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Systematic Research Article

HIGH-FLOW NASAL CANNULA VERSUS CONVENTIONAL OXYGEN THERAPY AND HIGH-FLOW NASAL CANNULA VERSUS CONTINUOUS POSITIVE AIRWAY PRESSURE IN INFANTS AND YOUNG CHILDREN WITH BRONCHIOLITIS: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Bronchiolitis is the leading cause of lower respiratory tract infection and hospitalization in infants, with oxygen therapy forming the cornerstone of supportive management. High-flow nasal cannula (HFNC) has emerged as a promising alternative to conventional oxygen therapy (COT), Continuous Positive Airway Pressure (CPAP) offering potential physiological and clinical advantages. However, evidence regarding its effectiveness and safety remains inconsistent. This systematic review evaluates the efficacy and safety of HFNC compared with conventional oxygen therapy or CPAP in infants with bronchiolitis by synthesizing evidence from original clinical studies. The objective is to systematically evaluate and compare the efficacy and safety of high-flow nasal cannula (HFNC) versus conventional oxygen therapy (COT), HFNC Vs CPAP, in infants with bronchiolitis by assessing treatment failure, escalation of respiratory support, need for intensive care admission, duration of oxygen therapy, length of hospital stay, adverse events, and overall clinical outcomes.

Materials and Methods: This systematic review was conducted in accordance with the PRISMA guidelines. A comprehensive literature search was performed using PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Google Scholar using the keywords bronchiolitis, high-flow nasal cannula, conventional oxygen therapy, continuous Positive Airway Pressure, infants and young children. Original research articles published from 2010 were included in the review. Studies were screened according to predefined inclusion and exclusion criteria, followed by full-text review. Relevant data on treatment failure, escalation of respiratory support, intensive care admission, duration of oxygen therapy, length of hospital stay, adverse events, and clinical outcomes were extracted and synthesized narratively. The study selection process was summarized using a PRISMA flow diagram.

Results: Compared with conventional oxygen therapy, high-flow nasal cannula (HFNC) consistently reduced treatment failure and the need for escalation of care while demonstrating a favorable safety profile. Compared with continuous positive airway pressure (CPAP), HFNC showed comparable efficacy in several studies, although CPAP was associated with higher treatment success in severe bronchiolitis. Most studies found no significant differences in intubation rates, duration of oxygen therapy, hospital length of stay, or adverse events. Predictors of HFNC failure included hypercapnia, greater illness severity, lower body weight, and younger age.

Conclusion: HFNC is a safe and effective non-invasive respiratory support modality for bronchiolitis, reducing treatment failure compared with conventional oxygen therapy. Although CPAP may provide greater efficacy in severe cases, HFNC offers better comfort and ease of use. Further large scale, multi-centre, high quality randomized controlled trials and well-designed prospective cohort studies, are needed to establish the optimal respiratory support strategy.
Keywords: bronchiolitis, high-flow nasal cannula, conventional oxygen therapy, Continuous Positive Airway Pressure, infants and young children.

INTRODUCTION

Bronchiolitis is the most common lower respiratory tract infection in infants and represents one of the leading causes of hospitalization during the first year of life worldwide. The disease is characterized by acute inflammation, edema, and necrosis of the small airway epithelium, accompanied by increased mucus production and bronchospasm, resulting in airflow obstruction and impaired gas exchange. Despite its predominantly self-limiting nature, bronchiolitis can progress to significant respiratory distress and hypoxemia, necessitating hospitalization and respiratory support, particularly among young infants and those with prematurity, congenital heart disease, or chronic lung disease.

High-flow nasal cannula (HFNC) therapy has emerged over the past decade as an increasingly utilized non-invasive respiratory support modality for infants with bronchiolitis. HFNC delivers heated and humidified oxygen-air mixtures at high flow rates that may exceed the patient's inspiratory flow demand, thereby providing several physiological benefits.

Hough JL et al. (2014) conducted a prospective observational study in 13 infants with bronchiolitis and found that high-flow nasal cannula therapy at 8 L/min significantly increased end-expiratory lung volume and improved respiratory rate, oxygen saturation (SpO_2), and oxygen requirement (FiO_2) compared with 2 L/min, indicating improved respiratory support with higher flow rates.[1]

Milési C et al. (2013) prospectively studied 21 infants younger than 6 months with acute RSV (Respiratory Syncytial Virus) bronchiolitis and found that HFNC therapy produced a flow-dependent increase in pharyngeal pressure. Flow rates ≥2 L/kg/min generated clinically meaningful positive airway pressure and were associated with reduced respiratory rate, decreased inspiratory effort, and lower work of breathing. Flows ≥6 L/min maintained positive pharyngeal pressure throughout the respiratory cycle, demonstrating effective respiratory muscle unloading and improved breathing mechanics.[2]

Wing R et al. (2012) retrospectively evaluated children with acute respiratory illness (ARI) admitted from the pediatric emergency department to the Pediatric Intensive Care Unit (PICU) before and after the introduction of HFNC. After adjusting for age, illness severity, admission month, and respiratory diagnosis, implementation of an HFNC protocol was associated with an 83% reduction in the odds of intubation (odds ration [OR] 0.17; 95% confidence interval [CI] 0.06–0.50; P = 0.001) compared with the pre-HFNC period. No significant differences were observed in mortality or median PICU length of stay, indicating that early HFNC use may reduce the need for invasive mechanical ventilation in pediatric ARI.[3]

Lal SN et al. (2018) conducted a randomized controlled trial in 72 infants with bronchiolitis, comparing nasal continuous positive airway pressure (nCPAP) with standard care. The nCPAP group showed significantly greater improvement in respiratory rate (14/32 vs. 5/35; P = 0.008), Silverman–Anderson score (P = 0.029), and Modified Pediatric Society of New Zealand Severity Score (P = 0.012). The study concluded that nCPAP was more effective than standard care in reducing respiratory distress in infants with bronchiolitis.[4]

In a phase 4 randomized controlled trial involving 202 children with moderate bronchiolitis, high-flow warmed humidified oxygen (HFWHO) did not significantly reduce the duration of oxygen therapy compared with standard oxygen treatment (20 vs. 24 hours; p = 0.61), but it significantly reduced treatment failure (14% vs. 33%; p = 0.0016), with similar ICU admission and adverse event rates, suggesting HFWHO may be beneficial as a rescue therapy rather than as routine first-line treatment (Kepreotes E et al. 2017).[5]

Given the increasing global use of HFNC and the growing body of original clinical research, a comprehensive synthesis of available evidence is warranted. This systematic review aims to evaluate and compare the efficacy and safety of high-flow nasal cannula therapy versus conventional oxygen therapy or Continuous Positive Airway Pressure in Infants and young children with Bronchiolitis by critically analyzing evidence from original clinical studies. Specifically, the review examines clinically important outcomes including treatment failure, escalation of respiratory support, need for intensive care admission, duration of oxygen therapy, hospital length of stay, adverse events, and overall clinical outcomes to provide evidence that may inform clinical decision-making and optimize respiratory management in infants and young children hospitalized with bronchiolitis.

Objectives: To systematically compare the efficacy and safety of high-flow nasal cannula (HFNC) Vs conventional oxygen therapy (COT) or Continuous

Positive Airway Pressure (CPAP) in infants and young children with bronchiolitis by evaluating treatment failure, escalation of respiratory support, intensive care admission, duration of oxygen therapy, hospital length of stay, adverse events, and overall clinical outcomes.

MATERIALS AND METHODS

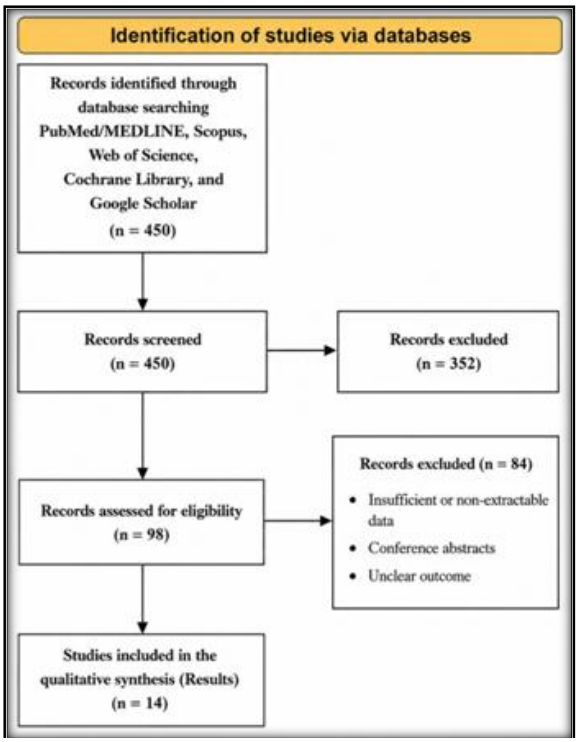

Figure 1: PRISMA Flow chart of Study Selection Process

This systematic review was conducted in accordance with the PRISMA guidelines. A comprehensive literature search was performed using PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Google Scholar using the keywords bronchiolitis, high-flow nasal cannula, conventional oxygen therapy, Continuous Positive Airway Pressure, infants and young children. Original research articles published from 2010 were included in the review. Original research articles comparing high-flow nasal cannula (HFNC) Vs conventional oxygen therapy (COT) or HFNC Vs Continuous Positive Airway Pressure in infants and young children with bronchiolitis were included. Studies were screened using predefined inclusion and exclusion criteria, followed by full-text review. Relevant data on patient characteristics, treatment protocols, treatment failure, escalation of respiratory support, intensive care admission, duration of oxygen therapy, length of hospital stay, adverse events, and overall clinical outcomes were extracted using a standardized data collection form. Studies were screened according to predefined inclusion and exclusion criteria, followed by full-text review and data synthesized narratively. Eligible study designs included original research studies, randomized controlled trials, cohort studies, case–control studies, cross-sectional studies, case study. Studies without extractable data or clearly defined outcome measures and conference abstracts were excluded.

Titles, abstracts, and full texts were independently screened by two reviewers, with disagreements resolved by consensus. Data extraction and quality assessment were performed independently using standardized tools appropriate to study design. Due to heterogeneity among studies, a qualitative synthesis was conducted.

RESULTS & DISCUSSION

Franklin D et al. (2018) conducted a multicenter randomized controlled trial involving 1,472 infants with bronchiolitis and found that high-flow nasal oxygen therapy significantly reduced treatment failure requiring escalation of care compared with standard oxygen therapy (12% vs. 23%; $p< 0.001$). However, no significant differences were observed in hospital stay, duration of oxygen therapy, ICU admission, or adverse events. The findings support high-flow oxygen as an effective strategy to reduce escalation of care in infants with bronchiolitis.[6]

Vahlkvist S et al. (2020) conducted a randomized trial and found that baseline mean pCO_2 was 6.7 kilopascals (kPa) in both groups, while the mean respiratory rate was 60 breaths/min in the CPAP group and 56 breaths/min in the HFNC group. Both therapies produced comparable reductions in respiratory rate, pCO_2, and Modified Woods Clinical Asthma Score, with no significant differences in treatment duration, hospitalization length, or treatment failure. However, the Neonatal Infant Pain Score (NIPS) was significantly higher in the CPAP group, indicating that HFNC was better tolerated and represents an effective alternative to CPAP in infants and young children with bronchiolitis.[7]

Habra B et al. (2020) retrospectively evaluated 137 infants and young children (1 month–2 years) with acute bronchiolitis admitted to the PICU, including 77 treated with HFNC, 10 with CPAP, and 50 with BiPAP. HFNC demonstrated a significantly higher treatment failure rate than CPAP or BiPAP (50.6% [39/77] vs. 0% [0/10] vs. 8% [4/50], $P< 0.01$). Of the 39 HFNC failures, 90% were successfully transitioned to BiPAP, while 4 required intubation and mechanical ventilation. All four BiPAP failures required intubation. No respiratory complications, mortality, or significant differences in PICU or hospital length of stay were observed among the groups. These findings suggest that CPAP and BiPAP were associated with lower treatment failure rates than HFNC in critically ill children with bronchiolitis.[8]

Sitthikarnkha P et al. (2018) conducted a randomized controlled trial involving 98 infants and children (1 month–5 years) hospitalized with respiratory distress, comparing HFNC with

conventional oxygen therapy. Treatment failure occurred in 8.2% (4/49) of the HFNC group versus 20.4% (10/49) of the conventional oxygen group (P = 0.09). After adjustment for body weight, underlying diseases, and respiratory distress score, HFNC was associated with 85% lower odds of treatment failure (adjusted OR 0.15; 95% CI 0.03–0.66; P = 0.01). Additionally, HFNC resulted in significantly greater improvements in respiratory score, heart rate, and respiratory rate at 120, 240, and 360 minutes compared with conventional oxygen therapy, suggesting superior clinical effectiveness in children with moderate-to-severe respiratory distress.[9]

Abboud PA et al. (2012) retrospectively reviewed 113 infants (≤12 months) with viral bronchiolitis treated with HFNC in the PICU. Ninety-two patients responded to HFNC, whereas 21 required intubations. Infants who failed HFNC had significantly lower body weight (p = 0.016), higher baseline and post-treatment PCO_2 (p< 0.001 for both), and higher Pediatric Risk of Mortality (PRISM III) scores (p< 0.001). A higher pre-HFNC respiratory rate was associated with a lower risk of respiratory deterioration (p< 0.001). Prematurity and age were not associated with HFNC failure, suggesting that hypercapnia and greater illness severity were key predictors of treatment failure.[10]

Milési C et al. (2017) conducted a multicenter randomized controlled trial involving 142 infants (≤6 months) with moderate-to-severe acute viral bronchiolitis, comparing HFNC (2 L/kg/min) with 7 cmH_2O nasal CPAP (nCPAP). HFNC did not demonstrate noninferiority to nCPAP, with a risk difference of −19% (95% CI: −35% to −3%; p = 0.707). Superiority analysis favored nCPAP, showing a 1.63-fold higher likelihood of treatment success (Relative risk [RR] 1.63; 95% CI: 1.02–2.63). However, intubation rates, duration of ventilatory support, Pediatric Intensive Care Unit (PICU) length of stay, and adverse events were comparable between groups, with no deaths or air leak syndrome reported.[11]

McKiernan C et al. (2010) retrospectively compared infants with bronchiolitis admitted before and after the introduction of HFNC in the Pediatric Intensive Care Unit (PICU). Following HFNC implementation, the intubation rate decreased significantly from 23% to 9% (P = 0.043), representing a 68% reduction after adjustment for age, weight, and RSV status. HFNC also produced a greater reduction in respiratory rate than other respiratory support modalities, and infants with the largest improvement were least likely to require intubation. Additionally, the median PICU stay decreased from 6 to 4 days, suggesting that HFNC may reduce the need for invasive ventilation and shorten intensive care hospitalization.[12]

Riese J et al. (2017) conducted a retrospective pre–post intervention study of 1,937 infants hospitalized with bronchiolitis, comparing outcomes before (n = 936) and after (n = 1,001) implementation of a general ward HFNC guideline. HFNC use increased significantly following guideline implementation (23.9% vs. 35.2%; P< 0.001). However, there were no significant changes in total hospital length of stay (P = 0.48), PICU length of stay (P = 0.06), PICU transfer rate (P = 0.97), intubation rate, or 30-day readmission. These findings suggest that although HFNC utilization increased, its broader implementation did not significantly improve major clinical outcomes in infants with bronchiolitis.[13]

Milési C et al. (2018) conducted a multicenter randomized controlled trial across 16 Pediatric Intensive Care Units (PICUs) involving 286 infants (≤6 months) with moderate-to-severe acute viral bronchiolitis, comparing HFNC flow rates of 2 L/kg/min (n = 142) and 3 L/kg/min (n = 144). Treatment failure was similar between groups (38.7% vs. 38.9%; P = 0.98). Worsening respiratory distress was the most common cause of failure (49% vs. 39%; P = 0.45). The 3 L/kg/min group experienced more discomfort (43% vs. 16%; P = 0.002) and a longer PICU stay (6.4 vs. 5.3 days; P = 0.048). Intubation rates (2.8% vs. 6.9%; P = 0.17) and durations of invasive and non-invasive ventilation were comparable, with no deaths or air leak syndrome reported. These findings indicate that increasing HFNC flow from 2 to 3 L/kg/min did not improve treatment outcomes.[14]

Suessman A et al. (2020) retrospectively evaluated 2,657 previously healthy children (<24 months) with bronchiolitis treated with HFNC in two pediatric emergency departments. The median age was 7 months, whereas intubated children had a median age of 3 months. Overall, 10% (271/2,657) required mechanical ventilation within 48 hours, and among 301 patients escalated to CPAP and/BiPAP, 91 subsequently required intubation. Younger age and a higher respiratory assessment score were independent predictors of intubation, while reduced tachycardia after HFNC initiation and presentation after day 5 of illness were associated with a lower risk of respiratory failure. A secondary analysis also suggested that bronchodilator use was associated with a reduced intubation rate.[15]

Borgi A et al. (2021) conducted a randomized controlled trial involving 255 infants with severe bronchiolitis, comparing high-flow nasal cannula (HFNC) with continuous positive airway pressure (CPAP)/nasal positive pressure ventilation (NPPV). Treatment success was significantly higher with CPAP/NPPV than with HFNC (70.4% vs. 50.7%; P = 0.001). Lower baseline pH was the only significant predictor of treatment failure in the CPAP/NPPV group (P = 0.035). Intubation rates and serious adverse events were comparable between the groups. Following HFNC failure, switching to CPAP/NPPV avoided intubation in 54% of cases, suggesting that although HFNC is safe and effective, CPAP/NPPV is more effective in preventing treatment failure in severe bronchiolitis.[16]

Antilici L et al (2025) evaluated high-flow nasal cannula (HFNC) versus standard oxygen therapy

(SOT) using a quasi-experimental design in children with moderate bronchiolitis. HFNC did not significantly reduce the duration of oxygen therapy, length of hospital stay, or treatment failure compared with SOT (P> 0.05). The authors concluded that routine first-line use of HFNC is not supported for moderate bronchiolitis, and further randomized controlled trials with standardized protocols are needed to better define its clinical role.[17]

Cesar RG et al. (2020) conducted a randomized controlled pilot study involving 63 infants with critical bronchiolitis, comparing high-flow nasal cannula (HFNC; n = 35) with continuous positive airway pressure (CPAP; n = 28). Treatment failure was comparable between the HFNC and CPAP groups (37.1% vs. 35.7%; P = 0.88), and the median PICU stay was similar (5 [4–8] vs. 5 [4–7] days; P = 0.46). The findings suggest that HFNC demonstrated clinical efficacy comparable to CPAP in infants with critical bronchiolitis.[18]

Shobat S & Saleh H (2026) conducted a retrospective analytical study involving 81 infants with moderate bronchiolitis, comparing high-flow nasal cannula (HFNC; n = 15) with standard oxygen therapy (SOT; n = 66). Hospital stay was significantly longer in the HFNC group than in the SOT group (4 [Interquartile Range {IQR}3–5] vs. 3 [IQR 2–3] days; P = 0.002), and HFNC remained independently associated with prolonged hospitalization (β = 1.31 days; 95% CI: 0.41–2.18). Early discharge within 48 hours was less frequent with HFNC (13.33% vs. 37.88%). The authors concluded that early HFNC use did not improve the disease course in moderate bronchiolitis, highlighting the need for large, standardized studies to identify patients most likely to benefit from HFNC.[19]

Table 1: Summary of Included Studies and Their Key Findings

Author	Key findings
Franklin D et al. (2018)	HFNC significantly reduced treatment failure requiring escalation of care compared with standard oxygen therapy, with no significant differences in hospital stay, oxygen therapy, ICU admission, or adverse events.
Vahlkvist S et al. (2020)	HFNC and CPAP showed comparable clinical outcomes, but HFNC was better tolerated and represents an effective alternative to CPAP.
Habra B et al. (2020)	HFNC demonstrated a significantly higher treatment failure rate than CPAP or BiPAP. CPAP and BiPAP were associated with lower treatment failure rates than HFNC.
Sitthikarnkha P et al. (2018)	HFNC was associated with 85% lower odds of treatment failure and significantly greater improvements in respiratory score, heart rate, and respiratory rate than conventional oxygen therapy.
Abboud PA et al. (2012)	Hypercapnia, greater illness severity, and lower body weight were key predictors of HFNC treatment failure.
Milési C et al. (2017)	HFNC did not demonstrate noninferiority to nCPAP. Superiority analysis favored nCPAP, while intubation rates and adverse events were comparable.
McKiernan C et al. (2010)	HFNC significantly reduced intubation rates, improved respiratory status, and shortened PICU stay.
Riese J et al. (2017)	Increased HFNC utilization did not significantly improve hospital stay, PICU length of stay, intubation rate, or readmission.
Milési C et al. (2018)	Increasing HFNC flow from 2 to 3 L/kg/min did not improve treatment outcomes and was associated with greater discomfort.
Suessman A et al. (2020)	Younger age and higher respiratory assessment scores predicted intubation, while reduced tachycardia after HFNC initiation was associated with lower respiratory failure risk.
Borgi A et al. (2021)	CPAP/NPPV achieved significantly higher treatment success than HFNC. Switching from HFNC to CPAP/NPPV avoided intubation in 54% of cases.
Antilici L et al. (2025)	HFNC did not reduce oxygen therapy duration, hospital stay, or treatment failure compared with standard oxygen therapy. Routine first-line HFNC was not supported for moderate bronchitis.
Cesar RG et al. (2020)	HFNC demonstrated clinical efficacy comparable to CPAP in critical bronchiolitis, with similar treatment failure rates and PICU stay.
Shobat S & Saleh H (2026)	HFNC was associated with longer hospital stay and did not improve the disease course compared with standard oxygen therapy in moderate bronchiolitis. Large standardized studies are needed.

CONCLUSION

Franklin D et al. (2018) concluded that HFNC is an effective and safe respiratory support modality that reduces treatment failure and the need for escalation of care in infants with bronchiolitis.[6]

Vahlkvist S et al. (2020) concluded that HFNC is a well-tolerated and effective alternative to CPAP in infants with bronchiolitis.[7]

High-Flow Warm Humidified Oxygen did not significantly reduce the duration of oxygen therapy compared with standard oxygen therapy but may reduce the need for intensive care in children with moderate bronchiolitis (Kepreotes E et al., 2017).[5]

Sitthikarnkha P et al. (2018) concluded that HFNC was more effective than conventional oxygen therapy in improving clinical outcomes and reducing the risk of treatment failure in children with moderate-to-severe respiratory distress.[9]

Abboud PA et al. (2012) concluded that baseline hypercapnia, greater illness severity, and lower body weight were important predictors of HFNC failure in infants with bronchiolitis.[10]

Milési C et al. (2017) concluded that nCPAP was more effective than HFNC as the initial respiratory support in infants with moderate-to-severe bronchiolitis, although both therapies had comparable intubation rates and safety profiles.[11]

McKiernan C et al. (2010) concluded that early implementation of HFNC reduced intubation rates, improved respiratory status, and shortened PICU stay in infants with bronchiolitis.[12]

Riese J et al. (2017) concluded that although HFNC use increased following implementation of a ward-based guideline, it did not significantly improve hospital length of stay, PICU utilization, intubation rates, or readmission in infants with bronchiolitis.[13] High-flow nasal cannula (HFNC) may improve clinical outcomes and reduce treatment escalation compared with low-flow oxygen without increasing adverse events. However, large randomized trials comparing HFNC with continuous positive airway pressure (CPAP) and using standardized bronchiolitis definitions and severity scores are needed to determine the optimal respiratory support strategy (Armarego M et al., 2024).[20]

Both high-flow nasal cannula (HFNC) and continuous positive airway pressure (CPAP) are effective non-invasive respiratory support modalities for bronchiolitis. While CPAP may be more effective in reducing treatment failure in severe cases, HFNC offers better comfort and easier application. Further high-quality randomized controlled trials are needed to define the optimal respiratory support strategy (Dr. Liqa ur Rehman et al., 2026).[21]

Overall, the available evidence suggests that high-flow nasal cannula (HFNC) is a safe and effective non-invasive respiratory support modality for infants and young children with bronchiolitis. Compared with conventional oxygen therapy, HFNC improves respiratory outcomes and reduces treatment failure and the need for escalation of care without increasing adverse events. However, HFNC does not consistently shorten the duration of oxygen therapy, hospital stay, or PICU utilization. In moderate-to-severe bronchiolitis, continuous positive airway pressure (CPAP) appears to provide higher treatment success and lower failure rates, whereas HFNC offers advantages in patient comfort, ease of application, and use as an initial or rescue therapy. Baseline hypercapnia, greater illness severity, and lower body weight are important predictors of HFNC failure. Further large, multi-centre randomized controlled trials and well-designed prospective cohort studies, using standardized bronchiolitis definitions, severity scoring systems, and treatment protocols are required to determine the optimal respiratory support strategy and identify patients most likely to benefit from HFNC.

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