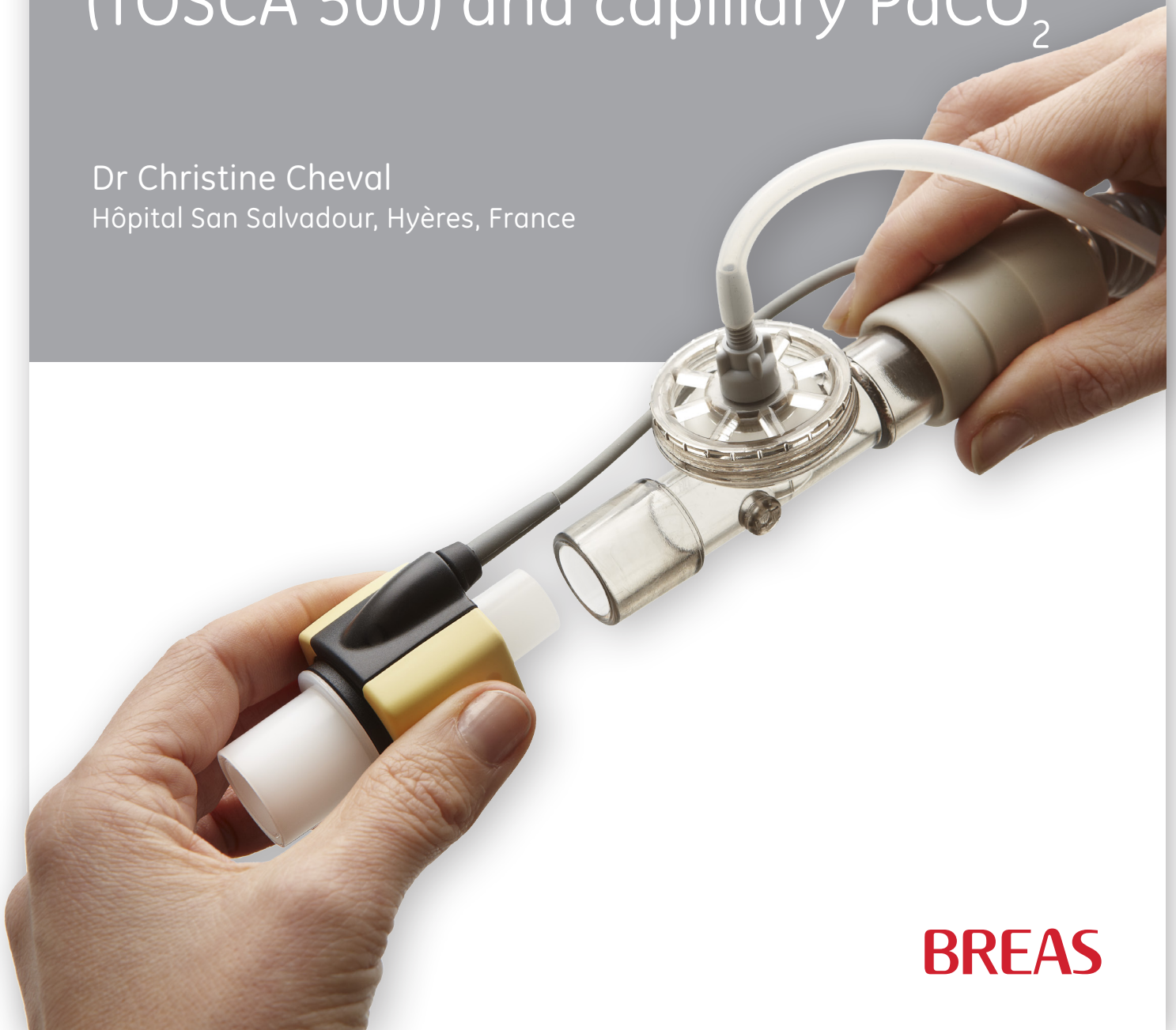


Interest of EtCO₂ monitoring with the Vivo 50 by comparing it to transcutaneous capnography (TOSCA 500) and capillary PaCO₂

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BREAS

Introduction

CO₂ is the product of the aerobic cellular metabolism. It is transported by the venous blood to the heart and eliminated by the lungs. The exhaled CO₂ reflects indirectly the cellular metabolism, the circulation and the ventilation. 5 to 10% of the CO₂ is eliminated by the respiratory system while the remaining part is treated by the liver and kidneys. The continuous measurement of CO₂ reflects the concentration found in the lungs throughout a ventilatory cycle.

The end-tidal CO₂ reflects the CO₂ concentration in the alveoli that are emptied last. Normal values are in the order of 5% or 35-37mmHg. A variable gradient exists between the EtCO₂ and the PaCO₂ value depending on the subjects being in a stable state or not, depending on the alveolar dead space which is also somewhat different depending on the literature source^{3,5}. Knowing this, the measurement of EtCO₂ allows for the evaluation of the PaCO₂ of patients with healthy lungs.

For some years, transcutaneous capnography has also been used to monitor patients with non-invasive ventilation (NIV) at home and can possibly become a standard procedure. Nevertheless this technique is rather costly and sometimes one encounters technical problems that are encountered making it difficult to apply it correctly.

The only fully reliable technique would be the continuous measurement of PaCO₂, but this is not available to be used in the hospital, and even less at home.

So without having the possibility to measure PaCO₂ continuously overnight or during the set-up of ventilation, there are two techniques left at our disposition, PtCO₂ and EtCO₂.

But, which one should be chosen? To answer this, we have compared the three techniques.

Aim of the work

The aim of this work is to compare, in a set of patients with invasive ventilation, the reliability of the EtCO₂ or PtCO₂ measurements against the reference method of PaCO₂ measurement by ABG over a period of 8 hours with a continuous usage of the first two techniques.

Methodology

We reviewed data of tracheostomised patients admitted at the Hospital San Salvadour and ventilated with a Vivo 50 (Breas, Sweden). All patients ventilated by any other ventilator or not chronically stable (acute pneumopathy, respiratory distress, ...) are excluded.

Each patient is equipped with an IRMA CO₂ sensor (Masimo Sweden AB, Sweden), connected to the Vivo 50 without the need for calibration or warming-up. In parallel, a transcutaneous CO₂ sensor, TOSCA 500 (radiometer Denmark) is placed on the forehead or earlobe of the patient. During the day three capillary blood gas samples are analyzed at H1, H4 and H8 and analyzed with an EPOC analyzer (Epopal, Canada) allowing for a quick collection of the results with a quality that is similar to the results obtained by a laboratory. The measured EtCO₂ and PtCO₂ values are registered at the same time as the blood sample.

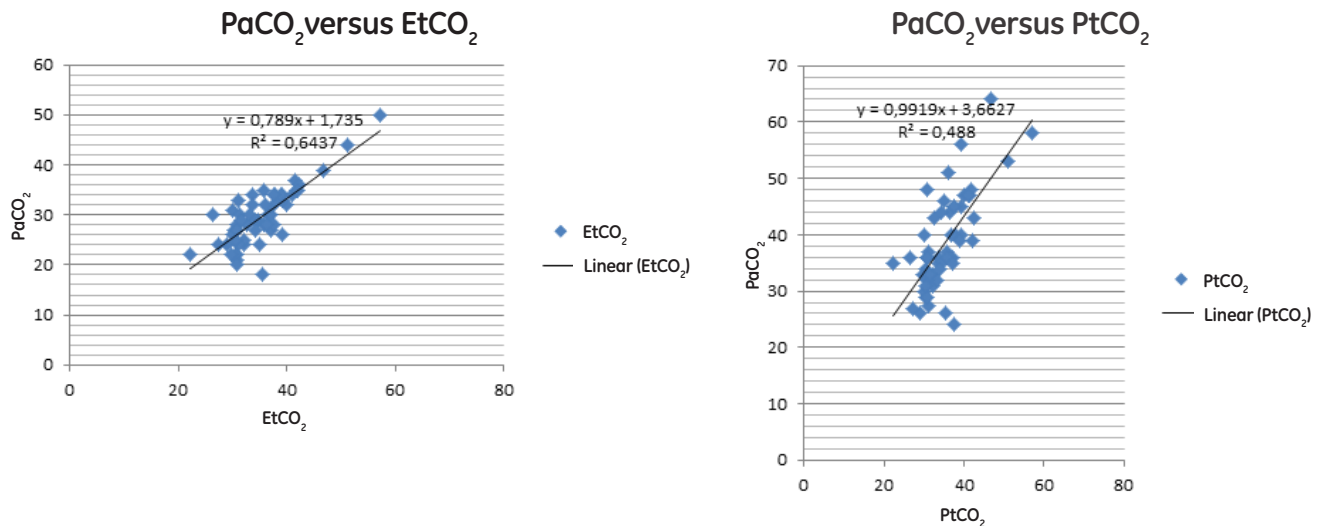
For the study, 20 patients have been included, 5 pediatric patients with an age ranging between 2 and 17 years and 15 adult patients. All patients are in a stable condition and ventilated (18 in a pressure mode and 2 in a volume mode) because of a restrictive or a neuromuscular disease. No changes to the ventilator setting were made during the period of the data collection.

Some patients used an heat moisture exchanger while others used a heated humidification system HC550 (F&P, New Zealand) with heated wire circuit. All patients are tracheostomized and ventilated with a single limb circuit with active exhalation valve. In some cases the cuff was not inflated at all, creating a leak which has been taken into account when setting up the ventilator, while in other cases the cuff was partially or completely inflated. These cases are considered as ventilation without leaks. In total 60 ABG's are analyzed.

Results

If we look at the 60 samples over all, we find a better correlation between PaCO₂ and EtCO₂ compared to PaCO₂ and PtCO₂, $r^2=0.6437$ vs 0.488 (fig1)

Fig 1: Correlation between PaCO₂ and EtCO₂



We note that at H1, one hour after start, there seems to be a better correlation between the EtCO₂ and the PaCO₂ compared to the PtCO₂ and PaCO₂. When looking at the subgroup of adult patients, we find a better correlation, regardless of the time, between PaCO₂ and EtCO₂ compared to PaCO₂ and PtCO₂ (H1: R²=0,66 versus 0,56 ; H4: R²= 0.78 versus 0,44 and H8: R²= 0.54 versus 0.15). In the sub-group of pediatric patients the data is less reliable because of the small tidal volumes (<250ml) and the relatively high leaks seen with 4 out of 5 patients.

Analysis of the subgroup of patients where the cuff was partially or fully inflated, shows that the correlation between PaCO₂ and EtCO₂ is better compared to PaCO₂ and PtCO₂ for all three measure points. Logically, we note that with uncuffed cannulas leaks occur around the cannula, causing the EtCO₂ measurement to become less accurate.

Discussion

One of the main problems of transcutaneous capnography is the need to have a perfect cohesion between the patient's skin and the sensor. But, since patients move and perspire and have more or less oily skins, the sensor often loosens, even in a controlled environment such as a hospital where regular checks are made and the sensor is put back in place.

With the measurement of EtCO₂ we avoid these problems because from the moment that the patient is ventilated, the connection with the sensor is reliable.

However the observed difference between PaCO₂ and EtCO₂ always shows a lower value for EtCO₂ because of the leaks and a part of the exhaled air not passing the sensor.

Conclusion

This study shows a good correlation between EtCO₂ and PaCO₂. So, EtCO₂ is a technique, which is easy to use and inexpensive, to evaluate the efficacy of the ventilation of tracheostomized patients during long-term treatment. The measurement of EtCO₂ allows to follow the variations in CO₂ as a result of setting changes made on the ventilator and allows for an easy adaptation even outside an ICU environment where regular analysis of ABG samples is hard to achieve and painful for the patient.

In conclusion, it seems to be possible to monitor the efficacy of ventilation in our patients by means of EtCO₂ measurements during the day or overnight and identify peaks of CO₂ linked to sleep and/or occurrence of apneas. EtCO₂ offers probably a more reliable and less expensive way of monitoring our patients compared to PtCO₂ but. But it would be good to perform a similar study on a group of patients under NIV with leaks.

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