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Research paper

# First-line treatment using high-flow nasal cannula for children with severe bronchiolitis: Applicability and risk factors for failure

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## ABSTRACT

**Background:** Viral bronchiolitis is the leading cause of hospitalization in children during the first 12 months of life. There is evidence to support the use of noninvasive ventilation in bronchiolitis. A recent respiratory management of bronchiolitis is the use of high-flow nasal cannula (HFNC) therapy. The primary objective of this study was to evaluate the use of HFNC as the first-line treatment for children with severe bronchiolitis and the secondary objective was to identify factors for HFNC therapy failure.

**Methods:** Observational prospective study in a pediatric intensive care unit (PICU), during two consecutive seasons (2013–2014 without recommendation and 2014–2015 with a study design suggesting HFNC as first-line treatment). The percentages of children treated with HFNC, nasal continuous or biphasic positive airway pressure (nCPAP/BiPAP) and invasive ventilation were compared. Associations between parameters recorded and HFNC therapy failure were established.

**Results:** The percentage of patients treated with HFNC at admission was higher during the second season (90%,  $n = 55/61$ ) than the first season (34%,  $n = 14/41$ ) ( $p < 0.0001$ ). In bivariate analysis, heart rate, pH, and  $p\text{CO}_2$  were significantly associated with the occurrence of HFNC therapy failure in time-varying Cox regression models using all available values (i.e., admission and repeated measures during the first 5 days of hospitalization). Only  $p\text{CO}_2$  remained independently associated as a factor of HFNC failure in the multivariate Cox model with a hazard ratio per 5 mmHg of 1.37 (95%CI: 1.01–1.87;  $P = 0.046$ ).

**Conclusion:** In our PICU, HFNC therapy for children with bronchiolitis can potentially decrease the use of nCPAP. In this study, the factor of failure was higher  $p\text{CO}_2$ . Studies to evaluate  $\text{PCO}_2$  level to discriminate HFNC versus CPAP indication could be useful.

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## 1. Introduction

Viral bronchiolitis is the leading cause of hospitalization in infants during the first 12 months of life. Approximately 100,000 bronchiolitis admissions occur annually in the United States at an estimated cost of \$1.73 billion [1]. Reported hospital admission rates for bronchiolitis vary from 2 to 10% and around 5–7% of these will result in admission to critical care for ventilator support because of respiratory failure [2]. Despite no clear recommendations on the management of acute respiratory failure in children

[3], the available data seem to show that noninvasive ventilation is associated with decreased duration of ventilator support and length of stay [4,5], especially in bronchiolitis [6,7]. Nasal continuous positive airway pressure (nCPAP) or biphasic positive airway pressure (BiPAP) has been widely used in children with severe bronchiolitis [2]. The latest addition to the respiratory management of bronchiolitis is the use of high-flow nasal cannula (HFNC) therapy [8,9]. High flow rates generate low levels of positive pressure in the upper airways and may also help wash out  $\text{CO}_2$  from the nasal and pharyngeal passages, which may increase the concentration of oxygen available for delivery from conducting to respiratory zones at the start of each inhalation [2]. During the inspiratory phase, HFNC maintains a pharyngeal pressure [10] and therefore reduces inspiratory nasopharyngeal resistance. In addition, a certain level of positive pressure may prevent small airway

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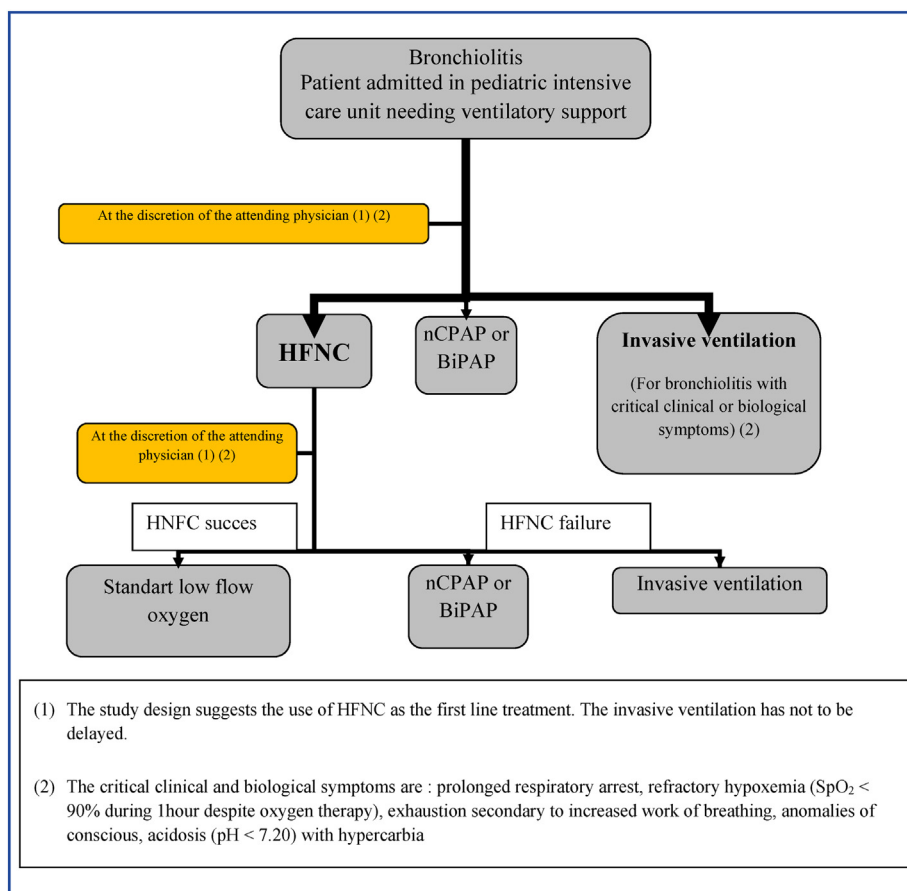
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collapse during expiration [11]. Studies in neonates have shown that HFNC therapy has similar clinical efficacy and safety to nCPAP as a mode of noninvasive respiratory support [12]. The beneficial effect of HFNC therapy has been shown as first-line treatment for intensive care unit adult patients with acute respiratory failure [13]. In the pediatric intensive care unit (PICU), Milési et al. showed that initial bronchiolitis management with HFNC with a flow of 2 L/kg/min did not have a failure rate similar to that of nCPAP. Discomfort was the leading cause of failure in the nCPAP and HFNC was associated with a higher degree of comfort [14]. In the emergency unit, HFNC with a flow of 1 L/kg/min did not significantly reduce time on oxygen compared with standard therapy [15]. Since HFNC is easier and better tolerated, and is associated with fewer skin complications [16], Metge et al. compared the use of nCPAP and HFNC as a noninvasive respiratory support system in infants with acute bronchiolitis: no difference between HFNC and nCPAP in the management of severe bronchiolitis was found [17]. The primary objective of this study was to evaluate the use of HFNC therapy as the first-line treatment for infants with severe bronchiolitis and the secondary objective was to identify risk factors for HFNC therapy failure from physiological parameters.

## 2. Materials and methods

This was a prospective, single-center, observational study that took place over two consecutive comparable time periods – 1 November to 31 March 2013–2014 and 2014–2015 – and was conducted by the PICU of the University of Lille Hospital Center, Lille, France. The inclusion criteria were age between 0 and

24 months, clinical diagnosis of severe bronchiolitis defined as the need for any ventilatory support based on clinical evaluation. Exclusion criteria were children admitted for bronchiolitis who did not require respiratory assistance. During the two periods, the intubation criteria used were prolonged respiratory arrest, refractory hypoxemia ( $SpO_2 < 90\%$  over 1 h despite oxygen therapy with  $FiO_2 = 100\%$ ), exhaustion secondary to increased breathing effort, consciousness abnormalities, acidosis ( $pH < 7.20$ ) with hypercapnia. The noninvasive ventilation criteria were left to the discretion of the attending physician in the PICU. During the first period (November 2013 to March 2014, group 1), there were no guidelines for choosing HFNC, nCPAP or BiPAP. During the second period (November 2014 to March 2015, group 2), a study design (Fig. 1) suggested the use of HFNC as the first-line treatment (before nCPAP or BiPAP) for included children. HFNC (Optiflow<sup>®</sup>, Fisher and Paykel Healthcare) via nasal cannula (Optiflow<sup>®</sup>, OPT 314 or OPT318, Fisher and Paykel Healthcare<sup>®</sup>) was exclusively administered with a gas flow of 2 L/kg/min using an active respiratory gas humidifier (MR 850, “invasive ventilation” setting, Fisher and Paykel Healthcare<sup>®</sup>). The flow rate of nCPAP or BiPAP (Infant Flow<sup>®</sup> Advance System, Viasys Healthcare<sup>®</sup>) was adapted to obtain a positive airway pressure from 4 to 6 cmH<sub>2</sub>O. Apneas were considered when there were more than three apneas longer than 10 s each per hour, clinically relevant with bradycardia, and the level of  $SpO_2$  less than 90%. No additional test was undertaken for this study. The modified Wood's Clinical Asthma Score (m-WCAS) was calculated at admission. The type of respiratory support, oxygenation variable ( $FiO_2$ ), respiratory rate (RR), heart rate (HR),  $SpO_2$ , apnea, pH and  $pCO_2$  were collected on admission in the first period and on admission and during the first 5 days of



**Fig. 1.** Study design suggested the use of HFNC as noninvasive first-line treatment for bronchiolitis during the 2014–2015 period. HFNC: high-flow nasal cannula; nCPAP: nasal continuous positive airway pressure; BiPAP: biphasic positive airway pressure.

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