# Non-invasive respiratory support in newborn infants

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## Abstract

Respiratory failure is the most common morbidity in newborn infants, often requiring respiratory support. Traditionally, invasive mechanical ventilation was the preferred method of neonatologists. Over the last two decades, various forms of non-invasive ventilation have become popular as modes of respiratory support in newborn infants, especially if they are born preterm. These modes differ from mechanical ventilation in not needing an endo-tracheal tube, and are commonly delivered by bi-nasal prongs. We review the common modes of non-invasive respiratory support in newborn infants, including their proposed mechanisms of action and the evidence supporting their use.

**Keywords** lung; newborn; non-invasive; preterm; ventilation

## Introduction

Historically endotracheal intubation and mechanical ventilation has been the primary mode of respiratory support for newborn infants with respiratory distress. As it became clear that invasive ventilation has deleterious effects particularly on the respiratory system, alternative means of respiratory support were sought. Non-invasive ventilation (NIV) has increasingly been used as technology has advanced and clinical experience has grown. NIV refers to any method of respiratory support without an indwelling endotracheal tube. NIV requires an external link between the ventilator and the upper airway of the baby – an interface. Nonetheless, even with an apparent good seal between the child and interface, NIV is associated with variable leaks through the infant's mouth which makes the pressure less consistent than in invasive ventilation. Another important difference with invasive ventilation is that a spontaneous breathing infant is essential in most cases for the use of NIV.

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## Modes of non-invasive respiratory support

A wide range of modes of non-invasive respiratory support exists. The modes (Table 1) can largely be classified as generating either variable levels of pressure or a constant pressure during the respiratory cycle. In nasal intermittent positive pressure ventilation (NIPPV) and bi-level positive airway pressure (BiPAP), a high and low level of pressure is generated. Nasal high-frequency ventilation (NHFV) is another technique of NIV generating a variable airway pressure, but only limited clinical data are available and it is not commonly used, so this mode will not be further discussed in this paper. A constant distending pressure throughout the respiratory cycle is applied using nasal continuous positive airway pressure (NCPAP). In heated humidified high flow nasal cannula (HHHFNC), a flow of more than one litre per minute secondarily generates a less predictable distending pressure. Low flow nasal cannula (LFNC) delivers oxygen at a flow of less than one litre per minute.

NIV, NCPAP, BiPAP/NIPPV, HHHFNC and LFNC, will be discussed in more detail in this review, including their proposed mechanism of action (Table 2) and the evidence supporting their use in newborn infants.

## Nasal continuous positive airway pressure (NCPAP)

### Mode

In NCPAP, a continuous pressure is administered to the airways, both during inspiration and expiration by a NCPAP system. These systems have four main components: a gas source providing heated and humidified air and/or oxygen, a pressure generator to create positive pressure, a circuit, and an interface to connect the circuit to the infant's upper airway. The consistent pressure is generated by either a variable (variable flow NCPAP) or continuous (constant flow NCPAP) gas flow to the infant. Although there are minor differences between constant and variable flow NCPAP, there is limited evidence to suggest superiority of any of the systems to improve clinical outcomes (NCPAP duration, NCPAP failure, complications).

### Mechanism of action

NCPAP generates a continuous distending pressure (CDP) that mechanically splints the airways. In the upper airways, this reduces the supraglottic resistance to airflow and stabilizes pharyngeal tone, preventing obstructive apnoea. The highly compliant chest wall of newborns is stabilized using NCPAP, which improves pulmonary mechanics and synchrony of thoracic and abdominal motion. In the lower airways, the CDP helps in maintaining functional residual capacity (FRC), thus ameliorating gas exchange and decreasing the work of breathing. The prevention of alveolar collapse at end expiration prevents atelectasis, decreases intrapulmonary shunting, conserves surfactant and decreases lung injury. Other benefits from NCPAP are improved nasopharyngeal dead space washout and possibly an improved metabolic balance as the cellular work is reduced (which leads to reduced carbon dioxide production) by delivering heated and humidified gas to the airways.





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### Common modes of non-invasive ventilation in newborn infants

Non-invasive ventilation

- Nasal Continuous Positive Airways Pressure (NCPAP)
  - Constant flow NCPAP: bubble NCPAP, ventilator derived NCPAP
  - Variable flow NCPAP: flow driver NCPAP
- Bi-level Positive Airway Pressure (BiPAP)
- Nasal Intermittent Positive Pressure Ventilation (NIPPV)
- Nasal High-Frequency Ventilation (NHFV)
- Heated Humidified High Flow Nasal Cannula (HHHFNC) Therapy
- Low Flow Nasal Cannula (LFNC) Therapy

**Table 1**

## Evidence supporting the use of NCPAP in newborn infants

**Primary respiratory support for preterm infants**: when NCPAP is started as part of or following initial resuscitation at birth, in a spontaneous breathing infant, this can be adequate support for RDS in preterm infants ("prophylactic NCPAP" or "elective early NCPAP"), and has been shown to be a superior alternative to intubation and ventilation with surfactant administration. Even in infants born at a gestational age of 25 weeks, this approach has proved successful. Early NCPAP in preterm infants is associated with a reduction in respiratory failure, use of exogenous surfactant, need for mechanical ventilation, overall mortality, and the combined rate of death and use of mechanical ventilation. When compared with routine intubation and surfactant administration, early NCPAP significantly decreased the composite outcome of bronchopulmonary dysplasia (BPD) or death, reduced the incidence of BPD, the need for mechanical ventilation, the use of surfactant and results in less respiratory morbidity in the first two years of life. Early NCPAP did not increase the risk of adverse outcomes in these infants when treatment with surfactant was delayed or not given. Early NCPAP has a reported failure rate of 21%–43%, and possibly higher in extreme preterm infants. The combination of early NCPAP with early (minimally-invasive) surfactant could have the benefits of both and may prevent NCPAP failure, but further results from clinical trials are awaited.

**Post-extubation respiratory support:** Extubation failure is common in newborn infants with a reported range from 30% to

### Proposed mechanism of action of various modes of NIV

| Mode | Mechanism of action | Clinical effect |
|---|---|---|
| NCPAP | Mechanically splinting of the airways | Prevents obstructive apneas |
| | Stabilization of the airways | Improved pulmonary mechanics |
| | | Improved synchrony of thoracic and abdominal motion |
| | Maintaining FRC | Improved gas exchange |
| | | Decreased work of breathing |
| | | Prevention of atelectasis |
| | | Less intrapulmonary shunting |
| | | Conservation of surfactant |
| | | Decreased lung injury |
| BiPAP/NIPPV | Mechanically splinting of the airways | Prevents obstructive apneas |
| | Stabilization of the airways | Improved pulmonary mechanics |
| | | Reduced thoraco-abdominal asynchrony |
| | Maintaining FRC | Improved gas exchange |
| | | Decreased work of breathing |
| | | Prevention of atelectasis |
| | | Less intrapulmonary shunting |
| | | Conservation of surfactant |
| | | Decreased lung injury |
| | Increased mean airway pressure | More recruitment of the lung |
| | | Further improvement of FRC |
| HHHFNC | Conditioning of the respiratory gases | Decreased resistance to gas flow through the nasopharynx |
| | | Decreased lung injury |
| | Improved lung compliance | Decreased work of breathing |
| | | Decreased lung injury |
| | Positive airway pressure | More lung recruitment |
| | | Decreased work of breathing |
| | | Improved oxygenation |
| | Dead-space washout | Reduction of physiological dead space |
| LFNC | Provision of oxygen | Improved oxygenation |

**Table 2**




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