, this procedure adds extra cost, extra time, extra radiation, and inconveniences both patients and nursing staff.

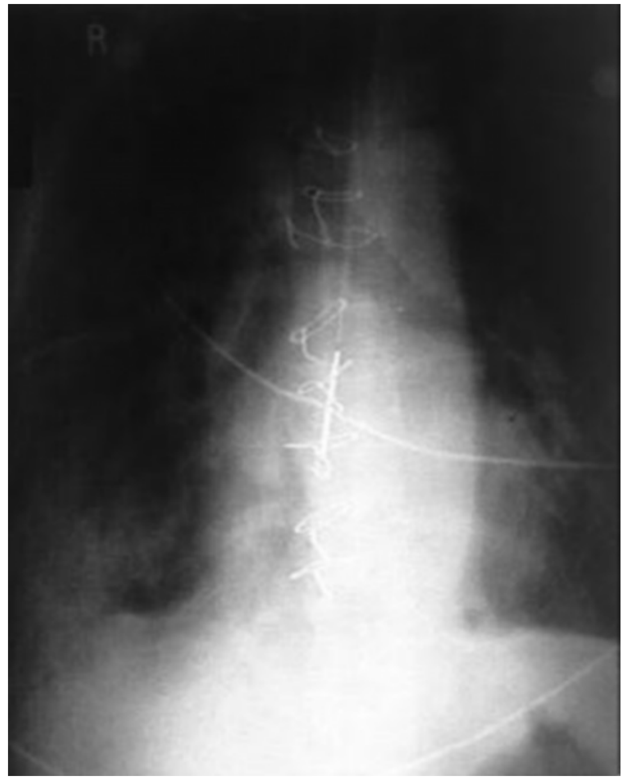

FIGURE 1 Portable antero-posterior radiograph showing the desired placement of the feeding tube at the midway position in the two-step radiography method. The feeding tube tip projects in the midline distal to the carina, indicating esophageal placement.

Sidesteam capnography uses infrared spectrophotometry to measure and display carbon dioxide levels in a sample of gas which is actively aspirated into the unit.[1 4] Capnography has been suggested in the literature as an aid to determine if feeding tubes or nasogastric tubes placed to their full distance have mistakenly ended up in the lungs,[15–17] but has not been investigated in a prospective manner.

We hypothesized that capnography utilized at the midway point of feeding tube placement would correctly identify transtracheal feeding tube location as compared with the two-step radiological approach in ICU patients. A secondary endpoint of this study was timesavings that could be achieved should capnography prove reliable in determining feeding tube location.

FIGURE 2 Portable antero-posterior radiograph showing the feeding tube tip projecting in the right mainstem bronchus at the midway position in the two-step radiography method.

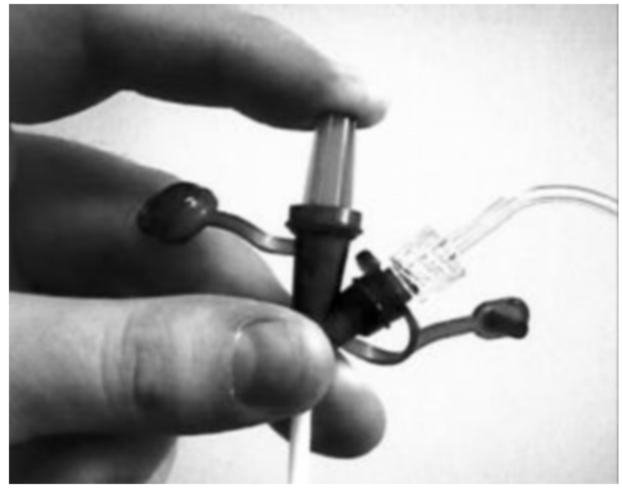

FIGURE 3 Set up for capnography with the Entriflex® feeding tube. The stylet is locked into the top of the tube prior to placement. When placed to the desired distance, 30 mL of air is insufflated through the side port of the tube to clear secretions. Standard narrow bore tubing with a male luer lock end is then directly attached to the side port of the tube to connect the tube with the capnography unit. A finger is used to occlude the hollow stylet end as shown in order that the gas is aspirated only from the distal eyelet holes of the feeding tube.

Methods

After Queen's University and Affiliated Teaching Hospitals Health Sciences Human Research Ethics Board approval, this study was undertaken in the 21-bed ICU of the Kingston General Hospital. Eligible subjects were those >18 yr of age designated as needing a feeding tube by the ICU physicians. Informed consent for inclusion in the study was waived because these patients were having the procedure done in the usual manner, with the exception of capnography being added. Exclusion criteria included patient or surrogate decision maker refusal for feeding tube placement, presence of any tracheal or esophageal pathology, presence of a bronchopleural fistula, any contraindication for both nasal or oral placement of feeding tubes, extreme hemodynamic instability, and the use of direct vision to pass the feeding tube.

Two-step radiography was used in each feeding tube placement, and capnography using an Ohmeda 5250 RGM monitor (Division of British Oxygen Company, Louisville, CO, USA) was performed at the midway position, which was defined as tube distance of 30 cm or 35 cm for oral or nasal approach, respectively. This capnography unit has a gas sampling rate of approximately 180 $mL{\cdot}min^{-1}$ and gives a "purging" warning when the flow rate drops 40 $mL{\cdot}min^{-1}$ less than the normal sampling rate and when a drop in barometric pressure of 90 mmHg below atmospheric pressure occurs. The feeding tubes utilized were 10 French Entriflex® dual port feeding tube with Flow-Through® Stylet manufactured by Sherwood Medical (St. Louis, MO, USA).

Each feeding tube was placed according to the following protocol. The feeding tube was placed either via a nasal or oral approach, to the aforementioned midway distance of 30–35 cm. A syringe was then used to push 30 mL of air through the feeding tube to clear any secretions which may have interfered with gas aspiration by the capnograph. The capnograph tubing was attached as shown in Figure 3, and the result was recorded as: normal capnogram, abnormal capnogram, purging warning, or no capnogram- no purging. A portable chest radiograph was obtained and the feeding tube was interpreted as being intra-esophageal, tracheobronchial, not visible, or indeterminate. Based on the results of the radiograph, the procedure was then completed if the feeding tube was localized to the esophagus, or abandoned if the tube was transtracheal or intra-oral. For those procedures (85) where the tubes were advanced to the completion distance, a confirmatory radiograph was obtained to determine final tube position prior to use. The time at each step of the procedure was recorded for later analysis.

A paired t test was used to compare mean duration of the two different methods. A sample size calculation was not performed but a convenience sample of 100 was chosen in order to expect a reasonable number of abnormal feeding tube placements.

Results

One hundred feeding tube placement attempts were included in this study. There were 11 feeding tubes placed into the respiratory system as diagnosed by radiography, for an incidence of 11% . Nine of these 11 were found to be in the right mainstem bronchus and two in the left mainstem bronchus. For each of these 11 placements, the capnograph displayed a normal capnogram. There were 89 placements where the feeding tube was not placed in the lung. Eighty-six of these placements were in the esophagus on the radiograph, and the capnograph read "purging" in all 86. There were three placements where a tube did not project within the thorax on the radiograph. The capnograph readings for these tubes included two "purging" warnings, and one reading of "no capnogram, no purging". Intra-oral placement was confirmed in all three by direct palpation of the coiled tube. In this small study, capnography was therefore 100% sensitive and 100% specific. A normal capnograph trace indicated tracheal placement and the lack of a normal trace indicated either esophageal or intraoral placement. One intra-esophageal feeding tube could not be passed through the distal esophagus for unknown reasons. This procedure was not included in the subsequent analysis of time comparisons.

The mean, median, and range of duration for each step of the placement procedure are shown in Table I. The 85 intra-esophageal placements where the feeding tube was advanced into the stomach or small bowel were analyzed for the length of time it took using the two-step radiological approach, and the length of time it would have taken if the first radiograph had been omitted based on the results of capnography (Table II). Our results show that the mean length of time it would have taken with capnography alone would have been 72.5 min, whereas with the two-step radiologic placement approach took 169.4 min, an average difference of 96.9 min (P <0.0001).

TABLE I Length of time for various steps in feeding tube placement

Stages of procedure	*Mean time (min)*	*Median time (min)*	*Range of time (min)*
Start of procedure to capnography	2	2	<1 – 10
Capnography to obtaining first radiograph	40	30	2 – 199
First radiograph to radiograph available for viewing	25	19	3 – 165
Available for viewing to radiograph read	17	6	<1 – 200
Radiograph read to procedure completed	9	5	1 – 95
Procedure completed to confirmatory radiograph obtained	39	28	3 – 153
Confirmatory radiograph obtained to final reading	30	24	3 – 130

TABLE II Total time comparison between the two methods

Method of confirmation	*Mean time (min)*	*Median time (min)*	*Range (min)*
Capnographic method	72.5 ± 45.2*	60	17 – 216
Two-step radiology	169.4 ± 85.8*	159	60 – 391

*Mean difference statistically significant using two-tailed paired t test (P<0.0001).

Discussion

ICU patients are considered at high risk of complications associated with feeding tube placement. Not surprisingly we had an 11% incidence of intra-tracheal feeding tube placement. In our study, capnography successfully diagnosed all 11 feeding tubes located in the respiratory system. The findings of carbon dioxide with normal capnograms is unequivocal evidence that the feeding tube is in the respiratory system, because there is no other place in the human body where carbon dioxide can be found to produce sustained normal capnograms.

Capnograph findings of purging occurred with all 86 tube locations within the esophagus. Purging also occurred with two of three tube locations within the oropharynx. When the capnograph was attached to the tube, the negative pressure generated within the feeding tube likely caused the esophageal and oral mucosa to become apposed to the tube's distal eyelet holes, occluding them and causing the purging warning. The one oral placement where no capnogram and no purging was evident likely resulted from the eyelet holes being situated far enough away from the mucosal surfaces so as not to be affected by negative pressure. While capnography could not differentiate whether purging indicated the tube was esophageal or intra-oral, patient safety is maintained. If the tube is advanced when it is curled in the mouth, it will simply continue to coil and will either become visible exiting the mouth at some point, or be diagnosed when the "pre-feed" radiograph fails to demonstrate the feeding tube in its expected location.

When placing a feeding tube using the two-step radiological procedure, most time is spent waiting for radiographs to be obtained and made available for viewing (Table I). Capnography use adds only seconds to a feeding tube placement procedure. By utilizing capnography, the steps detailed in columns two through five of Table I could be avoided. A scenario involving a feeding tube repeatedly entering a patient's respiratory system is an example where capnography could shave hours off the total time required for placement. Each respiratory placement could be diagnosed in seconds, with the tube being repeatedly withdrawn and re-advanced until capnography indicated a non-respiratory placement.

When using capnography, we still recommend obtaining and reviewing one radiograph after tube placement to ascertain final position prior to use. Radiographic evidence that the tip is in an appropriate position prior to administering feeds should be obtained . Also, even if the tube were placed via the esophagus, the tip may curl back into the esophagus, predisposing to regurgitation of the feeding solution. Finally, the tube may be located in either the stomach or small bowel, an important consideration when delivering enteral nutrition. Eliminating at least one radiograph per feeding tube placement compared to the two-step radiography method translates into less patient positioning for radiographs, less radiation exposure for both patients and staff, and would lead to earlier administration of enteral nutrition and medications.

We recognize one of the main limitations of this study is the small sample size (n=100) with only 11 tracheal placements. The possibility exists that a tracheally placed feeding tube would not show a normal capnogram if the lumen of the feeding tube were not perfectly patent, or if the eyelet holes were at the level of the cuff of the endotracheal or tracheostomy tube. We believe the protocol presented herein may help avoid these potential problems.

Conclusions

We have shown that respiratory placement of feeding tubes can be quickly and accurately identified in our ICU patient population by capnography. Also, capnography can decrease the average time to place a feeding tube compared to the two-step radiography method. For those institutions where a two-step radiographic approach is not deemed necessary for placing feeding tubes, the use of capnography should be considered since it adds little time to the procedure, and may help avoid complications of feeding tube placement.

Acknowledgements

We are grateful to Dr. Elizabeth vanDenKerkhoff for help with statistical analysis, and to the nurses and housestaff of Kingston General Hospital ICU for their efforts in entering placements into the study. We also wish to acknowledge the support of Datex-Ohmeda (Canada) for the loan of the capnography unit used in the study.

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