

Physiologic Effects of High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure

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Abstract

Rationale: High-flow nasal cannula (HFNC) improves the clinical outcomes of nonintubated patients with acute hypoxemic respiratory failure (AHRF).

Objectives: To assess the effects of HFNC on gas exchange, inspiratory effort, minute ventilation, end-expiratory lung volume, dynamic compliance, and ventilation homogeneity in patients with AHRF.

Methods: This was a prospective randomized crossover study in nonintubated patients with AHRF with PaO₂/setFiO₂ less than or equal to 300 mm Hg admitted to the intensive care unit. We randomly applied HFNC set at 40 L/min compared with a standard nonocclusive facial mask at the same clinically set FiO₂ (20 min/step).

Measurements and Main Results: Toward the end of each phase, we measured arterial blood gases, inspiratory effort, and work of breathing by esophageal pressure swings (Δ Pes) and pressure time product, and we estimated changes in lung volumes and ventilation

homogeneity by electrical impedance tomography. We enrolled 15 patients aged 60 \pm 14 years old with PaO₂/setFiO₂ 130 \pm 35 mm Hg. Seven (47%) had bilateral lung infiltrates. Compared with the facial mask, HFNC significantly improved oxygenation ($P < 0.001$) and lowered respiratory rate ($P < 0.01$), Δ Pes ($P < 0.01$), and pressure time product ($P < 0.001$). During HFNC, minute ventilation was reduced ($P < 0.001$) at constant arterial CO₂ tension and pH ($P = 0.27$ and $P = 0.23$, respectively); end-expiratory lung volume increased ($P < 0.001$), and tidal volume did not change ($P = 0.44$); the ratio of tidal volume to Δ Pes (an estimate of dynamic lung compliance) increased ($P < 0.05$); finally, ventilation distribution was more homogeneous ($P < 0.01$).

Conclusions: In patients with AHRF, HFNC exerts multiple physiologic effects including less inspiratory effort and improved lung volume and compliance. These benefits might underlie the clinical efficacy of HFNC.

Keywords: high-flow nasal oxygen; electrical impedance tomography; esophageal pressure; acute lung injury

High-flow nasal cannula (HFNC) is a noninvasive respiratory support designed to deliver 30–60 L/min of a heated, humidified mixture of air and oxygen through

specifically designed nasal prongs (1). HFNC was first used in preterm infants and pediatric patients (2) and recent large randomized clinical trials have promoted its use in adults

with acute hypoxemic respiratory failure (AHRF) (3). These trials demonstrated the potential of HFNC to improve clinical outcomes, such as reintubation rates and

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