Capnography Sample Line Design and Oxygen Delivery Influence ETCO2 Accuracy

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Background: Capnography is a non-invasive method for monitoring continuous carbon dioxide in the respiration cycle to assess a patient’s ventilatory status. This bench study investigates the effect of CO2 cannula design and oxygen flow on expired end-tidal CO2 accuracy (etCO2), as measured by a Microstream™ capnography monitor.

Differences in supplemental O2 flow rate and cannula design may impact dilution of expired air and etCO2 accuracy.1

The Microstream measurement system was designed and tested to be used exclusively with Microstream sampling lines for optimal results. Use of non-Microstream sampling lines is untested and may impact accuracy and quality of waveforms.

Method: A gas cylinder with 5% CO2 (34 mmHg) was connected to the trachea of the mannequin through a reducer and mass flow controller, to simulate steady-breathing exhaled mixed air. The non-invasive CO2 cannula sampling lines were applied to the mannequin’s face with the integrated O2 tubing connected to a 100% O2 gas cylinder. A Microstream™ capnography monitor measured the simulated exhaled gas samples.

EtCO2 levels (mmHg) were measured with O2 flow in the range of 0-10 lpm. At every level of O2 delivery, the CO2 gas was delivered to match the O2 flow and then increased by 2 lpm with the O2 flow constant as follows:

First measurement: O2 flow = CO2 flow, second measurement: O2 flow = CO2 flow + 2lmp (O2= zero, one measurement at 6lpm CO2)

Each consumable cannula filterline was test for all O2 flow rates before replacement. The test was done with 13 cannula filterline consumable designs 9 adult/4 pediatric) produced by seven different manufacturers, including nasal and oral-nasal cannula designs as described in the legend for Figure 1.

Test results: The etCO2 accuracy specifications (compared to a calculated reference) for the Medtronic Microstream™ enabled capnography is +/- 2mmHg.

At zero O2 flow and CO2 flow at 6lpm, all cannula designs provided an etCO2 measurement with the mouth of the mannequin partially open for measurement.

At the lowest O2 flow rate (2 LPM) 5 out of the 13 tested consumables ((Ventlab(ON3), Medtronic Microstream™(ONJ3), Medtronic Microstream™ (N3), Westmed(N1) and Respironics LoFlo(N2)) met Microstream™ gas sample etCO2 accuracy requirements.

At O2 flow rates from 4 LPM to 10 LPM, only 3 out of 13 consumables ((Ventlab(ON3), Medtronic(ONJ3) and Medtronic (N3)) met the etCO2 accuracy requirements.

Figure 1. EtCO2 Measurements as a Function of O2 flow and Cannula Design

Legend on cannula design.  Note: If no EtCO2 levels were shown in the graph, etCO2 levels of 0 mmHg were observed.

P: Pediatric; N: Nasal CO2 sampling; ON: Oral/nasal CO2 sampling; ONJ: Oral/nasal CO2 sampling with Uni-junctions;
1: Nare Bilateral Split with CO2 sampling in one nare and O2 delivery in opposite nare.
2: Nare prong split/stacked with CO2 sampling and O2 delivery in each nasal prong.
3. Separated O2 delivery via under nose vents

Conclusion: This test suggests that varying oxygen flow affects the etCO2 measurement accuracy when using Microstream™ capnography measurement technology. The results also indicated that using different cannula designs will affect etCO2 accuracy when delivering O2.

Limitation: Simulation bench testing on gas flow and mixing, further testing on humans is required.