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A Novel Mask with Selective Ports for Inflow and Outflow Reduces CO₂ Rebreathing during Non-Invasive Ventilation: A Physiological Study in Healthy Volunteers

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Abstract

Background: CO₂ rebreathing is one of the risks associated with noninvasive ventilation (NIV), possibly contributing to failure. In a bench study, we showed that a novel mask design, with separate limbs for inflow and outflow gases, significantly reduced CO₂ rebreathing in different ventilation settings.

Objectives: The study aimed to test whether a new mask design could 1) reduce CO₂ rebreathing in healthy volunteers during NIV (phase 1) and 2) reduce minute ventilation (phase 2).

Materials and methods: Healthy volunteers were randomly assigned to NIV using two masks in a crossover design: a traditional single-limb mask for inflow and outflow gases and a mask with two separated limbs. In phase 1, six ventilation settings were tested for each mask: CPAP (PEEP 5 cmH₂O) and pressure support ventilation (PSV, PS Level 5 cmH₂O) using a mechanical ventilator with a bias flow of 8 or 20 L/min; free-flow CPAP (PEEP 5 cmH₂O) with 60 or 90 L/min of gas flow. A nasal cannula was inserted in one nostril of the volunteers and connected to a CO₂ gas analyzer to measure CO₂ during the respiratory cycle. In phase 2, volunteers underwent a prolonged time of ventilation in CPAP 90 L/min and PSV with 20 L/min of bias flow. During free-flow CPAP, electrical impedance tomography was used to record the change in impedance during tidal breathing and then estimate tidal volume.

Results: Ten healthy adults were enrolled in phase 1, and 8 volunteers in phase 2. CO₂ during inspiration was significantly lower in each setting with the two-limb versus the one-limb mask ($p < 0.001$). The maximum CO₂ reduction was observed in the continuous-flow CPAP settings. EtCO₂ was lower with the two-limb mask compared to the one-limb mask ($p < 0.001$). However, no difference in minute ventilation was observed between the two masks.

Conclusion: The new mask design with two ports for inhaled and exhaled gases reduced the amount of CO₂ rebreathing in all tested ventilation settings. The CO₂ rebreathing reduction did not decrease minute ventilation in healthy volunteers.

Keywords: CO₂ rebreathing; Continuous positive airway pressure; Minute ventilation; Noninvasive ventilation; Pressure support ventilation.