Abstract Title: End-Tidal Carbon Dioxide Measurement Variations During Mask Ventilation

Presenting Author: Derek Sakata MD, University of Utah Department of Anesthesiology
Co-Authors: Trey Blackwell BS, Christian Orr MS-3, Joseph Orr PhD, University of Utah Department of Anesthesiology

Introduction: End-Tidal Carbon Dioxide ($ETCO_2$) measurement during mask ventilation of an apneic patient is an important measure of alveolar/therapeutic gas exchange. In the operating theatre, this measurement occurs via side stream sampling at the breathing circuit elbow or at the heat moisture exchange (HME) filter. Alternatively, if a patient is undergoing sedation, they will sometimes have a nasal canula in place. Some nasal cannulas (NC) have an $ETCO_2$ sampling port by which sampling can occur directly from the nares. If a patient becomes too sedated, they may exhibit hypopnea and/or apnea at which point the anesthetist may provide positive pressure mask ventilation over the canula with an air-cushioned mask (ACM). This positive pressure ventilation may occur while maintaining the NC in place which may predispose to leak and/or attenuated $ETCO_2$ signal during the ventilation process. We thus evaluated the effect of sampling location, at the breathing circuit elbow or NC, and tidal volume on the accuracy of the measured $ETCO_2$ with and without a NC between the mask and a simulated face.

Methods: Positive pressure mask ventilation was tested on a silicon-molded face (EcoFlex 00-10, Smooth-on, Macungie, PA) with a 3-D printed model of a nasal airway was connected to a test lung (TTL, Michigan instruments, Grand Rapids, MI) through a simulated trachea. CO_2 gas was continuously injected into the test lung using a mass flow controller (Alicat Scientific, Tucson, AZ). Five conditions were tested. In the first, the ACM was applied directly to the face with CO_2 sampled from the breathing circuit elbow and then in 4 conditions in which a NC, with associated CO_2 sampling, was between the ACM and face. In these 4 conditions, the NC was set at 0 lpm, 2 lpm, 4 lpm or attached to a novel O_2 delivery device that administers increased flow of O_2 to compensate for mask leak during positive pressure ventilation. The measured $ETCO_2$ was compared to a reference CO_2 measured at the simulated trachea.

Results: Across all tested tidal volumes, less attenuated $ETCO_2$ values were measured if sampling was done at the NC under conditions of no O_2 flow or the with the O_2 device only administering O_2 on mask ventilation (Figure 1).

Discussion: This study showed that even though placing the NC between the face and the ACM causes increased mask leak, it has the advantage of improved $ETCO_2$ measurement when there is no O_2 flow to the NC or used with the novel O_2 delivery device. Additionally, the masking mode of the O_2 delivery device improves $ETCO_2$ measurement because it increases exhaled tidal volume by compensating for mask leak during positive pressure ventilation. Also, since the O_2 device disables O_2 flow while the patient is exhaling, it does not dilute the end-tidal gas sample.

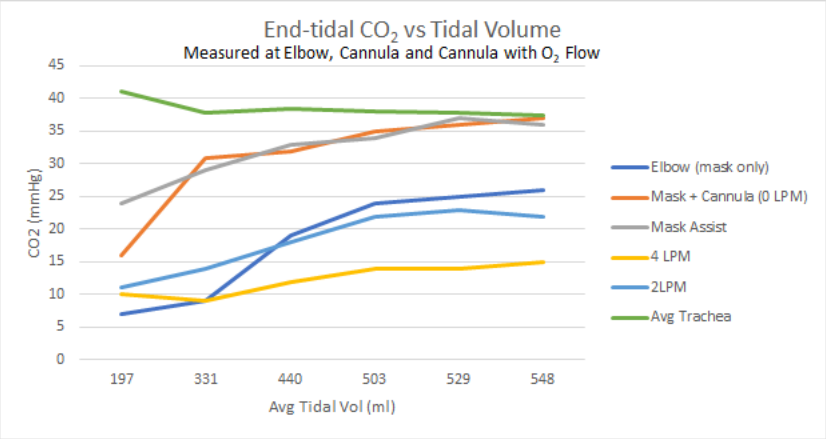
End-tidal CO_2 vs Tidal Volume
Measured at Elbow, Cannula and Cannula with O_2 Flow
CO2 (mmHg)
45
40
35
30
25
20
15
10
5
0
197
331
440
503
529
548
Avg Tidal Vol (ml)
Elbow (mask only)
Mask + Cannula (0 LPM)
Mask Assist
4 LPM
2LPM
Avg Trachea

Figure 1