High Flow Nasal Cannula compared to Continuous Positive Airway Pressure: a bench and physiological study

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Introduction: High flow nasal cannula oxygen therapy (HFNC) is a relatively new and a still being a promising treatment for adults with respiratory failure. It provides washout of anatomic dead space and generates positive pressure in the nasopharynx, leading to higher end-expiratory lung volume.
Objective: Explore whether the effects of HFNC are similar to continuous positive airway pressure (CPAP). Investigate possible explanations of respiratory changes. Last, the effects of mouth close vs. open during HFNC.
Methods: Two studies were conducted:1) Bench study using a manikin's head and lungs connected to an active breathing simulator generating steady inspiratory efforts with a set healthy lung compliance and airway resistance. Nasopharyngeal pressure was measured with a dedicated catheter, and tidal volume was obtained from the simulator at different HFNC flow rates, from 0 to 60L/min (mouth closed). 2) Physiological cross-over study with 10 healthy volunteers breathing while receiving HFNC at 20, 40 and 60L/min with the mouth open and close, and CPAP 4cmH_2O through face-mask. Nasopharyngeal pressure was measured using a dedicated 12 French catheter, as well as esophageal pressure (Cooper catheter). Tidal volume and flow were computed using a calibrated electrical impedance tomography (Pulmovista). We calculated the pressure-time product of the respiratory muscles, inspiratory and expiratory resistance. We used Friedman test and Nemenyi post hoc test, two-way ANOVA and Bonferroni post hoc test.
Results: The bench data showed a progressive nasopharyngeal pressure (up to 4 cm H_2O), and decreasing in tidal volume with the flow rate increment. In healthy volunteers during HFNC at 60L/min the nasopharyngeal pressure reached 6.8 cmH_2O with mouth closed, higher than CPAP; and 0.8 cmH_2O with mouth open; $p<0.001$. When increasing HFNC flow rate, respiratory rate decreased by lengthening expiratory time, tidal volume did not change, and effort decreased (pressure-time product per minute of the respiratory muscles); at 40L/min, effort was equivalent between CPAP and HFNC40 L/min and became lower at 60L/min ($p= 0.045$). During HFNC with mouth closed, and not during CPAP, resistance to breathing was increased, mostly during expiration.
Conclusions: In healthy volunteers with moth closed, HFNC at a flow of 40L/min delivers pressures comparable to CPAP 4cmH_2O, whereas at 60L/min it delivers pressures close to 7 cmH_2O. During HFNC, strictly closing the mouth can result in increased resistance to breathing both in a bench and in a healthy volunteer study. The increase in expiratory resistance that might explain the prolonged expiration and reduction in respiratory rate and effort, and contribute to physiological benefits.

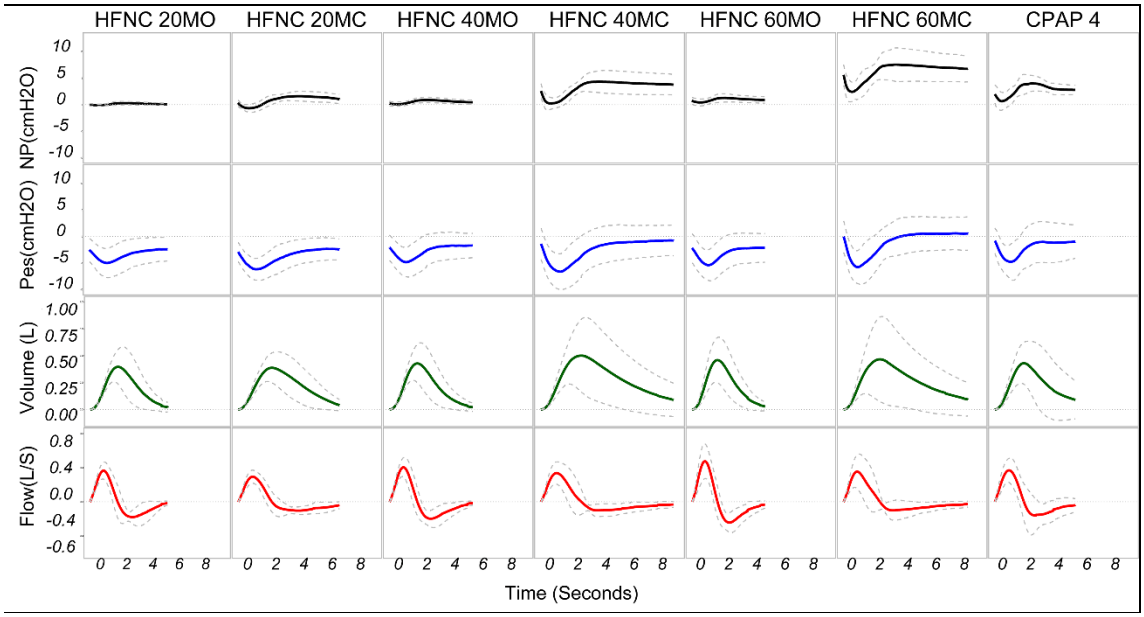

Figure 1 – Pressures, Volume and Flow in Human volunteers: average breath for each condition tested