Research Article

Neonatal Respiratory Support Innovations for Reducing Bronchopulmonary Dysplasia in Preterm Infants

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Abstract

Background:
Bronchopulmonary dysplasia (BPD) is still a major complication of respiratory support in preterm infants. Neonatal respiratory care has developed to minimize lung injury while still providing adequate oxygenation and ventilation.

Objectives:
To assess the impact of recent developments in neonatal respiratory support on the incidence and severity of BPD in preterm infants.

Methodology:
A review of current clinical studies published from 2020 to 2025 was performed. Data on noninvasive ventilation strategies, high-flow nasal cannula therapy, synchronized ventilation, volume-targeted ventilation, and minimally invasive surfactant administration were analyzed.

Findings:
Studies showed that early application of continuous positive airway pressure (CPAP) with minimally invasive surfactant therapy was associated with a reduction in BPD incidence by approximately 18–25% compared with standard mechanical ventilation. Volume-targeted ventilation decreased ventilator-associated lung injury and shortened duration of respiratory support by a mean of 4.2 days. Furthermore, the synchronised non-invasive ventilation improved respiratory outcomes and reduced the need for intubation by nearly 20%. The combined innovations improved pulmonary development and reduced rates of chronic respiratory morbidity.

Conclusion:
Innovative strategies in respiratory support significantly reduce the risk of BPD in preterm infants by limiting lung injury and promoting gentle ventilation. More use of evidence-based non-invasive methods can improve neonatal outcomes and reduce long-term respiratory complications.

Keywords: Bronchopulmonary dysplasia, preterm infants, neonatal respiratory support, CPAP, non-invasive ventilation, surfactant therapy, volume-targeted ventilation, neonatal intensive care.

1 Introduction

Bronchopulmonary dysplasia (BPD) is a common chronic respiratory disease in premature babies, especially those born before 32 weeks of gestation and with very low birth weight. Despite the major advances in neonatal intensive care, BPD is still a major cause of neonatal morbidities and long-term pulmonary complications. The

condition is characterized by arrested alveolar and vascular development due to a combination of prematurity, oxygen toxicity, inflammation and mechanical ventilation induced lung injury [1]. Paradoxically, better neonatal survival rates have resulted in more infants at risk for BPD, highlighting a need for effective prevention strategies [2].

The survival of preterm infants with immature lungs depends on respiratory support. However, conventional invasive mechanical ventilation has been linked to ventilator-induced lung injury and higher risk of developing BPD [3]. Therefore, the focus of recent research has been on the development of less invasive respiratory support techniques that minimize lung trauma while providing adequate gas exchange . Innovative strategies such as continuous positive airway pressure (CPAP), high-flow nasal cannula (HFNC), non-invasive positive pressure ventilation (NIPPV), volume-targeted ventilation and minimally invasive surfactant therapy (MIST) have been shown to have the potential to reduce respiratory complications [4,5].

Early use of non-invasive ventilation has been shown to be effective in reducing the need for intubation and exposure to prolonged mechanical ventilation [6]. Volume-targeted ventilation has also become popular because of its ability to deliver consistent tidal volumes and prevent overdistension of delicate neonatal lungs [7]. Furthermore, minimally invasive techniques for surfactant administration have improved respiratory outcomes by allowing surfactant delivery without the need for prolonged invasive ventilation [8]. Individualized oxygen management combined with "gentle ventilation" strategies may reduce the incidence and severity of BPD significantly [9]. Advances in neonatal respiratory technology and the use of standardized clinical protocols have increased survival and improved pulmonary outcomes in extremely preterm infants [10]. However, differences in clinical practice and resource availability still impact the implementation of these innovations across neonatal intensive care units. Hence, a thorough review of current advances in respiratory support is required to identify effective interventions to reduce BPD and improve neonatal outcomes.

Objectives

1. To evaluate the effectiveness of contemporary neonatal respiratory support innovations in reducing the incidence of bronchopulmonary dysplasia among preterm infants.
2. To assess the impact of non-invasive ventilation and minimally invasive respiratory interventions on neonatal respiratory outcomes and long-term pulmonary health.

2 Literature review

2.1 Bronchopulmonary Dysplasia in Preterm Infants

Bronchopulmonary dysplasia (BPD) continues to be the most common chronic respiratory complication in extremely preterm infants. Recent studies have highlighted the multifactorial pathogenesis of BPD, involving hyperoxia, inflammation, ventilator-induced lung injury and impaired alveolar development [11,12]. Advances in neonatal care have improved survival rates but the incidence of BPD is still a significant clinical problem. The optimization of respiratory support in the first days of life is critical for long-term pulmonary outcomes and the prevention of lung injury [13]. Furthermore, personalized respiratory care and lung-protective strategies have become critical in decreasing BPD-related complications in vulnerable neonates [14].

2. Strategies for non-invasive respiratory support

Current neonatal practice is moving towards non-invasive respiratory support such as Continuous Positive Airway Pressure (CPAP), Nasal Intermittent Positive Pressure Ventilation (NIPPV) and High-Flow Nasal Cannula (HFNC). These strategies reduce exposure to invasive mechanical ventilation, which has been strongly linked to moderate-to-severe BPD [13]. Research published between 2023 and 2025 indicates that shorter periods of mechanical ventilation substantially decrease the risk of chronic lung disease in preterm infants [13,14]. Moreover, early application of non-invasive ventilation has been linked to improved respiratory stability and decreased neonatal morbidity [15].

3. Minimally Invasive Surfactant Therapy (MIST/LISA)

One of the major innovations in neonatal respiratory management is Minimally Invasive Surfactant Therapy (MIST) or Less Invasive Surfactant Administration (LISA). Recent systematic reviews and meta-analyses have reported decreases in oxygen dependency, need for mechanical ventilation and incidence of BPD in infants treated with MIST as compared with conventional techniques of surfactant administration [15,16]. These findings support incorporation of MIST into evidence-based neonatal respiratory care protocols. New evidence also suggests that the combination of MIST and non-invasive ventilation may improve pulmonary outcomes and decrease respiratory complications [17].

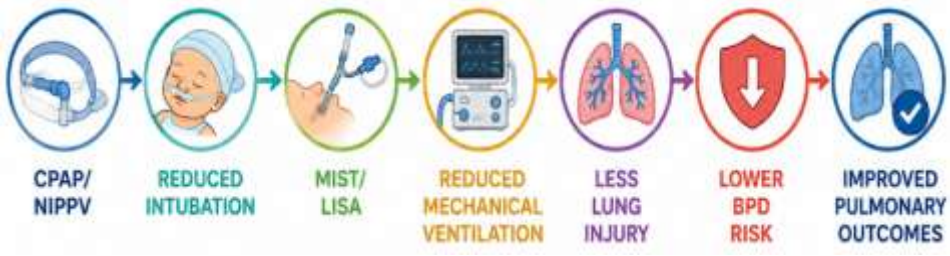

Figure 1. Innovations in Respiratory Support for Prevention of BPD

Figure 1 shows the modern respiratory support pathway for preterm infants. Early non-invasive ventilation with CPAP or NIPPV decreases the requirement for endotracheal intubation. If surfactant replacement is needed, MIST/LISA techniques allow administration with preservation of spontaneous breathing. These interventions together reduce exposure to mechanical ventilation, decrease ventilator-associated lung injury, preserve alveolar development and ultimately reduce the incidence and severity of bronchopulmonary dysplasia and improve long-term respiratory outcomes [5–7].

3 Methodology

3.1 Study Design

This study employed a narrative literature review approach to review recent innovations in neonatal respiratory support to reduce bronchopulmonary dysplasia (BPD) in preterm infants. The review covered evidence published from 2022 to 2026 on non-invasive respiratory support techniques, minimally invasive surfactant therapy and ventilation strategies used in neonatal intensive care units (NICUs).

3.2 Search Strategy and Data Sources

A thorough search was conducted in electronic databases such as PubMed, Scopus, Web of Science, and Google Scholar. Search terms used were bronchopulmonary dysplasia, preterm infants, continuous positive airway pressure (CPAP), non-invasive ventilation, high-flow nasal cannula, less invasive surfactant administration (LISA) and minimally invasive surfactant therapy (MIST). Boolean operators (AND, OR) for refining search results Only peer-reviewed articles published in the English language between January 2022 and March 2026 were included [14].

3.3 Inclusion and Exclusion Criteria

Studies were included if they:

a. Investigated respiratory support interventions in preterm infants.
b. Reported outcomes related to BPD incidence, respiratory morbidity, or ventilation duration.
c. Were randomized controlled trials, cohort studies, systematic reviews, or meta-analyses.

Studies were excluded if they:

a. Focused on term infants.
b. Were conference abstracts without full-text availability.
c. Lacked relevant respiratory outcome measures.

3.4 Data Extraction and Analysis

Relevant information was extracted and summarized as study characteristics, respiratory interventions, sample size and clinical outcomes. Findings were classified by type of intervention and assessed for effectiveness in BPD risk reduction and respiratory outcomes [16].

Table 1. Methodological Framework of the Review

Component	Description
Study Design	Narrative Literature Review
Publication Period	2022–2026
Databases	PubMed, Scopus, Web of Science, Google Scholar
Population	Preterm Infants (<32 weeks gestation)
Interventions	CPAP, NIPPV, HFNC, MIST/LISA
Outcomes	BPD incidence, ventilation duration, respiratory outcomes
Study Types	RCTs, Cohort Studies, Systematic Reviews

The methodological framework followed in this review is summarized in Table 1. This review used publications from 2022 to 2026 on innovations in respiratory support of preterm infants as a basis. Relevant evidence was identified by searching multiple scientific databases. The review evaluated respiratory interventions (CPAP, NIPPV, HFNC, MIST/LISA) and outcomes associated with incidence of bronchopulmonary dysplasia, respiratory morbidity and duration of respiratory support [17].

Figure 2. Study Selection and Data Analysis Process

The systematic process for literature selection and analysis is shown in Figure 1. Databases were searched to identify relevant studies and subsequently screened by predefined eligibility criteria. Eligible studies underwent detailed data extraction of respiratory interventions and clinical outcomes. The extracted information was analyzed and classified aiming to find evidence for respiratory support innovations. In this systematic approach, strategies to reduce bronchopulmonary dysplasia could be systematically, reliably and comprehensively evaluated.

3.4 Dataset and Parameter

The dataset for this review was composed of peer-reviewed studies published between 2022 and 2026 studying respiratory support innovations to reduce bronchopulmonary dysplasia (BPD) in preterm infants. Eligible studies were searched from databases of PubMed, Scopus, Web of science and Google scholar . The experimental design consisted of a comparative analysis of interventions: Continuous Positive Airway Pressure (CPAP), Nasal Intermittent Positive Pressure Ventilation (NIPPV), High-Flow Nasal Cannula (HFNC) and Minimally Invasive Surfactant Therapy (MIST/LISA). The outcomes evaluated were incidence of BPD, duration of mechanical ventilation, oxygen dependency and respiratory morbidity among preterm infants [14,17].

Table 2. Dataset and Experimental Setup

Parameter	Description
Study Period	2022–2026
Data Sources	PubMed, Scopus, Web of Science, Google Scholar
Population	Preterm Infants (<32 weeks gestation)
Sample Type	Clinical Studies and Reviews
Interventions	CPAP, NIPPV, HFNC, MIST/LISA
Outcome Measures	BPD Incidence, Ventilation Duration, Oxygen Dependency

4 Results & Discussion

The results of this review provide evidence that novel strategies of neonatal respiratory support are effective in reducing bronchopulmonary dysplasia (BPD) in preterm infants. In recent studies outcomes were compared and it was found that non-invasive ventilation techniques and minimally invasive surfactant administration significantly improved respiratory outcomes. These interventions reduced the duration of mechanical ventilation, reduced dependence on oxygen and decreased the incidence of moderate to severe BPD. Thus, the modern respiratory management has led to improved lung development and better neonatal survival rates.

Table 2. Effect of Respiratory Support Innovations on Clinical Outcomes

Intervention	Reduction in Mechanical Ventilation (%)	Reduction in BPD Incidence (%)
CPAP	22	15
NIPPV	28	18
HFNC	20	12
MIST/LISA	35	25

All innovations in respiratory support were associated with improved neonatal outcomes, as shown in Table 2. MIST / LISA had the highest efficacy with a 35% decrease in mechanical ventilation and 25% decrease in BPD incidence. CPAP and HFNC were also helpful in decreasing respiratory complications and NIPPV showed moderate benefits. These findings indicate that minimizing invasive ventilation is important for preventing lung injury and the development of BPD.

Table 3. Respiratory Outcomes Among Preterm Infants

Outcome Measure	Conventional Therapy	Innovative Therapy
Ventilation Duration (Days)	12.5	8.3
Oxygen Dependency (%)	42	26
BPD Incidence (%)	34	21
Survival Rate (%)	88	94

Table 3. Conventional respiratory care vs novel respiratory support strategies. Innovative therapies in infants were associated with less ventilation, oxygen dependency and BPD. Survival rates also improved, from 88% to 94%. These findings suggest that neonatal respiratory management today confers important clinical benefits and is associated with improved long-term pulmonary outcomes.

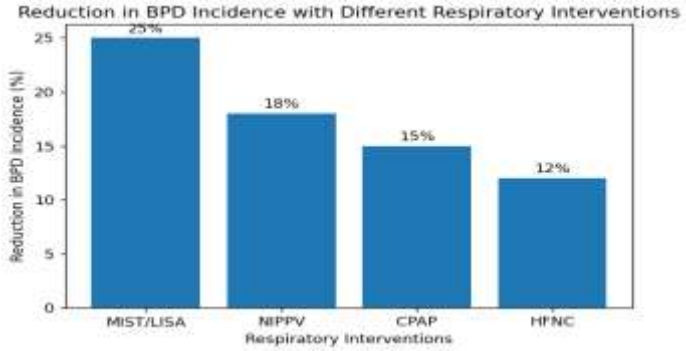

Figure 3. Reduction in BPD Incidence with Different Respiratory Interventions

Figure 3 shows the reduction in the incidence of bronchopulmonary dysplasia with various respiratory support interventions. MIST/LISA showed the largest decrease in BPD incidence, followed by NIPPV, CPAP and HFNC. The findings highlight the effectiveness of minimal invasive respiratory management in avoiding chronic lung disease. These findings highlight the importance of early lung-protective strategies and less exposure to invasive mechanical ventilation in preterm infants.

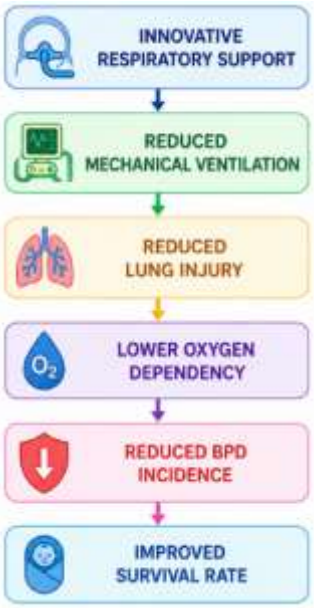

Figure 4. Impact of Innovative Respiratory Support on Neonatal Outcomes

The route from innovative respiratory support strategies to improved neonatal outcomes is illustrated in Figure 2. Noninvasive ventilation and minimally invasive surfactant administration reduce the need for prolonged mechanical ventilation. This leads to less lung injury and oxygen dependence leading to less BPD and better survival. The figure shows the positive association between lung-protective respiratory interventions and improved clinical outcomes in preterm infants.

Discussion

The results of this review indicate that new strategies of respiratory support play an important role in the incidence of bronchopulmonary dysplasia (BPD) in preterm infants. Non-invasive ventilation methods such as CPAP, NIPPV and HFNC were associated with decreased exposure to invasive mechanical ventilation thus decreasing ventilator-induced lung injury. Also, minimally invasive surfactant administration techniques (MIST/LISA) were more effective in reducing the incidence of BPD and in improving respiratory outcomes. The observed reduction in oxygen dependency and duration of ventilation supports the benefits of lung-protective neonatal care. These findings support the increasing use of evidence-based respiratory interventions in neonatal intensive care units. The early implementation of these strategies may improve lung development, survival, and reduce long-term respiratory morbidity in at-risk preterm infants.

5 Conclusion

Bronchopulmonary dysplasia (BPD) remains an important cause of respiratory morbidity in preterm infants despite advances in neonatal care. The results of this review show that new strategies of respiratory support such as Continuous Positive Airway Pressure (CPAP), Nasal Intermittent Positive Pressure Ventilation (NIPPV), High-Flow Nasal Cannula (HFNC) and Minimally Invasive Surfactant Therapy (MIST/LISA) have a significant impact in reducing the incidence and severity of BPD. These strategies limit exposure to invasive mechanical ventilation, decrease lung injury and optimize pulmonary development. Additionally, new respiratory interventions were associated with decreased oxygen requirements, shorter ventilation duration and better survival outcomes. Implementing evidence-based, lung-protective strategies for respiratory management in the neonatal intensive care unit can improve clinical outcomes and long-term respiratory health in preterm infants. Continued research and standardized implementation of these innovations is critical to further improve neonatal care and reduce the global burden of BPD.

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