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Unknown use of end-tidal CO_2 in metabolic emergencies in pediatric patients

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ABSTRACT

The authors describe two cases of metabolic acidosis, caused by diabetic ketoacidosis in the first case and by dehydration following gastroenteritis in the second one. Both patients were followed with noninvasive end-tidal CO_2 ($ETCO_2$) monitoring. A correlation between $EtCO_2$ and PCO_2 and HCO_3^- has been established in the literature. Noninvasive $ETCO_2$ is used in only 5–6% of metabolic emergencies. In contrast, users described its use as easy and convenient.

Key words: end-tidal CO_2, metabolic emergencies, pediatric patients, Noninvasive $ETCO_2$

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INTRODUCTION

Capnography is the measurement of the partial pressure of CO_2 in the air exhaled by the patient. We distinguish end-tidal CO_2 ($ETCO_2$), which represents the maximum numerical value at the end of the expiration, and the shape of the CO_2 wave, also called capnogram, which is a graphic presentation of the inhaled and exhaled concentration or partial pressure of CO_2. Changes in $ETCO_2$ values are useful for assessing the severity of a pathology as well as the response to treatment. This measurement is more commonly performed during mechanical ventilation but could also easily be used noninvasively.[1] The authors describe how following $ETCO^2$ allows monitoring of treatment for dehydration in two common pediatric situations: diabetic ketoacidosis and acute gastroenteritis. This technique allows a noninvasive, quantified metabolic monitoring of the rehydration process.

CLINICAL CASE 1

A 15-year-old patient was admitted for abdominal pain, nausea, and vomiting in a diabetes setting. The first biological tests revealed the following: arterial pH, 7.08; base excess (BE), −20 mmol/L; pCO_2, 28.4 mmol/L; HCO_3^-, 8.4 mmol/L; glycemia, 23.1 mmol/L; blood beta-hydroxybutyrate, 7.6 mmol (Nl < 0.5)/L. Ketoacidosis was treated with a hydration of 3 L/m^2 and a continuous infusion of rapid-acting insulin. Continuous noninvasive monitoring of $ETCO_2$ was performed using a Viamed Capnometer (Viamed Limited, Keighley, United Kingdom) using nasal cannulas. The initial value was 17 mmHg, which increased to 32 mmHg at the end of continuous IV insulin infusion. During this 6-h period, we observed a correlation between $ETCO_2$ and pH, PCO_2, HCO_3^-, and respiratory rate (Figure 1).

CLINICAL CASE 2

An 8-month-old patient was admitted to the emergency department with fever and diarrhea for 4 days. The patient exhibited clinical signs of dehydration with deep apathy and a weight loss approaching 10% of the body weight. A first measurement of capillary blood gases showed a pH of 7, 32, pCO_2 of 24 mmol/L, HCO_3^- of 16 mmol/L and EB of −12. A rehydration by naso-gastric tube was tried but discontinued because of failure (diarrhea of >20 cc/kg/h and a drop of capillary pH to 7.24). Intravenous rehydration was initiated with $ETCO_2$ monitoring. The initial value was 23 mmHg, which increased to 30 mmHg.

By then, the patient was transferred to a normal ward for further rehydration. During this 6-h period, we observed a correlation between $ETCO_2$ and pH, pCO_2, HCO_3^-, and respiratory rate (Figure 2).

DISCUSSION

These two observations illustrate the way in which continuously monitored $ETCO_2$ reflects a significant degree of correlation with the metabolic variations of these two patients. The improvement in the hydration state resulted in an increase in bicarbonate. As a result of this increase, the respiratory compensation fades, which results in a decrease in respiratory rate and a proportionate increase in CO_2 and $ETCO_2$ values.

A survey conducted in a network of pediatric emergency departments in the United States and Canada showed that 88% of emergency departments have access to $ETCO_2$ to monitor intubated patients and 53% have a noninvasive system. Only 20% of these hospitals use it for moderate sedation, 16% for trauma and 6% for acid-base metabolic disorders.[2]

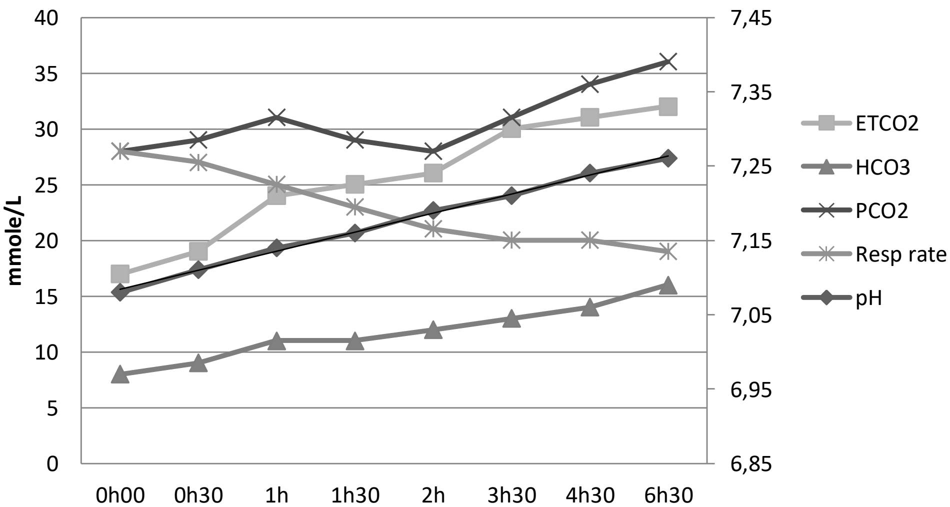

Figure 1: Correlation between $ETCO_2$, and pH, pCO_2, HCO_3. values, and respiratory rate during rehydration during ketoacidosis rehydration. Improvement of metabolic acidosis following administration of fluid and insulin results in elevated bicarbonate with a decrease in respiratory compensation marked by a decrease in respiratory rate and an increase in CO_2 and $ETCO_2$.

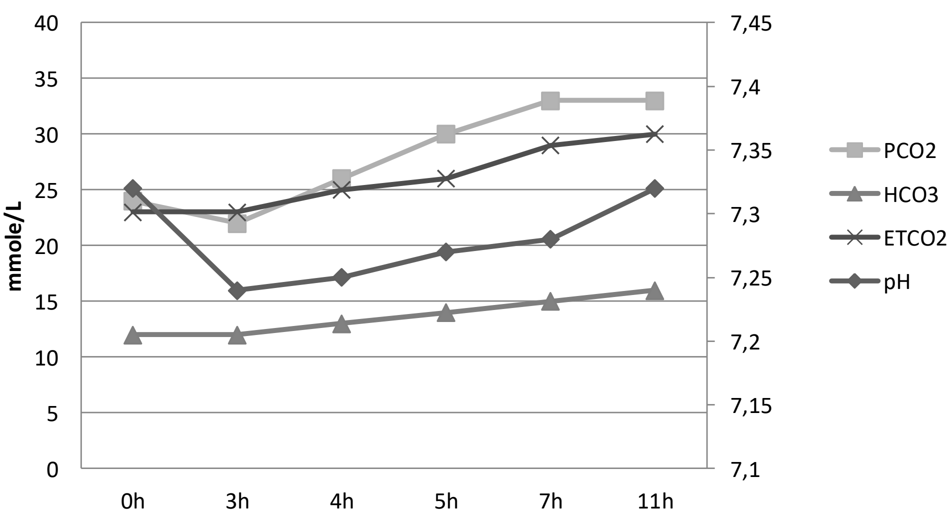

Figure 2: Correlation between $ETCO_2$ and pH, pCO_2, HCO_3. values during post-gastroenteritis rehydration. Rehydration results in increase of bicarbonate and a decreased respiratory compensation with a decrease in respiratory rate and elevation of PCO_2 and $ETCO_2$.

The correlation was established between noninvasive $ETCO_2$ and capillary PCO_2 with a difference of ~2 mmHg (P<0.001).[3] The ventilatory response in moderate ketoacidosis without lactic acidosis was investigated by showing a correlation between pH and arterial CO_2.[4] The same author has shown a relationship between the measurement of arterial CO_2 and bicarbonate and proposed the following equation: $PaCO_2 = 1.5 \times [HCO_3] + 8$.[5,6] The use of $ETCO_2$ has been studied in ketoacidosis, where a correlation is observed among $ETCO_2$, pH, and bicarbonate (P<0.001).[7] It was also shown that the risk of cerebral edema was related to bicarbonate at time 0 and remained correlated at the sixth hour.[7] Similarly, a multicenter trial evaluating the risk of cerebral edema in pediatric patients with ketoacidosis showed a decrease in the relative risk of edema of 3.4 (95%CI: 1.9–6.3; P<0.001) for every decrease of 7.8 mmHg of PCO_2.[8] This shows again the interest of the instantaneous monitoring of $ETCO_2$ in this pathology.

In diarrhea with vomiting and dehydration, the measurement of HCO_3 is an important element in assessing the degree of dehydration of a pediatric patient. $ETCO_2$ and bicarbonate were independently correlated in gastroenteritis dehydration. A good discriminating value based on ROC curves has been demonstrated for bicarbonate thresholds of 13, 15, and 17 mmol/L (AUC at 0.94, 0.95, and 0.90, respectively).[9]

The use of $ETCO_2$ is perceived as easy by pediatric emergency physicians.[3] The reason given for not using it is the lack of equipment. The same survey was conducted in pediatric intensive care units and showed the same results. The 100% of respondents find it easy to use and 5% used it in acid-base disorders.[10]

CONCLUSIONS

In agreement with the literature, the monitoring of $ETCO_2$ is uncommon in acid-base disorders (5–6%)[3,10] but is a reliable, easy-to-use, and noninvasive and does not require painful repeated capillary punctures for the pediatric patients. Further studies are necessary to highlight this technique among emergency practitioners for the treatment of metabolic disorders.

Conflict of Interest

None declared.

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