Continuous end-tidal carbon dioxide monitoring for confirmation of endotracheal tube placement is neither widely available nor consistently applied by emergency physicians

N M Delorio

Methods: Emergency physicians in the USA were surveyed by mail in the beginning of the year 2000 regarding availability at their institution of both colorimetric/qualitative and quantitative end-tidal CO₂ capnography, frequency of use in their own practice, and descriptor of their hospital (academic, community teaching, and community non-teaching). Additionally, data were obtained from the National Emergency Airway Registry 97 series (NEAR) about how many intubations used this method of confirmation. NEAR site coordinators were surveyed as well.

Results: Of 1000 surveys, 550 were returned (55%). Colorimetric technology existed in 77% of respondents’ hospitals (n = 421); 25% of respondents (n = 138) had continuous monitoring capability. Physicians practising at academic hospitals were more likely to have continuous monitoring (36%; n = 196) than community teaching institutions (32%; n = 173) and non-teaching centres (18%; n = 100) (p<0.001).

Conclusions: Despite recommendations from national organisations that endorse continuous monitoring of end-tidal CO₂ for confirming endotracheal tube placement, it is neither widely available nor consistently applied.

Survey content and administration

A single mailing was carried out via US Mail. No incentives were offered for responding, though we provided a self-addressed stamped envelope for returning the completed survey. Participants were asked voluntarily for their help. Questions asked included whether the respondent’s primary department was the academic, community teaching, or community non-teaching; whether physicians regularly used this modality to confirm non-arrest intubations; whether they had colorimetric and/or quantitative end-tidal CO₂ measurement available, how often the physician used each of these modalities in confirming non-arrest intubations (always, often, rarely, never), and the type of hospital (academic, community teaching, or community non-teaching) at which the respondent practised. A multiple-choice format was used, and the name of the respondent’s hospital was elicited, though in a separate area of the questionnaire. Respondents were notified that this information would be removed before data analysis. The author’s email address was provided. See box 1 for the complete survey instrument.

Data analysis

Percentages were calculated for answers to questions 1, 2, 4, 5, and 8. Multivariate analysis was performed regarding the relation between type of hospital (question 8) and answers to questions 1, 2, 4, 5, and 8.
questions 1, 2, 4, and 5 (those assessing availability and use of modalities). Questions 3, 6, and 7 were excluded from the data analysis due to lack of usable data.

Box 1: Survey instrument

1. Is colorimetric ETCO2 measurement (e.g. Easy-Cap) available at your department?
   - Yes
   - No

2. If so, how often do you use this method to confirm ETT placement in non-arrest intubations?
   - Always
   - Often
   - Rarely
   - Never

3. If you have this modality available but choose not to always use it, why not? (May choose more than one)
   - Feel other methods (e.g. direct visualization, auscultation of breath sounds) are more effective
   - Cost
   - Difficulty of use
   - Use continuous monitoring instead
   - Other

4. Is continuous, quantitative ETCO2 monitoring available in your department?
   - Yes
   - No

5. If so, how often do you use this method to confirm ETT placement in non-arrest intubations?
   - Always
   - Often
   - Rarely
   - Never

6. If you have this modality available but choose not to always use it, why not?
   - Feel other methods (e.g. direct visualization, auscultation of breath sounds) are more effective
   - Cost
   - Difficulty of set-up
   - Other

7. If you have both colorimetric AND continuous monitoring available, describe how you use these.
   - Only use colorimetric method
   - Only use continuous method
   - First confirm with color change, then hook up quantitative monitor
   - Nurse already has continuous monitor set up so colorimetric version unnecessary
   - Other
   - Not applicable

8. Please select the best descriptor of your hospital.
   - Academic
   - Community teaching hospital
   - Community non-teaching hospital

ETCO2, end-tidal carbon dioxide; ETT, endotracheal tube

METHODS: PART II
Design/survey population, content, and administration

In part II of the study, the National Emergency Airway Registry (NEAR 97) was examined. This is a databank of (at the time) 35 hospitals (box 2) which provided information on all their intubations. Data were collected on how many intubations used either qualitative or quantitative end-tidal CO2 to confirm tube placement in non-arrest patients. This information was obtained by correspondence with the registry coordinators. Next, site coordinators of the 35 hospitals were mailed the survey from part I of the study. The NEAR study was approved by the institutional review board of each participating hospital.

Data analysis

Surveys in this part of the study were analysed as in part I.

RESULTS

In part I of the study, 550 of 1000 usable surveys were returned (55%). Ultimately, all surveys were analysed regardless of whether or not multiple physicians from a hospital responded. A total of 77% physicians reported that colorimetric/qualitative technology exists at their hospitals (n = 421). However, continuous monitoring was available at only 25% (n = 138) of respondents’ sites.

Regarding differences between types of hospital, academic practitioners were more likely to have continuous monitoring available (36%; n = 196) than either community teaching physicians (32%; n = 173) or non-teaching physicians (18%; n = 100) (p<0.001). Among the physicians who had this technology in their emergency departments (n = 138), 14% ‘‘always’’ used it in non-arrest settings (n = 19), whereas 57% ‘‘rarely’’ or ‘‘never’’ employed it (n = 75). The availability of qualitative technology varied by respondents’ hospital type, with 89% of academic hospitals, 83% of community teaching hospitals, and 70% of non-teaching hospitals having this capability.

Part II of the study provided endotracheal tube placement confirmation data in 6009 of the registry’s 6695 non-arrest intubations. Of these, 12% (n = 716) used quantitative end-tidal CO2 assessment, and 60% (n = 3608) were confirmed with qualitative methods. Thus, at least 28% of intubations used neither type of device.

Of 35 NEAR site coordinators, 29 responded to the survey (83%). In 52% (n = 15) of NEAR hospitals, continuous end-tidal CO2 monitoring was available; 86% of site coordinator respondents (n = 25) did practise at a site where colorimetric technology was available. Continuous detection was used ‘‘rarely’’ or ‘‘never’’ by 47% (n = 7) of responders from centres with this modality; 40% ‘‘always’’ used it (n = 6). Continuous monitoring was available in 4/6 NEAR community teaching hospitals (67%), 11/20 academic hospitals (55%), and 1/3 community non-teaching hospitals (p = not significant).

DISCUSSION

Multiple position statements have recently endorsed or mandated the use of end-tidal CO2 detectors in the confirmation of endotracheal tube placement. In March 2001, the Emergency Medicine Journal issued this declaration:

Independent confirmation of correct tube placement by the use of devices that detect end-tidal CO2 is mandatory for every endotracheal intubation performed in the emergency department and as part of the assessment of all patients who arrive at the emergency department already intubated.
In the patient with a perfusing rhythm, end-tidal CO₂ detection is the best method for verification.

End-tidal CO₂ detection has also appeared in the 2002 American Heart Association (AHA) protocols for Advanced Cardiac Life Support (ACLS):

Expired CO₂ detectors are very reliable in patients with perfusing rhythms and are recommended to confirm tube position in these patients (Class IIa).

Finally, the Association of Anaesthetists of Great Britain and Ireland and the American Society for Anesthesiologists (ASA) embrace the use of end-tidal CO₂ detection in their guidelines:

[Capnography is] essential to the safe conduct of anaesthesia.

Continual monitoring for the presence of expired carbon dioxide shall be performed unless invalidated by the nature of the patient, procedure or equipment.

The present study found that even in the light of strong position statements supporting the use of end-tidal CO₂ monitoring in the confirmation of intubations by many professional societies in emergency medicine, anaesthesia, and prehospital care, emergency departments are not universally endorsing this modality. The vast majority of physicians did not have quantitative monitoring at their disposal at the time of the study. Though many more do have the use of qualitative methods such as colorimetric devices, even this number is not 100%. The type of hospital influences the likelihood of available technology. Even the NEAR sites, ostensibly centres committed to monitoring and researching airway practices, report similarly low rates of availability and use of this modality.

More disheartening is the fact that physicians have not embraced this practice even if it is available in their practice settings. Though not officially analysed in the study results because of a lack of valid responses, the survey instrument did include a space for respondents to write in reasons they might have felt such monitoring was not necessary. Reasons cited for this included the belief that other methods, such as colorimetric monitoring, pulse oximetry, visualising tube condensation, or chest radiography were just as reliable, and a perceived difficulty of set-up. Unfortunately, literature does not support the adequacy of alternative methods. In the presence of a continuous waveform, quantitative assessment of end-tidal CO₂ should be the gold standard for intubation confirmation. Pulse oximetry may remain in the normal range for up to five minutes after the cessation of lung ventilation. Colorimetric or qualitative assays have reported sensitivities of as low as 72% in one prospective study of 106 patients for detecting esophageal intubation. Another study found a sensitivity of 98% but a specificity of only 78%. A recent Best Evidence Topic Report in this journal concluded that the colourimetric CO₂ detector is as accurate as IR capnography at detecting tracheal intubation, but is potentially less accurate at detecting esophageal intubation.

Esophageal detector devices have a reported accuracy of as low as 50%. Clearly, these alternative methods are not enough, though the study respondents may not be aware of these numbers.

**Limitations**

This study does have limitations that open the way for future research in this area. The response rate of 55%, although good...
for a survey, does leave the practices of almost one half of the
target population unknowable. Data from the study popula-
tion of ACEP members may not be generalisable to
emergency physicians as a whole, especially those in other
countries. The nature of a survey study makes the possibility
of reporting bias inevitable. Finally, capnography is a new,
rapidly expanding technology that may be more available
today than at the time of the study. Still, it would seem that
those who responded to the survey would be over-representa-
tive of physicians who use this, suggesting that real life
numbers would actually be even lower.

CONCLUSIONS
This study shows that despite strong calls for the practice of
confirming endotracheal tube placement with end-tidal CO2
measurement, our specialty’s practitioners are not in com-
pliance. Physicians and operational managers in emergency
departments need to be further educated so that this
technology becomes more widely available and more consis-
tently used.

Competing interests: none declared

REFERENCES
2 Kannan S, Manji M. Survey of use of end-tidal carbon dioxide for confirming
tracheal tube placement in intensive care units in the UK. Anaesthesia
3 Verification of endotracheal tube placement: policy statement. American
College of Emergency Physicians. www.acep.org/1,4923,0.html (accessed
16 February 2004).
4 Verification of endotracheal intubation: policy resource and education papers.
American College of Emergency Physicians. www.acep.org/1,4924,0.html
(accessed 16 February 2004).
5 Position statement number 1. Confirmation of endotracheal tube placement with
6 O’Connor RE, Swor RA. Verification of endotracheal tube placement following
intubation. National Association of EMS Physicians Standards and Clinical
7 American Heart Association. Guidelines 2000 for cardiopulmonary
resuscitation and emergency cardiovascular care. Circulation
2000;102(Suppl I):I86-I89.
8 Recommendations for Standards of Monitoring During Anaesthesia and
Recovery. 3rd edition, December 2000. The Association of Anaesthetists of
2004).
9 The American Society of Anesthesiologists. Standards for Basic Anesthetic
Monitoring. Approved by House of Delegates, October 1986, amended
(accessed 16 February 2004).
10 Macleod BA, Heller MB, Gerard J, et al. Verification of endotracheal tube
placement with calorimetric end-tidal CO2 detection. Ann Emerg Med
11 Li J. A prospective multicenter trial testing the Scotti device for confirmation of
12 Hogg K, Tice S. Colourimetric CO2 detector compared with capnography
13 Pelucio M, Halligan L, Dhindsa H. Out-of-hospital experience with the syringe