QUESTION 2

SHOULD CARBON DIOXIDE DETECTORS BE USED TO CHECK CORRECT PLACEMENT OF ENDOTRACHEAL TUBES IN PRETERM AND TERM NEONATES?

SCENARIO

The Pedi-Cap device (Covidien, Mansfield, Massachusetts, USA) is frequently used in neonatal resuscitation to check the position of the endotracheal (ET) tube in term and preterm neonates. As a paediatric trainee having worked in various regions of the UK you note a huge variability in this practice. Clinical assessment of chest expansion and air entry, with improvement in saturations, colour and heart rate have been used for decades and work well. Is the Pedi-Cap superior to clinical assessment for checking the position of the ET tube?

STRUCTURED CLINICAL QUESTION

During intubation of neonates [patients], is a carbon dioxide detector [intervention] better than clinical assessment [comparison] to detect correct endotracheal tube placement [outcome]?

SEARCH STRATEGY AND OUTCOME

Medline (1948–April week 1, 2011) and Embase (1947–15 April 2011) using the Ovid interface and the Cochrane Library were searched using the search terms: Neonate/Newborn/Preterm/Infants/Babies AND Carbon dioxide detector/CO_2 detector/Pedi-Cap/Capnography/End tidal CO_2 AND Intubation/Endotracheal tube; limits: Humans.

The search of Medline yielded 41 articles and Embase yielded 43 articles (2 unique articles). No relevant reviews were found in the Cochrane Library.

Thirty-nine articles were excluded, leaving four well conducted prospective studies for review (table 2).

There were no randomised controlled trials.

COMMENTARY

Proper placement of the ET tube during resuscitation can be difficult, especially in neonates, and evidence suggests a significant rate of oesophageal intubation when neonatal tracheal intubation is attempted: the rates of successful intubation at the first attempt vary from 24% in junior trainees to 86% in consultants.[1] Direct laryngoscopy and observation of the ET tube passing between the vocal cords is the standard criterion for verifying ET intubation.[2] Detection of end-tidal carbon dioxide, however, serves as a valuable adjunct to confirm ET intubation, detect inadvertent oesophageal intubation and monitor for accidental tracheal extubation.

Many studies have shown the colorimetric $ETCO_2$ (end-tidal carbon dioxide) detector to be sensitive and specific in confirming ET intubation in haemodynamically stable adults and children.[3] However, there has always been a concern that carbon dioxide in a neonatal small tidal volume may be diluted in the large dead space of the early versions of these detectors, resulting in false negative results (ie, indicating oesophageal placement despite the correct intratracheal position of the ET tube). Therefore, a specific paediatric disposable colorimetric $ETCO_2$ detector (Pedi-Cap) with an internal volume of 3 ml is used during neonatal intubation.[4]

In direct comparisons in adults, capnography was superior to clinical assessment but no single technique was perfect, and capnography was found to be less accurate in cardiac arrest.[5] In paediatric patients weighing more than 2 kg and with spontaneous circulation, detection of exhaled carbon dioxide confirmed tracheal tube position in all cases, but during cardiac arrest the possibility of a false negative result required further confirmation of tracheal tube position.[6]

Four good quality neonatal studies[4 7 10 11] found that capnography/Pedi-Cap identified tracheal tube position more rapidly than clinical assessment. In all studies direct visualisation of tracheal tube position (or clinical assessment) was used as the final 'gold standard'. Hosono *et al* compared capnography with defined clinical assessments. Capnography was completely accurate in all babies studied, all of whom had spontaneous circulation and were less than 32 weeks gestation. This study also had a well defined method for defining tracheal tube position.[7] All studies utilised a separate team to measure exhaled carbon dioxide, with the clinical team blinded to the measurements, and all four examined neonates with spontaneous circulation. Several cases of false negatives in neonates as well as false negatives occurring in adult and paediatric cardiac arrest have been reported.[8] Therefore, capnography should be interpreted carefully in extremely small neonates or in those in whom extensive resuscitation is required.

All studies showed that detection of exhaled carbon dioxide confirms tracheal intubation in neonates with a cardiac output more rapidly and more accurately than clinical assessment alone. False negatives may occur in very low birthweight neonates and in those in cardiac arrest.[8] False positives may occur in the presence of colorimetric devices contaminated with epinephrine (adrenaline), surfactant or atropine.[9] There is no comparative information to recommend any one method for the

Table 2 Should carbon dioxide detectors be used to check correct placement of endotracheal tubes in preterm and term neonates?

Citation	Study group	Study type	Outcome	Key results	Comments
Hosono *et al*[7]	54 intubations in 40 neonates in the delivery room were analysed Mean birth weight 839±263 g Mean gestational age 27.0±2.5 weeks	Prospective cohort	ETT placement was compared using Pedi-Cap by an investigator not involved in the resuscitation, and by evaluation of clinical parameters by a resuscitation team unaware of the $ETCO_2$ data The clinical parameter was used as the gold standard The times taken to detect accurate placement of the ETT using $ETCO_2$ vs clinical determination of tracheal or oesophageal tube placement were compared	Capnography: sensitivity and specificity 100% Clinical: sensitivity 92.5% and specificity 82.4% Mean time for capnographic determination was significantly less than for clinical determination for both tracheal 7.5 (±1.3) s vs 17.0 (±3.4) s ($p<0.01$) and oesophageal intubation 6.5 (±0.7) s vs 19.9 (±1.8) s ($p<0.01$)	Resuscitation team blinded to $ETCO_2$ result. Investigator not involved in resuscitation
Repetto *et al*[10]	27 intubations in 16 patients were analysed Birth weight 575–2040 g Gestational age 23–34 weeks	Prospective cohort	The times taken using $ETCO_2$ and clinical determinations of ETT placement in the delivery room were compared	The median (range) times required for capnographic and clinical determination of tracheal intubation were 9 (4–26) s vs 35 (18–70) s ($p<0.001$), and for oesophageal intubation were 9 (4–17) s vs 30 (25–111) s ($p=0.001$)	High rate of oesophageal intubation (11/27=40%) Only delivery room intubations Hand-held, portable CO_2 monitor providing CO_2 readout was used instead of Pedi-Cap Investigator not involved in resuscitation, or resuscitation team unaware of the $ETCO_2$ data
Aziz *et al*[4]	45 newborns (450–4620 g) who needed endotracheal intubation 34 (53.3%) were intubated in the delivery room and 21 (46.7%) in the NICU	Prospective cohort	Accuracy and ease of the Pedi-Cap Pedi-Cap correlation with clinical evaluation and radiography findings for endotracheal intubation Pedi-Cap correlation with clinical evaluation for ETT in the oesophagus Comparison of time required to determine tube position by clinical evaluation and $ETCO_2$	Correlated in 30 of 33 patients (sensitivity 91%, specificity 100%) Correlated in 12 of 12 patients (sensitivity, specificity, and PPV and NPV were all 100%) Clinical evaluation: 0–90 s (mean 39.7±15.3 s) $ETCO_2$ detector: 4–12 s (mean 8.1±2.9 s) ($p<0.001$)	Resuscitation team blinded to the colour status of the Pedi-Cap Three false negatives with severe cardiorespiratory depression Negative result in CPR is not assessable as four infants needing most resuscitation were excluded No measure of success of resuscitation
Roberts *et al*[11]	100 intubations in 55 neonates in the NICU were studied Mean birth weight 1419±811 g Mean gestational age 28.5±4.0 weeks	Prospective cohort	Capnography and clinical examination for identification of tube position were analysed The time required for establishing by clinical confirmation whether the tube was in the trachea or not was compared to that required for capnography	40/100 intubation attempts resulted in oesophageal intubation Capnography correctly identified oesophageal tube placement in 39/40 and did so in a mean of 1.6±2.4 s. Capnography failed to identify successful endotracheal intubation on only one occasion Clinical indicators of tube position required 97.1+/–92.6 s to identify oesophageal intubation and failed to identify successful endotracheal intubation in 5 of 60 cases	Useful observational study and the intubating clinicians were blinded to the capnography Study was carried out in a neonatal unit and not in the delivery room A hand-held, portable CO_2 monitor was used instead of Pedi-Cap

$ETCO_2$, end tidal CO_2; ETT, endotracheal tube; NICU, neonatal intensive care unit; NPV, negative predictive value; PPV, positive predictive value.

detection of exhaled carbon dioxide in the neonatal population. It appears important to use $ETCO_2$ detection during neonatal intubation.

Clinical bottom line

- Detection of exhaled carbon dioxide confirms tracheal intubation in neonates with a cardiac output more rapidly and more accurately than clinical assessment alone. (Grade B)
- False negatives may occur in neonates with cardiac arrest. (Grade C)
- It is unclear if false positives occur with colorimetric devices contaminated with epinephrine, surfactant or atropine. (Grade D)

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