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# Research in Developmental Disabilities



## Capnography in patients with severe neurological impairment



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### ABSTRACT

Respiratory disease is a common reason for hospitalization and mortality in persons with severe intellectual and developmental disability. Capnography is the measurement and numerical display of end-tidal carbon dioxide (EtCO<sub>2</sub>). This was a prospective, case controlled, cross sectional study to assess differences of baseline EtCO<sub>2</sub> values between neurologically impaired patients and healthy individuals. 86 neurologically impaired patients were evaluated in the study group. Their mean age  $\pm$  SD was 25.65  $\pm$  10.48 years with 41% males. 53 healthy children and young adults were evaluated in the control group. Their mean age  $\pm$  SD was 21.95  $\pm$  10.38 years with 54.7% males. Patients with severe neurological impairment had higher baseline EtCO<sub>2</sub> values than healthy individuals. Kyphoscoliosis and the use of antipsychotic drugs were the major factors to increase EtCO<sub>2</sub> levels. Knowing the patient's baseline EtCO<sub>2</sub> value, as well as baseline oximetry, could guide treatment decisions, when assessing the patient's oxygenation and ventilation during acute respiratory illness, and can potentially prevent unnecessary laboratory and imaging investigations as well as over treatment. Future research can shed light on the utility of capnometry and clinical implications of higher baseline EtCO<sub>2</sub> values among neurologically impaired patients.

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Respiratory illness is a most common reason for hospital admission in children with profound developmental impairment (Mahon, 2004). It is also the most common cause of death (Hollins, Attard, von Fraunhofer, McGuigan, & Sedgwick, 1998; Plioplys, Kasnicka, Lewis, & Moller, 1998; Westbom, Bergstrand, Wagner, & Nordmark, 2011), and carries higher morbidity than any other cause (Bagdure, Curtis, Dobyns, Glodé, & Dominguez, 2010; Lucas, 2010). A number of factors contribute to respiratory difficulties, such as oropharyngeal motor problems, gastro-esophageal reflux, poor cough and airway clearance, respiratory muscle weakness, kyphoscoliosis, sleep apnea, chronic colonization with resistant bacteria, and the development of bronchiectasis. Other pediatric respiratory conditions such as asthma are also represented in this population (McCrea, O'Donnell, & Brown, 2013; Seddon, 2003).

Patients presenting to the emergency department (ED) in general, and children with developmental impairment in particular, often require assessment of their oxygenation, ventilation and acid–base status. Noninvasive rapid assessment of

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these measures would greatly facilitate evaluation of these ED patients. The assessment of oxygenation by oximetry has become commonplace in monitoring patients with disorders of oxygenation, however it does not reflect the acid base status in patients with chronic lung disease. In recent years, capnometry has emerged as a useful measure of ventilation, perfusion and acid base status. It has become the standard procedure for patient monitoring during anesthesia, for the confirmation of the endotracheal tube position (Neumar et al., 2010), and during procedural sedation analgesia (Krauss & Hess, 2007). Additionally, it is well studied in a wide range of clinical circumstances (Krauss, 2008).

When patients with developmental impairment present to the ED with respiratory complaints, there is usually a lack of information about their previous diseases and baseline ventilation status, and there may be a tendency to perform unnecessary laboratory and imaging investigations as well as over treatment.

Microstream technology allows for accurate non-invasive end-tidal CO<sub>2</sub> (EtCO<sub>2</sub>) measurements in infants and children with a mean difference between the arterial to end-tidal carbon dioxide tension gradient of  $1 \pm 6$  mmHg (Casati et al., 2000; Colman & Krauss, 1999). EtCO<sub>2</sub> is the maximum expired carbon dioxide concentration during a respiratory cycle. The graphical representation of the concentration or partial pressure of expired carbon dioxide during a respiratory cycle is shown in a waveform format and is known as a capnogram, which provides information not only regarding pulmonary function, but also indirect cardiac function, ventilator function and perfusion.

Good correlation has been demonstrated among patients with normal lung function (O'Flaherty, 1994), in nonintubated patients presenting with a variety of conditions to EDs (Barton & Wang, 1994) and in children with respiratory distress (Moses, Alexander, & Agus, 2009; Yosefy, Hay, Nasri, Magen, & Reisin, 2004).

The aim of our study was to compare baseline EtCO<sub>2</sub> values in neurologically impaired patients with healthy individuals.

## 1. Methods

### 1.1. Study setting and design

This was a prospective, case controlled, cross sectional study to assess differences of baseline EtCO<sub>2</sub> values between neurologically impaired patients and healthy individuals. The study was approved by the institutional review board (IRB) of Rambam Health Care Campus, and informed consent was obtained from the patients, parents or guardian.

Profoundly neurologically impaired patients aged 4–40 years, residing in the residential care center “Hod Care Home” for people with intellectual and developmental disability under the auspices of the Division for Intellectual and Developmental Disabilities of the Ministry of Social Affairs were considered for inclusion. Exclusion criteria included acute respiratory or infectious disease, chronic metabolic disorder with acidosis, chronic cardiovascular diseases and patients who did not cooperate with EtCO<sub>2</sub> measurements. The control group included healthy children and young adults aged 2–37 years visiting their hospitalized relatives at Meyer's Children Hospital in Rambam Health Care Campus, Haifa, Israel.

### 1.2. Study protocol and measurements

The medical record was used to obtain demographic data (age, and gender), patient history and medical conditions, including medications used, kyphoscoliosis, history of prematurity, gastroesophageal reflux, gastrostomy, tube feeding and neuromuscular disease.

EtCO<sub>2</sub> was measured using a portable handled Capnograph (Microcap<sup>®</sup> Plus; Covidien) with oral-nasal cannula. A 60 s stabilization period was used before initiation of EtCO<sub>2</sub> recording, to allow subjects to adjust to breathing with the cannula in place. After stabilization, a 30–60-s EtCO<sub>2</sub> measurement was obtained. To allow for minor fluctuation in EtCO<sub>2</sub> corresponding to normal respiratory variation, the recorded value was the EtCO<sub>2</sub> reading displayed most frequently during the recording period.

The main study outcomes were evaluating the EtCO<sub>2</sub> differences between neurologically impaired patients and healthy individuals, and among the neurologically impaired patients, finding the variables that can predict higher EtCO<sub>2</sub> values.

### 1.3. Statistical analysis

Statistical analysis was performed using SPSS 21 (SPSS-IBM). The Mann–Whitney *U* test was used to analyze EtCO<sub>2</sub> differences between the neurologically impaired patients and the healthy individuals, since EtCO<sub>2</sub> was not normally distributed.

Among the neurologically impaired patients Pearson correlation was used to determine the relationship between Capnography and all other quantitative parameters. Fisher exact test was used to assess differences between categorical parameters.  $P < 0.05$  was considered as significant.

## 2. Results

86 neurologically impaired patients were evaluated in the study group. Their mean age  $\pm$  SD was  $25.65 \pm 10.48$  years with 41% males. Eight patients were excluded from data analysis (six patients did not cooperate with the measurements, and two patients had congestive heart failure). Their characteristics are shown in Table 1.

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