High-Velocity Nasal Insufflation in the Treatment of Respiratory Failure: A Randomized Clinical Trial

Pratik Doshi, MD*; Jessica S. Whittle, MD; Michael Bublewicz, MD; Joseph Kearney, MD; Terrell Ashe, RRT; Russell Graham, RRT; Suesann Salazar, RRT; Terry W. Ellis, Jr, RRT; Dianna Maynard, RRT; Rose Dennis, RRT; April Tillotson, RRT; Mandy Hill, DrPH; Misha Granado, MPH; Nancy Gordon, MS; Charles Dunlap, RRT; Sheldon Spivey, RRT; Thomas L. Miller, PhD

*Corresponding Author. E-mail: pratik.b.doshi@uth.tmc.edu.

Study objective: We compare high-velocity nasal insufflation, a form of high-flow nasal cannula, with noninvasive positive-pressure ventilation in the treatment of undifferentiated respiratory failure with respect to therapy failure, as indicated by requirement for endotracheal intubation or cross over to the alternative therapy.

Methods: This was a multicenter, randomized trial of adults presenting to the emergency department (ED) with respiratory failure requiring noninvasive positive-pressure ventilation. Patients were randomly assigned to high-velocity nasal insufflation (initial flow 35 L/min; temperature 35°C (95°F) to 37°C (98.6°F); FiO_2 1.0) or noninvasive positive-pressure ventilation using an oronasal mask (inspiratory positive airway pressure 10 cm H_2O; expiratory positive airway pressure 5 cm H_2O). The primary outcome was therapy failure at 72 hours after enrollment. A subjective outcome of crossover was allowed as a risk mitigation to support deferment of informed consent. Noninferiority margins were set at 15 and 20 percentage points, respectively.

Results: A total of 204 patients were enrolled and included in the analysis, randomized to high-velocity nasal insufflation (104) and noninvasive positive-pressure ventilation (100). The intubation rate (high-velocity nasal insufflation=7%; noninvasive positive-pressure ventilation=13%; risk difference=−6%; 95% confidence interval −14% to 2%) and any failure of the assigned arm (high-velocity nasal insufflation=26%; noninvasive positive-pressure ventilation=17%; risk difference 9%; confidence interval −2% to 20%) at 72 hours met noninferiority. The effect on PCO_2 over time was similar in the entire study population and in patients with baseline hypercapnia. Vital signs and blood gas analyses improved similarly over time. The primary limitation was the technical inability to blind the clinical team.

Conclusion: High-velocity nasal insufflation is noninferior to noninvasive positive-pressure ventilation for the treatment of undifferentiated respiratory failure in adult patients presenting to the ED. [Ann Emerg Med. 2017;■:1-11.]

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INTRODUCTION

Background

Dyspnea and acute respiratory failure are among the top 5 reasons for patients to present to the emergency department (ED).[1] Tools available to emergency physicians for respiratory support include oxygen therapy, noninvasive positive-pressure ventilation, and mechanical ventilation. More recently, oxygen through a high-flow nasal cannula has been used to provide respiratory support as an escalation from simple oxygen therapy. In contrast to traditional nasal cannula therapy, a high-flow nasal cannula can deliver up to 100% oxygen by nasal cannula.[2,3] Additionally, it has been shown to induce a mild distending pressure[4] and improve ventilation efficiency by way of extrathoracic dead-space clearance.[5-7]

High-velocity nasal insufflation, a form of high-flow nasal cannula, focuses on optimum efficiency of the dead-space purge to augment ventilation (removal of carbon dioxide from the dead space between breaths), in addition to providing other effects of high-flow nasal cannula.[6,8] This is accomplished by use of small-bore nasal cannulae (typically 2.7-mm internal diameter for adult patients) to produce high velocity flow that is approximately 360% greater than that of the larger-bore cannulae used in previous studies. According to flow analyses[8] and clinical experience,[9] high-velocity nasal insufflation typically requires a flow of 25 to 35 L/min in adults to accomplish a complete purge of the extrathoracic anatomic reservoir between breaths.

Editor's Capsule Summary

What is already known on this topic

Noninvasive positive-pressure ventilation is an established emergency department (ED) treatment for patients requiring respiratory support. High-velocity nasal insufflation by nasal cannula might be easier to apply but is less studied.

What question this study addressed

This randomized, nonblinded, noninferiority trial compared high-velocity nasal insufflation with noninvasive positive-pressure ventilation in 204 ED patients with respiratory distress. Treatment failure was defined as intubation or crossover to alternate therapy.

What this study adds to our knowledge

High-velocity nasal insufflation had a treatment failure rate that was noninferior to that of noninvasive positive-pressure ventilation.

How this is relevant to clinical practice

High-velocity nasal insufflation may be a reasonable treatment option for select ED patients with respiratory distress.

Importance

The application of high-flow nasal cannula in the ED has not been well studied, and when it has, the focus has been on oxygen delivery.[10,11] Patients presenting to the ED with respiratory distress often require interventions before determination of the underlying pathology, and can be hypoxic, hypercapnic, or both. Conventionally, noninvasive positive-pressure ventilation is used in this setting because of its ability to support both type 1 (hypoxic) and type 2 (hypercapnic) respiratory failure, and has been well established for the treatment of chronic obstructive pulmonary disease and cardiogenic pulmonary edema.[12] Several trials have demonstrated high-flow nasal cannula to be efficacious as a means of supporting hypoxic patients who are not hypercarbic.[13-16] Experience[9] and preclinical data[6,8] suggest that high-velocity nasal insufflation may be effective in patients requiring ventilatory support as well. Therefore, it is important to assess whether high-velocity nasal insufflation can be used in the early management of respiratory distress patients in the same manner as noninvasive positive-pressure ventilation.

Goals of This Investigation

The goal of this study was to assess the ability of high-velocity nasal insufflation to support patients with undifferentiated respiratory failure in the ED who required ventilatory support. The hypothesis of this trial was that high-velocity nasal insufflation is noninferior to noninvasive positive-pressure ventilation in treatment of undifferentiated respiratory failure with respect to therapy failure, as indicated by the requirement for intubation or crossover to the alternate therapy.

MATERIALS AND METHODS

Study Design and Setting

This study was a prospective, multicenter, parallel-group, randomized controlled trial of 2 noninvasive ventilatory support modalities, high-velocity nasal insufflation and noninvasive positive-pressure ventilation, using a noninferiority model. The trial was conducted at 5 centers across the southeastern United States, 2 academic and 3 community centers (Table E1, available online at http://www.annemergmed.com). Clinical management independent of the study interventions was conducted according to standard care in each facility. All respiratory interventions were tracked for 72 hours after randomization; beyond 72 hours, patients requiring ventilatory support were reasoned to be in a long-term or progressive condition.

The study was approved by the institutional review board at each of the centers, and safety was monitored by an independent data and safety monitoring board. The nature of the study required a mitigation of risk owing to the state of duress at the point of randomization. Hence, the study design necessitated the a priori option to cross over to the alternate therapy (high-velocity nasal insufflation or noninvasive positive-pressure ventilation) at the request of the treating physician. Although escalation to intubation was the intended primary endpoint, a subjective crossover was treated as a failure of the assigned therapy if the patient was not in need of immediate intubation.

Data were collected by research teams at each site and placed in a database. Data management and analysis were performed by third-party data capture and management providers who were not the sponsor. The full trial protocol is included in Appendix E1, available online at http://www.annemergmed.com.

Selection of Participants

Patients presenting to the ED with respiratory compromise were screened for eligibility. Each site screened consecutive