High-Frequency Ventilation as a Mode of Noninvasive Respiratory Support

Amit Mukerji, MD, FRCP(C)[a,*], Michael Dunn, MD, FRCP(C)[b,c]

KEYWORDS

• Noninvasive high-frequency ventilation • Ventilator-induced lung injury
• Bronchopulmonary dysplasia • Nasal intermittent positive pressure ventilation
• Ventilation efficacy • Postextubation prophylaxis • Alveolar development

KEY POINTS

- In recent decades, use of noninvasive respiratory support in preterm neonates has increased in an effort to minimize ventilator-induced lung injury.
- A variety of noninvasive modes exist but despite extensive research, the optimal modality, interface, and settings remain unknown.
- Noninvasive high-frequency ventilation (NIHFV) is a relatively new mode that aims to combine the efficacy of high-frequency ventilation with the gentleness of noninvasive support.
- Current evidence suggests that NIHFV may be superior to other noninvasive modes in terms of supporting alveolar ventilation and preventing need for endotracheal mechanical ventilation.
- Large, adequately powered comparative trials are warranted to establish the superiority as well as indications, optimal settings, and safety of noninvasive high-frequency ventilation.

INTRODUCTION

The use of noninvasive respiratory support (NRS) in neonatal intensive care has increased in recent decades as a means to reduce ventilator-induced lung injury (VILI).[1–3] Various modes of NRS available and in common use include nasal continuous positive airway pressure (nCPAP), bilevel (or biphasic) nCPAP, nasal intermittent positive airway pressure (NIPPV), and heated humidified high flow nasal cannula.[2]

[a] Division of Neonatology, Department of Pediatrics, McMaster Children's Hospital, McMaster University, 1280 Main Street West, HSC-4F1E, Hamilton, Ontario L8S 4K1, Canada; [b] Department of Pediatrics, University of Toronto, Toronto, Ontario, Canada; [c] Department of Newborn and Developmental Pediatrics, Sunnybrook Health Sciences Centre, Room M4-222, 2075 Bayview Avenue, Toronto, Ontario M4N 3M5, Canada
* Corresponding author.
E-mail address: mukerji@mcmaster.ca

Clin Perinatol 43 (2016) 725–740
http://dx.doi.org/10.1016/j.clp.2016.07.008
perinatology.theclinics.com

A relatively new form of NRS gaining popularity is noninvasive high-frequency ventilation (NIHFV).[4,5] This modality aims to combine the proficiency of high-frequency ventilation with the gentleness of NRS. Even though its clinical use was first described almost 2 decades ago,[6] evidence for its efficacy and safety in comparison to other NRS modes remains limited. In this article, we present the rationale for the use of NIHFV, review the existing evidence, and highlight key knowledge gaps that warrant further investigation.

NONINVASIVE RESPIRATORY SUPPORT

Endotracheal positive pressure ventilation (PPV) has been strongly implicated in the causation of VILI in preterm neonates.[7–11] Studies have revealed that endotracheal PPV is associated with a number of adverse outcomes, including bronchopulmonary dysplasia (BPD), subglottic stenosis, infection, and air leak syndromes.[12–15] These observations have prompted a number of clinicians to move toward the preferential use of nCPAP as a primary mode of respiratory support.[3,16] Although it might be argued that the uptake has been slow and variable, it is now recommended that nCPAP be used whenever possible to minimize the exposure of preterm infants to the harmful effects of endotracheal PPV.[17]

Although CPAP is very effective in stabilizing the compliant chest wall, splinting the upper airways, helping with the maintenance of FRC, and reducing work of breathing,[16,18] many preterm infants cannot be adequately maintained on nCPAP and require higher levels of support.[19] In some cases, this is a consequence of severe lung disease that necessitates intubation and mechanical ventilation, but in many cases, infants fail because their spontaneous respiratory drive is insufficient to provide adequate alveolar ventilation. Impending respiratory failure is often heralded by increasing oxygen requirements, increased work of breathing, increased frequency or severity of apneas, and CO_2 retention with respiratory acidosis.[20]

Rather than moving directly to intubation and mechanical ventilation in infants who are failing nCPAP, clinicians have used other methods of NRS in an attempt to enhance the level of support and thereby stabilize the infant.[21,22] Because all minute ventilation must be provided through the spontaneous efforts of an infant on nCPAP, noninvasive modes that can provide a degree of ventilation in addition to the stabilizing effects of CPAP are desirable. Several have been developed and tested; in particular, NIPPV and NIHFV show promise.[2,23,24]

NIPPV can be used as an alternative mode of primary NRS instead of nCPAP or as a mode to “rescue” infants failing nCPAP. Previous trials comparing use of NIPPV to nCPAP either as initial respiratory support or after extubation suggested superiority,[22,25,26] but a recent large multicentre randomized controlled trial did not show any benefit with use of NIPPV over nCPAP.[27] The use of traditional unsynchronized NIPPV to support tidal ventilation is limited because the timing and magnitude of delivered breaths are unrelated to the baby’s spontaneous efforts, leading to a large proportion of delivered breaths being ineffective.[21] This problem may be ameliorated by the application of newer ventilators with effective triggering in noninvasive modes. Noninvasive neurally adjusted ventilator assist for the delivery of synchronized and proportional NIPPV is highly promising and currently under investigation.[28] NIHFV has a theoretic advantage over NIPPV in that it does not depend on synchronization for effective ventilation.[24,29] In addition, it may be a more powerful ventilation tool, potentially making it a more effective noninvasive mode for rescue after nCPAP failure.

Avery and coworkers[30] published one of the first reports illustrating the possible benefits of liberal use of nCPAP rather than invasive mechanical ventilation. Clinicians