# 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 descripted 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.

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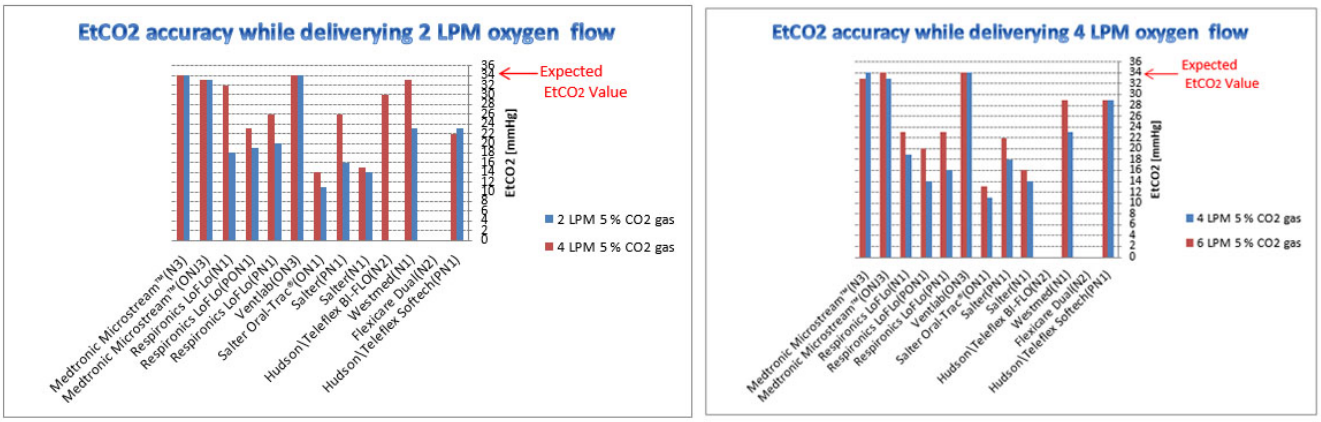
[1] Ebert, Thomas J. MD, et al. The Effectiveness of Oxygen Delivery and Reliability of Carbon Dioxide Waveforms: A Crossover Comparison of 4 Nasal Cannula. Anesthesia & Analgesia: February 2015 - Volume 120 - Issue 2 - p 342–348.

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.