TEMPERATURE INDEPENDENCE OF AN ELECTRO ACOUSTIC CAPNOGRAPH

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Abstract: End tidal carbon dioxide measurement with an electro acoustic sensor has recently been demonstrated. The sensor consists of an acoustic resonator coupled to a low cost electro acoustic element. The aim of this study was to verify if ambient temperature variation would affect the measurements. By simultaneous measurements with a reference sensor, the electro acoustic capnograph was tested on subjects performing exercise, hypo- and hyperventilation. The output from the experimental device correlated well with the reference CO_2 readings with a correlation coefficient of 0.91 at varied temperature and relative humidity.

Introduction

A new capnograph technique in main stream application has recently been presented [1].

A linear relationship was obtained within the accuracy of the measurement, with a correlation coefficient of 0.976 when measured at constant ambient temperature and humidity [1].

The sensor used in the capnograph is based on the measurement of the impedance of an electro acoustic element coupled to an acoustic resonator [2]. The impedance characteristic is depending on the sound velocity within the gas mixture contained in the acoustic resonator.

It has been shown in an earlier study that there is an approximately linear relation between the acoustic impedance and the CO_2 concentration [2]. The sensor principle has also shown a fast response to increasing CO_2 concentration in laboratory experiments [3].

At constant temperature and humidity, the sound velocity is determined by the average molecular weight of the gas, and is therefore influenced by the CO_2-concentration, since CO_2 is considerably heavier than oxygen and nitrogen, which dominates the average molecular weight of air.

The aim of this study was to verify if ambient temperature variation would affect the measurements.

Materials and Methods

The sensor system used for this study is explained in [1]. The voltage output signal from the sensor system was correlated to a reference sensor connected in a side-stream configuration (Microcap® Plus, Oridion Inc. Israel, www.oridion.com).

Several repetitions of exercise, hyper- and hypoventilation were performed, resulting in different CO_2-concentrations. In all measurements, approximate steady state conditions were established before readings were made.

The temperature in the room was varying from 19 to 26 °C and the relative humidity was varying from 28 % to 33 % during the tests.

Baseline variation due to temperature variations were also analysed from 19 to 25 °C at a constant relative humidity at 33 %.

Results

Figure 1 shows the results of 67 end tidal level measurements obtained from the electro acoustic sensor plotted against the recorded end tidal CO_2-concentration measured using the reference capnograph.
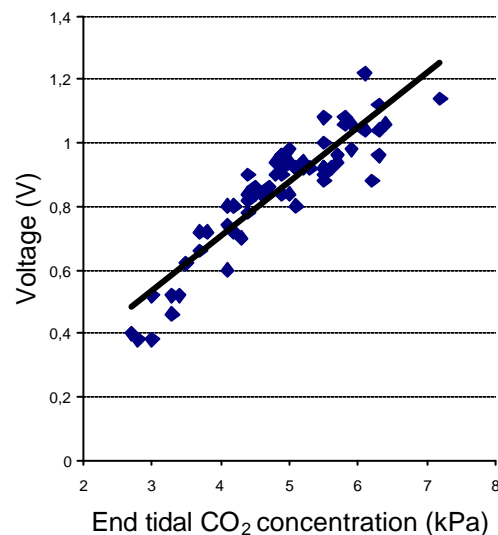

Figure 1. The relationship between the CO_2-concentration of the reference sensor and the output voltage of the electro acoustic sensor system.

A linear relationship is obtained within the accuracy of the measurement, with a correlation coefficient of 0.91. If the values above 5 kPa are excluded, because of less accuracy of the reference in this interval, the correlation coefficient will be 0.95.

The average of measurement errors is estimated to 0.3 kPa for all the measurements.
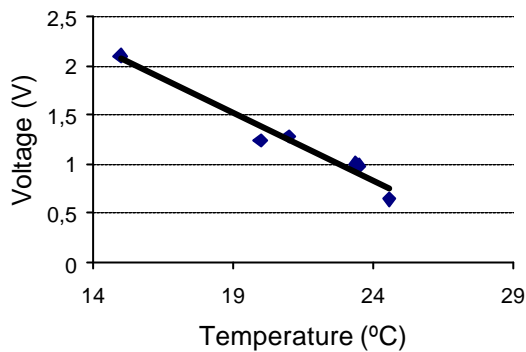

Figure 2. Temperature influence of the baseline.

The ambient temperature affected the base line with 0.6 Volt from 19 to 23ºC, Figure 2. The end tidal measurements were affected with 0.1 Volt in the same temperature interval, Figure 3.
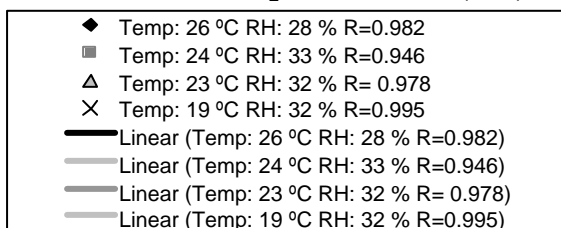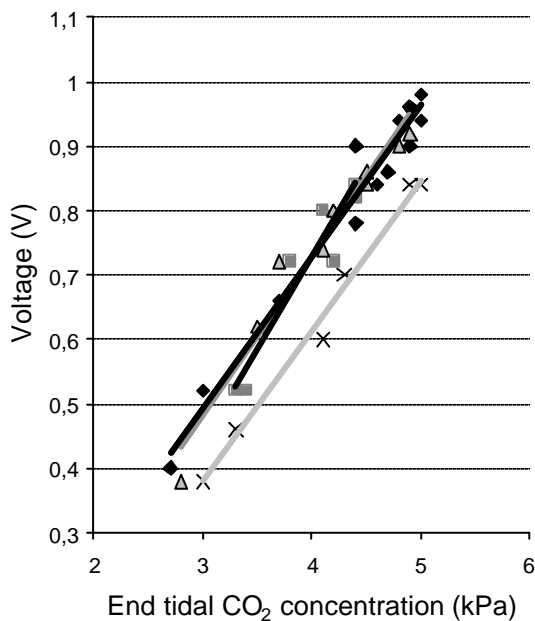

Figure 3. Temperature influence of the output signal from the electro acoustic sensor system.

Discussion

The increase in output signal compared to the reference, at 23 ºC compared to that of 19 ºC, shows that cold inspired air would affect the measurements, but not as much as for the baseline. One explanation is that the sensor may act as a heat exchanger.

The measurements were shown to correlate well with those obtained with the reference sensor, with an estimated accuracy of 0.3 kPa as discussed above, which is believed to be adequate in clinical applications. The influence of temperature and humidity to the measurements must be further analysed.

The electronic activation and detection mode used in this study has several shortcomings, and should be considered provisional. The impedance characteristic for each individual sensor is not considered in this set up.

Conclusions

The results of this study indicate that the use of elements for effective heat and humidity exchange reduces the influence of temperature and humidity to acceptable levels.

References

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