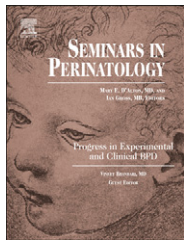
Seminars in Perinatology 37 (2013) 108–114

Available online at www.sciencedirect.com

SciVerse ScienceDirect

www.elsevier.com/locate/semperi



Regular article

The potential of non-invasive ventilation to decrease BPD

Vineet Bhandari, MD, DM

Division of Perinatal Medicine, Department of Pediatrics, Yale University School of Medicine, New Haven, CT, USA

ARTICLE INFO

Keywords:
SNIPPV
NIPPV
Nasal ventilation
Neonate
Respiratory distress syndrome
Surfactant
Bronchopulmonary dysplasia

ABSTRACT

Bronchopulmonary dysplasia (BPD), the most common chronic lung disease in infancy, has serious long-term pulmonary and neurodevelopmental consequences right up to adulthood, and is associated with significant healthcare costs. BPD is a multifactorial disease, with genetic and environmental factors interacting to culminate in the characteristic clinical and pathological phenotype. Among the environmental factors, invasive endotracheal tube ventilation is considered a critical contributing factor to the pathogenesis of BPD. Since BPD currently has no specific preventive or effective therapy, considerable interest has focused on the use of non-invasive ventilation as a means to potentially decrease the incidence of BPD. This article reviews the progress made in the last 5 years in the use of nasal continuous positive airways pressure (NCPAP) and nasal intermittent positive pressure ventilation (NIPPV) as it pertains to impacting on BPD rates. Research efforts are summarized, and some guidelines are suggested for clinical use of these techniques in neonates.

Introduction

Bronchopulmonary dysplasia (BPD) is the most common chronic lung disease in infancy.[1,2] While a variety of genetic and environmental factors interact in the pathogenesis of BPD, one critical factor is prematurity.[1,2] For the purposes of this review, BPD has been defined using the National Institutes of Health (NIH) consensus definition, which requires for infants <32 weeks of gestation to have needed supplemental oxygen for at least 28 days, and assessment at 36 weeks corrected postmenstrual age (or discharge, if earlier) for the need for supplemental oxygen and/or positive pressure support.[1,2] BPD is associated with significant long-term complications including repeated hospitalizations, neurodevelopmental impairment and abnormal pulmonary function tests extending across childhood to adulthood.[1,2] These translate to significant healthcare costs.[3,4] Since there is no preventive and/or specific effective therapy available for BPD, efforts have focused on modifying environmental factors to decrease and/or ameliorate the severity of the disease. One such approach has been avoiding the use of invasive ventilation. Nasal continuous positive airway pressure (NCPAP) has been extensively studied in multiple randomized controlled trials (RCT) with equivocal results.[5] Over the last decade, use of nasal intermittent positive pressure ventilation (NIPPV) in premature neonates has increased considerably.[6] This review focuses on studies of NCPAP and NIPPV published in the last 5 years, with the primary outcome of BPD.

NCPAP and BPD

Anecdotal evidence and small RCTs have suggested that early NCPAP use could lead to a decreased incidence of BPD.[7,8] However, this has not been borne out by 2 recent large RCTs that compared extremely preterm neonates randomized to NCPAP or intubation at birth.[9,10] In the first study, in infants born at 25–28 weeks gestation (n = 610),

E-mail address: vineet.bhandari@yale.edu

0146-0005/13/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1053/j.semperi.2013.01.007

early NCPAP did not significantly reduce the rate of BPD/death, as compared with the infants who were intubated at birth.[9] In addition, the NCPAP group of infants had a significantly higher rate of pneumothoraces.[9] In the SUPPORT study ($n = 1316$) of infants with gestational ages of 24 to <28 weeks at birth, the rates of BPD/death were not significantly different in the NCPAP vs. intubation and surfactant administration groups.[10]

NCPAP with surfactant and BPD

The failure of only providing early NCPAP to decrease BPD has brought up the notion that denying early surfactant to these premature infants may be contributing to such results.[5] The experience with the INtubation SURfactant Extubation (INSURE) procedure has suggested that this technique may diminish the development of BPD.[11] A meta-analysis concluded that early surfactant-replacement therapy with extubation to NCPAP within 1 h, compared with later selective surfactant replacement and continued mechanical ventilation with extubation from low ventilator support, was associated with a lower incidence of BPD [Risk Ratio (RR) 0.51, 95% Confidence intervals (CI) 0.26, 0.99].[12]

The CURPAP RCT investigated whether prophylactic surfactant followed by NCPAP compared with early NCPAP application with early selective surfactant would reduce the need for mechanical ventilation in the first 5 days of life.[13] The CURPAP study of infants ($n = 208$) at 25–28 weeks of gestation at birth did not find prophylactic surfactant superior to NCPAP and early selective surfactant in reducing the need for mechanical ventilation in the first 5 days of life or decreasing BPD.[13] A recent meta-analysis comparing prophylactic vs. selective surfactant use concluded that the latter approach decreased BPD [RR 1.13, 95% CI 1.00, 1.28] and BPD/death [RR 1.13, 95% CI 1.02, 1.25].[14] Similar results were also noted if infants <30 weeks gestational age at birth were only included in the analysis.[14]

Hence, the data would suggest that initial stabilization on NCPAP followed by early selective surfactant replacement would perhaps be the ideal approach. Recently, efforts have been made to deliver surfactant by avoiding endotracheal tube (ETT) intubation altogether,[15,16] but additional research is required before these approaches can be recommended as a means to deliver surfactant. Further research will be needed to assess if such an approach to administer surfactant, thus avoiding ETT intubation and invasive ventilation, decreases BPD.

While the experience with NCPAP in neonates as a means to avoid invasive ventilation is extensive, 50–80% of such neonates will still develop respiratory failure that will necessitate ETT intubation.[9,10,17] The use of different devices to deliver NCPAP has not significantly impacted on the rates of infants on NCPAP requiring re-intubation.[18–20]

This failure rate of NCPAP led to a renewed interest in the use of NIPPV in neonates in the post-surfactant era.[21–23] In the beginning, NIPPV was studied as a means to improve extubation success, but now has progressed to be studied as an initial mode of non-invasive support, with early selective use of surfactant. Currently, NIPPV continues to be used in neonates worldwide, and caregivers have accumulated considerable experience with this technique in the international arena.[6,17,19,24–27]

NIPPV nomenclature

NIPPV is essentially a mode of providing intermittent mandatory ventilation (IMV) using nasal prongs.[28] When it is synchronized, it is referred to as synchronized NIPPV or SNIPPV. The primary mode of NIPPV refers to its use soon after birth with or without a short period (≤2 h) of intubation for surfactant delivery, followed by extubation.[28] The secondary mode refers to its use following a longer period (>2 h to days to weeks) of intubation.[28]

NIPPV technique

The pre-surfactant era experience with NIPPV was complicated by increased gastrointestinal perforations[29]; hence, in the post-surfactant period, investigators used SNIPPV in the first 3 RCTs.[21–23] All used the Infant Star® ventilator with the StarSync® (CareFusion, San Diego, CA) module to provide SNIPPV. Subsequent SNIPPV studies in neonates have also mostly used the same ventilator.[30–36]

The SNIPPV mode of ventilation as recommended by us[28] is different from the nasal synchronized respiratory support provided by the Infant Flow SiPAP Comprehensive® ventilator (CareFusion, San Diego, CA). The latter is a bi-level device, providing higher and lower pressures, with much longer inspiratory times, compared to SNIPPV mode.[28] The PIPs generated by the SiPAP device are typically 9–11 cmH_2O, much lower than what we have advocated.[28]

Since the Infant Star® ventilator was phased out in the USA, it has necessitated moving back to using the NIPPV mode. We have had good experience with the Bear Cub 750 PSV® (CareFusion, San Diego, CA)[35,36] and more recently, the Avea® ventilator (CareFusion, San Diego, CA). A variety of other ventilators have been used in the NIPPV mode in published studies. These include the SLE 2000® (SLE Ltd., South Croydon, UK),[37] VIP Bird-R Sterling® (CareFusion, San Diego, CA),[38] Drager Babylog 8000® (Drager Medical Inc., Telford, PA),[38] Servo-i® (Maquet Medical Systems, Wayne, NJ) and Inter Neo® (Intermed Inc, Sao Paulo, Brazil).[39] We believe that any ventilator capable of providing NCPAP and IMV modes of ventilation in neonates can be used to provide NIPPV, as per our suggested guidelines.[28] In a majority of situations, the problems of nuisance alarms and leak compensation can be corrected by appropriate software modifications in the ventilator and nursing-interventional strategies.

Regarding the nasal interface, the use of short bi-nasal prongs is recommended, rather than single nasal prongs, since they are easier to apply and maintain in position, and are less susceptible to blockage secondary to secretions.[40]

SNIPPV studies and extubation

Initial studies focused on SNIPPV used in the secondary mode (refers to its use following a period of intubation of >2 h to