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Is capnometry helpful in children with bronchiolitis?

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ABSTRACT

Background: Acute bronchiolitis is the most frequent lower respiratory tract infection in infants. Only small subsets of patients develop severe disease resulting in hospitalization despite having no identifiable risk factors. There is still a debate as to the role of capnometry in assessing ventilation in children with acute respiratory distress, and bronchiolitis in particular.

Methods: This was a prospective, single blind cohort study in which children younger than two years presenting to the emergency department (ED) with bronchiolitis were included. Our primary outcome was the correlation between the end tidal CO2 ($EtCO_2$) and the clinical decision of hospital admission and discharge. Our secondary outcome measure was the correlation of $EtCO_2$ upon arrival to the ED and clinical measures of bronchiolitis severity. Finally, by using multivariate models, we looked for other parameters that could contribute to the prediction of illness severity.

Results: One hundred and fourteen children with bronchiolitis were evaluated. Their median $EtCO_2$ upon arrival to the ED was 34 mmHg (range 24–65 mmHg). $EtCO_2$ values upon admission or discharge were not statistically different among patients who were hospitalized and among those who were discharged from the ED. Among admitted patients, we found no correlation between capnometry readings at admission and number of oxygen desaturation days, nor with the length of hospitalization. Wang clinical respiratory severity score was found, by using multivariate models, to predict nasogastric tube need, oxygen desaturation days, and length of hospitalization.

Conclusion: Capnometry readings upon arrival to the ED did not predict hospital admission or hospital discharge eligibility. Among hospitalized patients, $EtCO_2$ did not correlate with the evaluated disease severity measures. Wang score was found to be the most consistent predictor of significant outcomes.

1. Introduction

Acute bronchiolitis is the most frequent lower respiratory tract infection in infants [1]. It carries a substantial morbidity [2], with an increasing trend in the rates of hospitalization in the USA and Canada over the last few decades [3–5]. RSV infections are extremely common in children under two years and resolve naturally; only a small subset (~5%) develops severe disease resulting in hospitalization despite having no identifiable clinical risk factors. Clinical assessment using respiratory scores [6,7] is being used by clinicians, trying to predict the clinical course of the disease. But prediction can be challenging, with possible inter-observer variability using those scores [8]. There is a need for a tool to determine which child, among those who visit the Emergency department (ED), can be discharged home, and who should be admitted. Although, there may be impairment in both oxygenation and ventilation in RSV bronchiolitis patients, only the assessment of oxygenation using oximetry has become common practice. While, assessment of ventilation by monitoring of CO_2 is not routinely used as criteria for hospitalization and nor as a measure for follow-up or discharge.

Capnometry is a commonly used technology that allows for non-invasive measurement of maximum expired carbon dioxide concentration during a respiratory cycle - end tidal CO2 ($EtCO_2$). In recent years, capnometry has emerged as a useful tool to measure ventilation, perfusion and acid base status. It is well studied in intubated and non-intubated patients in a wide range of clinical circumstances [9–12] including children with respiratory distress [13]. One of the concerns using capnometry is its accuracy when compared to partial arterial carbon dioxide pressure (PaCo2),

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especially in non-intubated patients. Recently, a couple of technologies were developed to tackle this problem, including microstream technology that allows high accuracy in non-invasive $EtCO_2$ measurements in infants and children, with a mean difference between the arterial to end-tidal carbon dioxide tension gradient of 1 ± 6 mmHg [14,15]. Good correlation has been demonstrated among patients with normal lung function [16], in non-intubated patients presenting to EDs with a variety of conditions [17] and also in children with respiratory distress [13,18–20].

There is still debate in the literature as to the role of capnometry in bronchiolitis. Lashkeri et al. [21] studied $EtCO_2$ measurements in children with bronchiolitis to determine its prognostic utility using admission rates, and clinical severity score [7]. They found capnometry not to predict prognosis. On the contrary, Kugelman et al. [22] found transcutaneous CO_2 to correlate with disease severity clinical score including oxygen requirement, heart rate, and respiratory rate.

The aim of this study was to evaluate the utility of $EtCO_2$ measurement at arrival to the ED as a predictor of hospital admission and discharge, as well as a predictor of illness severity.

2. Methods

2.1. Study setting and design

This was a prospective, single blind cohort study assessing $EtCO_2$ values in children presenting with bronchiolitis at a level III, urban pediatric emergency department with 25,000 visits per year.

The institutional review board (IRB) of Rambam Health Care Campus approved the study and the parents of all children signed an informed consent prior to the participation in the study.

We included 114 infants younger than 2 years presenting to the ED (between October 2013 and April 2014) with clinical bronchiolitis (as determined by the treating physician). Exclusion criteria were any history of oncological or metabolic disorder.

Our primary outcome measure was the correlation between the end tidal CO2 ($EtCO_2$) and clinical decision of hospital admission and discharge or the need for ICU. Our secondary outcome measure was the possible correlation of $EtCO_2$ upon arrival to the ED and clinical measures of bronchiolitis severity including length of hospitalization, the need of supplemental oxygen and nasogastric tube feeding.

2.2. Study protocol and measurements

Children diagnosed with bronchiolitis by the ED physician, at arrival to the ED, were recruited to the study using sample of convenience. Patient enrollment occurred when investigators were present in the ED to enter patients. Enrollment occurred (intermittently) 7 d/wk during day, evening, and night shifts.

$EtCO_2$ was measured by a nurse, which was not involved in the treatment of the child, as part of the routine vital signs and nursing documentations. Afterwards, treating physician assigned each patient a 12 point clinical severity score (Wang score) [6] using the following parameters: respiratory rate, respiratory muscle retractions, wheezing and feeding difficulties.

The treating physician was responsible for the decision of admission and treatment, and was blinded to the $EtCO_2$ readings. Criteria for admission included: age younger than 2 months, oxygen desaturation, difficulties with feeding, significant work of breathing or apneas and the physicians clinical judgement. Hospitalized children had additional $EtCO_2$ measurement just prior to discharge, after discharge decision was already made by the treating pediatrician.

Ethical considerations prevented us from obtaining arterial CO_2 measurements of patients with clinical bronchiolitis, since it is not routinely performed in our institution.

$EtCO_2$ measurements were performed using a portable handled Capnograph (Microcap® Plus; Covidien) with oral-nasal cannula. A 60 s stabilization period was used before initiation of $EtCO_2$ recording, to allow subjects to adjust to breathing with the cannula in place. After stabilization, a 30–60 s $EtCO_2$ measurement was obtained. To allow for minor fluctuation in $EtCO_2$ corresponding to normal respiratory variation, the recorded value was the $EtCO_2$ reading displayed most frequently during the recording period [23].

All data was retrieved from the patient's electronic medical record including: demographic data (age, and gender), history (medical conditions, history of prematurity, previous wheezing episodes, family history of asthma and smoking), vital signs on arrival (pulse rate, respiratory rate, oxygen saturation, and temperature), and data regarding hospitalization (Wang clinical score, number of days with oxygen desaturation, fever, and nasogastric feeding, length of hospitalization, viral etiology if applicable, admission to pediatric intensive care unit (PICU), mechanical ventilation, high flow ventilation therapy, medications administered and radiographic findings on chest x-ray).

In our institution, viral etiology is searched only among admitted patients with respiratory illness, and includes Influenza, Adeno, Parainfluenza, RSV, and Human Metapneumovirus (HMPV).

Number of days with oxygen desaturation, fever and nasogastric feeding were calculated according to calendric days. Length of hospitalization was calculated as hours from admission to the ED to discharge from the ED or pediatric ward.

2.3. Statistical analysis

Statistical analysis was performed using SPSS version 21 (SPSS Inc. Chicago, IL, USA). Descriptive statistics were performed for all parameters in the research. Paired tests were used for differences between capnometry readings at admission and discharge. Results are described as mean ± SD. T-test or Mann-Whitney U tests were used to assess differences between capnometry readings at arrival to the ED and categorical parameters such as prematurity, family history of asthma, smoking etc. Pearson correlation tests were used to determine the relationships between quantitative parameters and capnometry readings. Fisher exact test or Pearson chi-square was used to assess differences between categorical parameters. Based on capnometry range of values of patients discharged from the ED, Z score was calculated for patients who were admitted, in order to find the children that will have worse outcomes. Multivariate Logistic regression was used for the prediction of outcome parameters such as the used of nasogastric tube feeding, based on several independent parameters. $P < 0.05$ was considered as significant.

3. Results

3.1. Characteristics and $EtCO_2$ readings on arrival and on discharge

114 children with clinical bronchiolitis were evaluated in our study; Characteristics and clinical conditions at arrival to the ED are presented in Table 1.

The median $EtCO_2$ values of all children participated in this study upon arrival to the ED was 34 mmHg (range 24–65 mmHg). No statistical significance was found between the measured $EtCO_2$ of patients who were admitted and those who were discharged from the ED (median 35 mmHg (range 25–65 mmHg) and median 34 mmHg (range 24–42 mmHg) respectively; $p = 0.22$). The median $EtCO_2$ values of all children participated in this study upon discharge was 34 mmHg (range 24–48 mmHg). No statistical