ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 08, pp.36007-36009, August, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

COMPARISON OF END TIDAL CARBON-DI-OXIDE AND CLINICAL SIGNS IN ASSESSING ENDOTRACHEAL INTUBATION IN CHILDREN

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ARTICLE INFO

Article History:
Received 03rd May, 2016
Received in revised form
29th June, 2016
Accepted 05th July, 2016
Published online 20th August, 2016

Key words:

Endotracheal intubation,
Capnography,
Clinical assessment.

ABSTRACT

Objectives: To compare the efficacy of end tidal carbon-di-oxide with clinical assessment in endotracheal tube placement in children and to correlate EtCo2 with various clinical conditions. Methods: Patients between 1 month to 18 years of age admitted to the emergency room requiring tracheal intubation were studied excluding patients admitted with cardiac arrest.
Design and Setting: Prospective analytical study done in emergency room of a tertiary care pediatric hospital between September 2010 and June 2012.
Results: Capnography identified all esophageal and airway intubations accurately except for 1 airway intubation. Clinical assessment identified all airway intubations correctly but only 1 out of 5 esophageal intubations. The mean time taken for confirmation of ET tube position by capnography was 8.15 ± 4.07secs and by clinical assessment was 22.45 ±14.44 secs and esophageal intubation by capnography was confirmed in 12.4 ± 4.77 sec and by clinical assessment in 35.8 ± 12.79 secs. EtCo2 identified underlying circulatory/ metabolic derangement thereby helping appropriate management.
Conclusions: Capnography and clinical assessment were sensitive in identifying airway intubations, however only capnography was 100 % specific in identifying esophageal intubations. The mean time to assess tracheal and esophageal intubation was significantly less with capnography. Capnography did not discriminate between tracheal and bronchial intubation. Capnography helped monitoring response to treatment in children with shock, respiratory failure.

Citation: Geetha, J. and Radhika, R. 2016. "Comparison of end tidal carbon-di-oxide and clinical signs in assessing Endotracheal intubation in children", *International Journal of Current Research*, 8, (08), 36007-36009.

INTRODUCTION

Endotracheal intubation is a commonly performed procedure in life-threatening situations. Inadvertent, undetected esophageal intubation is catastrophic. The usual clinical methods of confirming endotracheal tube (ETT) position, such as bilateral auscultation for breathsounds, visualizing chest movement, fogging of the ETT, auscultation over the stomach, occasionally fail. Although visualization of the ETT going through the vocal cords is confirmatory, it can get displaced. CO2 is exhaled through the trachea and is not usually detected in the esophagus thereby capnometry can distinguish between endotracheal and esophageal intubation. The new 2010 American Heart Association Guidelines now endorse wave form capnography as a Level I recommendation for confirming endotracheal intubation (Pediatric advanced life support 2010 guidelines).

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MATERIALS AND METHODS

This prospective analytical study was conducted in the emergency room of a tertiary care pediatric facility between September 2010 and June 2012. Patients 1 month to 18 years of age admitted to the emergency room requiring tracheal intubation were included in the study and those requiring intubation for cardiac arrest were excluded. Ethical committee clearance from the institution was obtained. Demographic details of the patient and pre intubation vitals such as oxygen saturation, heart rate, blood pressure, diagnosis, indication for intubation were recorded.

Five point auscultation (bilateral infraclavicular, bilateral infraaxillary and epigastrium) was used to confirm endotracheal tube position by clinical assessment. For confirmation with $EtCo_2$, capnography reading documented after providing four positive pressure ventilation was noted. Criteria used to define the normal tracheal capnogram were (i) the presence of at least four expiratory phases, and (ii) a stable

peak CO_2 concentration. Criteria used to define esophageal intubations were (i) no expiratory phases during four positive-pressure ventilations, and (ii) a low peak CO_2 concentration that rapidly tapered to zero during four positive-pressure ventilations. Doctors performing the intubation and clinical examination for confirmation of endotracheal tube were blinded. Data collection was done by either of the investigators who were not blinded.

RESULTS

66 intubations were performed in our study population of 61 children. 61 intubations were in the airway (tracheal/ bronchial) and 5 were esophageal intubations. Capnography confirmed 60 out of 61 airway intubations and failed in one child. All 5 esophageal intubations were identified accurately by capnography. Clinical assessment identified all 61 airway intubations and only 1 out of 5 esophageal intubations. Clinical assessment was 100% sensitive and 20% specific while capnography was 100% specific and 98.36%sensitive in confirming endotracheal intubation (Table1) Of the 61airway intubations, 44 were tracheal and 17 were in the right main bronchus as confirmed by clinical examination. The mean time taken for confirmation of ET tube position with capnography was 8.15 ± 4.07sec and by clinical assessment the mean time was 22.45 ±14.44 sec (p value <0.01).

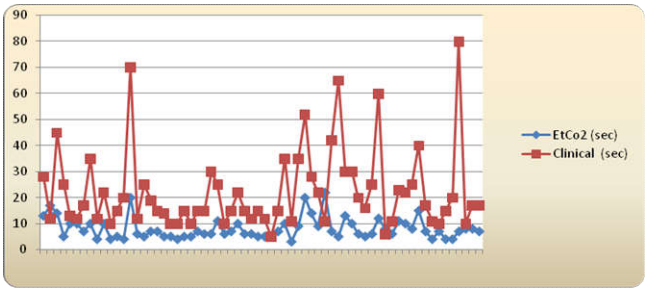

Figure 1. Comparison of the time taken for ET tube confirmation by clinical examination and capnography

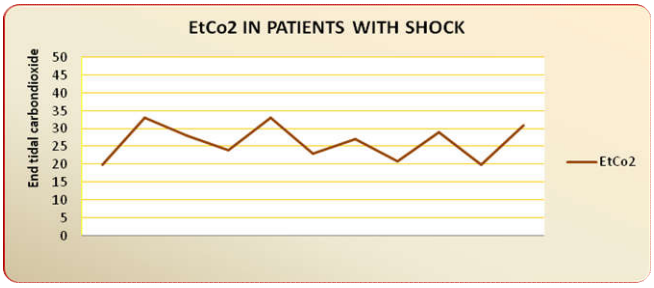

Figure 2. $EtCo_2$ values in patients with shock

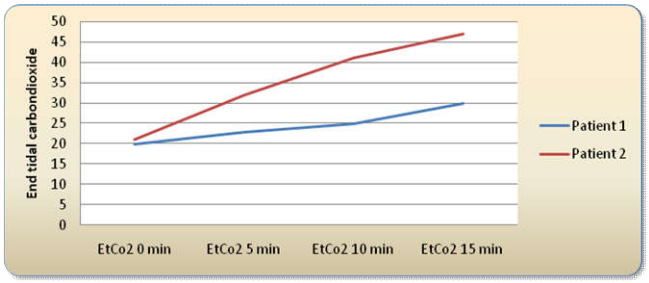

Figure 3. Trend of $EtCo_2$ in patients with shock during resuscitation

The mean time taken for confirmation of esophageal intubation by capnography was 12.4 ± 4.77 sec and by clinical assessment was 35.8 ± 12.79 sec (p value < 0.01). (Figure 1) $EtCo_2$ values in children diagnosed to have shock were below the normal range of 35 – 45. (Figure 2) Serial $EtCo_2$ values in two children with severe shock showed an increasing trend with fluid resuscitation and inotropic support. (Figure 3) Analysis of $EtCo_2$ values in children with poor respiratory effort (respiratory failure), revealed higher than normal $EtCo_2$ values (Figure 4).

DISCUSSION

Early recognition of esophageal intubations in a sick child with very poor reserves is vital. Clinical assessment of endotracheal tube position can be inconclusive. Upto 25% of intubations can be esophageal (Batra and Cohn, 1983). Of the total 66 intubations done in our study, 5 (7 %) were esophageal intubations. Among the 61 airway intubations, 60 of them were accurately identified to be in airway by capnography except in 1 patient with pulmonary hemorrhage as the $EtCo_2$ sensor was contaminated with blood. Capnography also identified all 5 esophageal intubations accurately however the sensitivity and specificity of capnography in identifying endotracheal tube position in our study was 98.36% and 100% respectively in comparison to 100% sensitivity and specificity reported in previous studies (Shigeharu Hosono *et al*., 2009). Clinical assessment to confirm tube position identified all airway (tracheal and bronchial) intubations and only 1 out of 5 esophageal intubations correctly. This was comparable to the study by Hosono (2009) where all tracheal intubations and 11 out of 14 esophageal intubations were identified correctly. Confirming endotracheal intubation by clinical examination is not foolproof as breath sounds can be appreciated even in patients with esophageal intubations (Birmingham *et al*., 1986; Batra and Cohn, 1983). Extraneous noises during the management of critically ill patients in the prehospital or ED setting can make auscultation challenging. Airflow during positive pressure ventilation may sound different than in spontaneously breathing patients, and transmitted sounds can be misleading, particularly to inexperienced providers (Knapp *et al*., 1999). Sensitivity and specificity of clinical assessment in confirming endotracheal intubation in our study was 100% and 20% respectively in comparison to a sensitivity of 92.5% and specificity of 82.4% by Hosono conducted on very low birth weight neonates and could be due to differences in study population. Although EtCo2 helped determine if the ET tube was positioned in the airway or esophagus, it was not of much help in differentiating between main airway (trachea) or right bronchus intubation and 17 (27%) of airway intubations were found to be in the right bronchus in our study. Considering the complications associated with bronchial intubation, clinical assessment of ET tube position is mandatory. Schwartz *et al*. concluded that the incidence of right main stem intubation in the critical care setting, not detected by clinical examination, but discovered on the chest radiograph after intubation was 4%[8]. Accidental bronchial intubation has been reported in 3.7% incidents with capnography remaining normal or unremarkable during 88.5% of the episodes (McCoy *et al*., 1998). The mean time taken to confirm airway intubation by capnography was 8.15 ± 4.07 secs and 22.45 ± 14.44 secs by clinical assessment

(p value 0.01) which is similar to the time for confirming endotracheal intubation in neonates, by capnography 7.5 ±1.3 sec vs. 17.0 ± 3.4 sec by clinical assessment (Shigeharu Hosono *et al*., 2009). The probable reason for the discrepancy in time for determination of accurate ET intubation by clinical assessment was due to the fact that the time included confirming not only tracheal intubation but also tracheal vs. bronchial intubation. Esophageal intubations were confirmed by capnography in a mean time of 12.4 ± 4.77 sec and clinical assessment in 35.8 ± 12.79sec (p value <0.01) in comparison to 6.5 ±0.7 sec vs. 19.9 ±1.8 sec in the study in neonates which was similar to the study by Robert *et al* who demonstrated that capnography provides a rapid, reliable, and practical method for differentiating endotracheal from esophageal tube placement (Roberts *et al*., 1995). Main stream capnography during neonatal resuscitation is reliable and rapid in detecting esophageal intubation (Repetto *et al*., 2001). Correlating $Etco_2$ and clinical status, it was observed that of the 11 patients with shock who were intubated 7 % had EtCo2 values lower than the normal range. This is due to the reduction in cardiac output and pulmonary blood flow during shock resulting in a decrease in partial pressure of CO_2 at the end of expiration ($PETCO_2$) (Leigh *et al*., 1961; Askrog, 1966). $EtCo_2$ values greater than the upper limit of normal was observed in children with poor respiratory effort (respiratory failure) probably due to the accumulation of carbon dioxide secondary to inadequate excretion through lungs. This observation was however not consistent because bag and mask ventilation was required in a significant number of children prior to intubation.

Conclusion

Capnography can identify all tracheal and esophageal intubations accurately and earlier in comparison to clinical examination however it cannot differentiate between tracheal and bronchial intubation. Capnography can guide the response to treatment in patients with shock and in patients with respiratory failure..Capnography is an invaluable tool in the pediatric emergency room.

Contributions

Geetha J collected data, analysed and prepared manuscript, Radhika R conceived the study, guided, analysed, critically reviewed the manuscript.

Acknowledgements

Dr. Andal, Head of Dept of pediatrics, Kanchi Kamakoti CHILDS Trust hospital for reviewing the study as it progressed and providing valuable suggestions

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