



## Outcome of Non Invasive Ventilation in Children with Acute Respiratory Failure

Authors

**Ajithkrishnan. A.S<sup>1</sup>, Mohamed Thanzeel.T.A<sup>2</sup>**

<sup>1</sup>Paediatric intensivist and Additional Professor of Paediatrics, SATH, GMC, Thiruvananthapuram

<sup>2</sup>Junior Resident, Department of Paediatrics, SATH, Government Medical College, Thiruvananthapuram

### ABSTRACT

**Introduction:** During the last 10 years NIV has been increasingly used in children with acute respiratory distress and failure. Recently some prospective studies have shown that NIV appears to be a safe and effective treatment in children with acute respiratory failure.

**Methods:** During the one year study period, a total of 114 children with acute respiratory failure irrespective of causes, were admitted in PICU and non-invasive ventilation by ventilator CPAP was given as a primary intervention and the outcome was assessed. Need for invasive ventilation as per predefined criteria was taken as failure and children weaned from NIV was taken as success.

**Results:** Majority of the cases were pneumonia (58%) followed by bronchiolitis (14%) and bronchial asthma (12%). Overall success rate for NIV was 72%. The success rate for pneumonia without underlying congenital heart disease was 70%, for bronchiolitis 100% and for bronchial asthma 86%. It was found to be useful for other causes of respiratory failure also. Failure rate for ARDS was high in this study and these children should be frequently monitored for NIV failure.

**Conclusions:** NIV is effective in improving or reversing acute respiratory failure in majority of patients with pneumonia, bronchiolitis, bronchial asthma and submersion injuries. The outcome depends on the severity of the illness at the time of institution of NIV and nature of the disease.

**Keywords:** NIV, ventilator CPAP, children, acute respiratory failure.

### Introduction

Non-invasive ventilation (NIV) refers to the delivery of assisted ventilation without the use of endotracheal tubes or a tracheostomy. NIV is a relatively new ventilatory mode that has been increasingly used in the acute setting over the past 15 years, demonstrating beneficial effects in the adult and paediatric population with different types of respiratory failure<sup>1, 2</sup>. NIV recruits the lung, increasing functional residual capacity, improves respiratory dynamics, reduces

respiratory work, and optimizes gas exchange. Several studies in the adult populations have shown that NIV is a safe and effective therapy for patients with hypercapnic acute respiratory failure (ARF) due to chronic obstructive pulmonary disease (COPD) exacerbation, hypoxemic ARF due to cardiogenic pulmonary oedema or community-acquired pneumonia, and ARF in the immunocompromised patients with pulmonary infiltrates. In these patients, NIV is associated with an improvement in respiratory status,

diminishes the rate of intubation when compared to conventional medical therapy, and the risk of ventilator associated pneumonia and other nosocomial infections<sup>3,4</sup>. The best-documented application of NIV in paediatric patients is in chronic patients in the home setting. NIV has proven to improve or reverse nocturnal hypoventilation in infants and children with various causes of chronic respiratory failure, such as neuromuscular diseases, severe upper airway obstruction and cystic fibrosis. NIV is also a well-established therapy in neonates for early stabilization in very low birth weight newborns, as a primary mode for respiratory distress syndrome treatment, in the management of apnoea of prematurity and for prevention of extubation failures<sup>5</sup>. During the last 10 years NIV has been increasingly used in children with acute respiratory distress and failure. The reported studies on this form of ventilatory support are mainly retrospective, non-controlled clinical trials. Recently some prospective studies have shown that NIV appears to be a safe and effective treatment in children with acute respiratory problems<sup>6,7</sup>.

The primary objective of the present study was to assess the clinical efficacy of NIV in avoiding endotracheal intubation in children with acute respiratory failure and to demonstrate clinical and gasometric improvement in those patients.

### Materials and Methods

The study was done in Sree Avitom Thirunal Hospital, Mother and Child Division of Government Medical College, Thiruvananthapuram, a tertiary care centre in Kerala. The study was done in a period of one year, after getting approval from Institutional Review Board. Children in the age group of 1 month to 12 years with acute respiratory failure irrespective of cause of respiratory failure was taken up for study. NIV was used as a primary ventilatory support in these patients with the objective of clinical improvement and avoidance of endotracheal intubation.

The inclusion criteria were: acute respiratory failure (hypoxemia – transcutaneous oxygen saturation (SpO<sub>2</sub>) < 92% at room air and venous pCO<sub>2</sub> > 50-60 mmHg). Clinical status of the patient and the work of breathing were also important factors when deciding to begin NIV. Patients were selected regardless of the underlying disease process contributing to respiratory failure.

**Exclusion criteria were:** cardio respiratory arrest, hemodynamic instability despite vasoactive treatment, Glasgow coma score <8, need for airway protection or need of immediate intubation to avoid respiratory arrest. Patients with NIV after extubation were not included in this study, although we use it as a method of weaning from mechanical ventilation. Children with exacerbation of chronic respiratory failure, severe upper airway obstruction and apnoea were also excluded.

### Method of selection of patients

Children with respiratory distress were admitted in the ward and severity of distress was assessed. Children with moderate or severe distress were given continuous positive airway pressure using indigenous CPAP machine. SpO<sub>2</sub> was continuously monitored in the ward. Those children who showed SpO<sub>2</sub> less than 92% or any evidence of clinical worsening were shifted to PICU where ABG/VBG was sent depending on the diagnosis of underlying disease. Children with respiratory failure who were not having exclusion criteria were administered NIV as primary intervention.

### Ventilatory support strategies

NIV was delivered by continuous (CPAP) orbi-level (BiPAP) positive airway pressure. In CPAP, a continuous pressure is delivered to the lower airways through the pharynx by different types of airway interfaces, such as nasal prongs, face masks. BiPAP is pressure-targeted type of NIV which gives respiratory support at two levels i.e., the inspiratory positive airway pressure (IPAP) and CPAP or end-expiratory pressures. The interface to the patient was chosen among the

following three (according to patient age, comfort and availability): nasal or mouth-nose mask, binasal short prosthesis. Conventional and specific NIV ventilators were used to apply NIV. CPAP was begun with 4-5 cmH<sub>2</sub>O, and progressively increased the pressure according to the need or tolerance of the patient. BiPaP was begun with an expiratory positive airway pressure (EPAP) of 4-5 cmH<sub>2</sub>O and an inspiratory positive airway pressure (IPAP) of 8-10cmH<sub>2</sub>O. IPAP was then increased by 2 cmH<sub>2</sub>O intervals according to the patient's needs and tolerance. CPAP or BIPAP was chosen depending on: if it was type I or type II acute respiratory failure, ventilators available or patient's tolerance/improvement. The necessary inspiratory fraction of oxygen was used to maintain a SpO<sub>2</sub> above 94%. With the BiPaP Harmony®, supplemental oxygen was administered through the circuit to achieve SpO<sub>2</sub> > 94%. Ventilator parameters were adjusted according to clinic and gasometrical evolution. In every case a minimum respiratory backup frequency was programmed, ranging from 10 to 30 cpm depending on the child's age. NIV was reduced progressively in accordance to the degree of clinical improvement, and was discontinued when the patient had normal RR for age, oxygen requirement < 40%, a lower pCO<sub>2</sub> without ventilatory support, and periods with good clinical tolerance without NIV support. This was a subjective decision, non-based on any specific standardized criteria. Treatment for underlying cause of respiratory distress / failure were done according to the standard hospital protocol. Nutritional support was delivered by oral or via naso or orogastric tube. Sedation was given for selected patients.

Clinical and gasometric monitoring like respiratory rate, heart rate, SpO<sub>2</sub>; ABG/VBG was obtained before and at 2, 4, 6, 12, 24 and 48 h of NIV. To estimate oxygenation pulseoximetric saturation or PaO<sub>2</sub>/FiO<sub>2</sub> were used. Some patients do not have all of the gasometric evaluations in the referred time. NIV success was defined as: i) objective reduction in respiratory effort,

demonstrated by reduction in RR and HR; ii) reduction in oxygen demand; iii) improvement in gasometric parameters (pH, pCO<sub>2</sub>) and subsequently weaned from NIV. NIV failure was defined as the need for endotracheal intubation. Intubation criteria were: absence of improvement, worsening of gasometric parameters or deterioration in the clinical status of the patient. Children in whom invasive ventilation was required were termed NIV failure and children who were weaned from NIV was termed success. The following variables were also collected for each patient: age, sex, weight, personal relevant medical history (prematurity, chronic pulmonary disease, congenital cardiac disease), ARF type and cause, NIV characteristics (type of mask, ventilator, NIV mode and used parameters), use of sedatives, NIV duration, NIV outcome, NIV complications, length of hospital stay. The subjects were followed up until ICU discharge or death, whichever was earlier.

## Results

During the one year study period a total of 134 children with acute respiratory failure were admitted in PICU. Of these 20 children were administered NIV for palliative care in acute exacerbation of chronic respiratory failure due to neuromuscular weakness and hence excluded. The study population consisted of 114 children, majority (50%) were in the age group of 1 to 5 years. The most common primary diagnosis was pneumonia seen in 66 patients (58%), of which 20 children were having underlying congenital heart disease. This was followed by bronchiolitis in 16 (14%) and bronchial asthma in 14 (12%) patients. Other diagnoses were ARDS (5%), pulmonary oedema (5%) and submersion injury (5%). 82 patients were weaned from the ventilator and 32 patients needed invasive mechanical ventilation. Of the 32 children who required invasive ventilation 14 children survived. The overall success rate of NIV was 72% and failure rate was 28%. Indication for invasive ventilation were, increase in FiO<sub>2</sub> requirement in 30%, for

increasing respiratory distress/ desaturation in 70%, for respiratory muscle fatigue in 11 % and for non-compliance for 6%.

The success of NIV in children with pneumonia was 70%, but the success rate of pneumonia with underlying congenital heart disease was only 50%. 8 out of 10 children in this category who required invasive ventilation died. NIV success rate in children with bronchiolitis and submersion injuries was 100% and 86% in bronchial asthma. The success rate in ARDS was 33%. The duration of ventilation was less than in one day in 13%, 1 to 3 days in 38% and more than 3 days in 49%. The details of outcome is shown in table.1. The failure rate was not dependant on duration of NIV. The compliance to NIV was very good. Only one child was intubated because of intolerance. Complications were very less. Only two children developed pressure sores whereas 40 children had mild swelling of the face which disappeared over a period of 24 hours.

**Table.1** Outcome of NIV in acute respiratory failure in children

Diagnosis	Given NIV	Success No %	Failure No %	Death No
Pneumonia	46	32 70%	14 30%	4
Pneumonia with CHD	20	10 50%	10 50%	8
Bronchiolitis	16	16 100%	0 0%	0
Bronchial asthma	14	12 86%	2 14%	2
ARDS	6	2 33%	4 66%	2
Pulmonary oedema	6	4 66%	2 33%	2
Submersion injury	6	6 100%	0 0%	0
Total	114	82	32	

## Discussion

The usefulness of NIV is definitely proven in conditions such as acute exacerbations of chronic obstructive pulmonary disease,<sup>8</sup> acute cardiogenic pulmonary edema<sup>9</sup> and postoperative respiratory failure. The use of NIV in acute respiratory failure has also been described in immunocompromised patients,<sup>10</sup> patients with pneumonia,<sup>11</sup> weaned from or with failed extubation<sup>12</sup> and asthma<sup>55</sup> with varying degrees of success.

However, data in children are comparatively lacking. More and more studies are coming up which have shown that NIV appears to be a safe and effective treatment in children with acute respiratory problems.

The results of this study shows that non-invasive ventilation can be used as a primary intervention in the management of children presenting with acute respiratory failure. Overall success rate of NIV in our study was 72% which is comparable to other studies<sup>14,15,16</sup>. These studies have shown success rates for NIV to be between 57 and 92%. Different success rates are probably related to heterogeneity of the groups regarding age and diagnosis. Our study population was a heterogeneous group which represent most of the tertiary care centres in India. The commonest diagnosis was pneumonia followed by lower airway obstruction (bronchiolitis/ bronchial asthma). The success rate of NIV in pneumonia was 70%, bronchiolitis was 100% and bronchial asthma 86%. The success rate in pneumonia children with underlying congenital heart disease was only 50%, probably because the disease was severe at the time of presentation because children in this group who failed NIV, the death rate was 80%. This observation is similar to Caples SM et al<sup>17</sup> where success in the use of NIV in their population of patients was largely dependent on the cause of respiratory failure as well as on illness severity, as reflected by their Paediatric Risk of Mortality (PRISM) and Paediatric Logistic Organ Dysfunction (PELOD) scores on day 1. NIV was found to be useful for other causes of respiratory distress/ failure like pulmonary oedema and submersion injuries. We have tried NIV in children with ARDS with frequent monitoring. Though there was a success rate of 33%, the number of patients were very small to make any comment.

## Conclusion

NIV can be used in the initial management of acute respiratory failure in children. Overall success rate of NIV in this study was 72%. NIV is effective in improving or reversing acute respiratory failure in majority of patients, and can decrease the need for endotracheal intubation. NIV can be used in the primary management of ARF due to pneumonia, bronchiolitis, bronchial

asthma and submersion injuries. The outcome depends on the severity of the illness at the time of institution of NIV and nature of the disease. Failure rates are high in ARDS and hence children should be frequently monitored for the possibility of NIV failure and need for invasive ventilation. Clinical and gasometric monitoring helps in the recognition of NIV failure.

## REFERENCES

1. Teague WG. Non-invasive positive pressure ventilation: current status in paediatric patients. *PediatrResp Rev* 2005;6:52-60.
2. Rimmensberger PC. Noninvasive pressure support ventilation for acute respiratory failure in children. *Schweiz Med Wochenschr* 2000;130:1880-6
3. Antonelli M, Conti G, Esquinas A, et al. A multi-center survey on the use in the clinical practice of NIV as first intervention for acute respiratory distress syndrome. *Crit Care Med* 2007;35:18-25.
4. Antonelli M, Conti G, Moro MI, et al. Predictors of failure of noninvasive positive pressure ventilation in patients with acute hypoxemic respiratory failure: a multi-center study. *Intensive Care Med* 2001;27:1718-2
5. Ramanathan R, Sardesai S. Lung protective ventilatory strategies in very low birth weight infants. *J Perinatol* 2008;28:S41-6.
6. Soto R, Maquilon C, Saldias F. Ventilación no invasiva en pacientes con daño pulmonar agudo. *Rev ChilEnfRespir* 2008;24:215-8.
7. Essouri S, Chevret L, Durand P, et al. Noninvasive positive pressure ventilation: five years experience in a pediatric intensive care unit. *PediatrCrit Care Med* 2006;7:329-34.
8. Bott J, Carroll MP, Conway JH, Keilty SE, Ward EM, Brown AM, et al. Randomized controlled trial of nasal ventilation in acute ventilatory failure due to chronic obstructive airways disease. *Lancet*. 1993;341:1555-7.
9. Rasanen J, Heikkila J, Downs J, Nikki P, Vaisanen I, Vitanen A. Continuous positive airway pressure by face mask in acute cardiogenic pulmonary edema. *Am J Cardiol*. 1985;55:296-300.
10. Hilbert G, Gruson D, Vargas F, Valentino R, Gbikpi-Bennisan G, Dupon M, et al. Noninvasive ventilation in immunosuppressed patients with pulmonary infiltrates, fever, and acute respiratory failure. *N Engl J Med*. 2001;344:481-7.
11. Confalonieri M, Pontena A, Carbone G, Porta RD, Tolley EA, Umberto Meduri G. Acute respiratory failure in patients with severe community acquired pneumonia: a prospective randomized evaluation of noninvasive ventilation. *Am J RespirCrit Care Med*. 1999;160:1585-91.
12. Kilger E, Briegel J, Haller M, Frey L, Schelling G, Stoll C, et al. Effects of noninvasive positive pressure ventilatory support in non COPD patients with acute respiratory insufficiency after early extubation. *Intensive Care Med*. 1999;25:1374-80.
13. Soroksky A, Stav D, Shpirer I. A pilot prospective, randomized, placebo-controlled trial of bilevel positive airway pressure in acute asthmatic attack. *Chest*. 2003;123:1018-25.
14. Mayordomo-Colunga J, Medina A, Rey C, et al. Predictive factors of non invasive ventilation failure in critically ill children: a prospective epidemiological study. *Intensive Care Med* 2009;35:527-36.
15. Larrar S, Essouri S, Durand P, et al. [Effects of nasal continuous positive airway pressure ventilation in infants with severe acute bronchiolitis]. *Arch Pediatr*. 2006;13:1397-03. [Article in French]
16. Thill PJ, McGuire JK, Baden HP, et al. Noninvasive positive pressure ventilation

in children with lower airway obstruction.

PediatrCrit Care Med 2004;5:337-42.

17. Caples SM, Gay PC. Noninvasive positive pressure ventilation in the intensive care unit: a concise review. Crit Care Med. 2005;33:2651-8.