Abstract Title: Evaluation of System to Reduce Leak During Manual Ventilation Over Cannula

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Introduction:

Preoxygenation prior to endotracheal intubation is standard practice to mitigate hypoxemia following induction of general anesthesia.[5] Commonly the delivery method is via anesthesia machine breathing circuit and air-cushioned mask (ACM). The downside of preoxygenation with an air-cushioned mask is that it requires a tight seal, otherwise the air leak results in inferior pre-oxygenation. McQuade et. al found that supplementing a bag-valve-mask (BVM) with O2 administration via nasal cannula (NC) at 15L/min could offset the effects of an imperfect seal as did Hayes-Bradley et. al.[3,4] NC supplementation also offers the added benefit of allowing the clinician to pause BVM ventilation to assess for spontaneous breathing while continuing to oxygenate the patient. We are evaluating a novel O_2 NC delivery system that, upon sensing a positive pressure $\geq$ 2.5 cm H_2O, administers oxygen via NC at 30L/min. The purpose of this study is to evaluate this device's ability to compensate for leak during positive pressure mask ventilation.

Methods:

Positive pressure mask ventilation and associated leak was tested via air-cushioned mask ventilation of a silicon-molded face (EcoFlex 00-10, Smooth-on, Macungie, PA) with a 3-D printed model of a nasal airway. The nasal airway was connected to a test lung (TTL, Michigan instruments, Grand Rapids, MI), set at a compliance of 50 ml/cm H_2O, through a simulated trachea (12mm inner diameter tube) with a 5.6 mm parabolic flow restrictor between the lung and trachea. For consistency, a noninvasive ventilator (V60, Philips-Respironics, Carlsbad, CA) was used instead of a BVM. A flow sensor (NM3, Philips-Respironics, Wallingford, CT) measured volume of gas delivered. Four conditions were tested. In the first, the ACM was applied directly to the face and then in 3 conditions in which a NC was between the ACM and face. In these 3 conditions, the NC was set at 0 lpm, 4 lpm or attached to the novel O_2 delivery device. Each of the 4 conditions were tested under 6 different average downward forces of the mask by using a an elastomeric mask. A Leak was determined by comparing the difference in tidal volumes (TV) without leak, ventilator connected directly to the test lung, and that generated by each mask condition.

Results:
Below are the results for the tidal volume (mls) delivered and percentage leak in each test condition.

Average Downward Force on Mask (lbs.)	Control	Mask only (mls(% leak))	Cannula under mask (mls(% leak))		
			0 lpm	4 lpm	O_2 Device
2.4	650	280 (57%)	49 (92%)	152 (77%)	278 (57%)
3.0	650	384 (41%)	244 (62%)	342 (47%)	392 (40%)
3.4	650	489 (25%)	354 (46%)	432 (34%)	507 (22%)
3.8	650	555 (15%)	425 (35%)	464 (29%)	604 (7%)
4.2	650	575 (12%)	446 (31%)	490 (25%)	650 (0%)
4.7	650	599 (8%)	450 (31%)	533 (18%)	650 (0%)
Avg % Leak	N/A	26%	50%	38%	21%
Std. Dev.	N/A	19.2%	24.2%	21.3%	23.4%

Discussion:
With increased downward pressure, gas leak was minimized but not eliminated. Addition of the nasal canula between the mask and face increased leak and was only partially mitigated with increased downward force and/or addition of 4 lpm. Using the novel O2 device mitigated leak such that masking was comparable or better than that with the mask only. The importance of this is that ventilation requires muscle memory that takes time and much practice to develop proficiency. Additionally, sedation is a balance of comfort and breathing in which a nasal canula is utilized. Should hypopnea or apnea occur, ventilation will be augmented with a cushioned mask. Removing the canula adds one additional step when time is of the essence. Even without a canula, for novices, masking while mitigating leak is difficult. It can even be more difficult when the patient has a beard or is edentulous.

References

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