ORIGINAL ARTICLE

Non-Invasive Ventilation in a Paediatric Intensive Care Unit (PICU) with Respiratory Failure: Experience at a Tertiary Care Hospital in Dhaka

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Abstract:

Noninvasive ventilation (NIV) has now become an integral tool within the treatment of both acute and chronic respiratory failure, and at an equivalent time reducing the necessity for invasive ventilation. A cross sectional, retrospective study based on a retrospective review of hospital medical records of patients who underwent NIV in the period between January 2017 and December 2019, to determinate the efficacy of NIV in pediatrics whom admitted to Pediatric intensive care unit (PICU) with respiratory failure (short term evaluation), demographic and clinical data were collected before and after applying the NIV. The data included heart rate (HR), respiratory rate (RR), oxygen concentration (PO2) and CO2 concentration (PCO2). NIV was used for a total of 61 pediatric patients admitted to PICU during the period of the study. Pneumonia was the commonest indication for the NIV (n=25, 41.0%), and continuous positive airway pressure (CPAP) was used in 52(85.2%) patients. The mean duration of NIV was 8±7.2 days, there was a significant clinical improvement after one hour from application of NIV. The mean improvement in RR was from 48.4±2.2 to 35.0±1.5 (P=0.000), SPO2 was improved from 88.1±1.8 to 96.5±0.7 (P= 0.000), and the PCO2 was improved from 61.4±6.1 to 48.7±3.7 (P=0.002). Five patients were failing to respond to the NIV and shifted to mechanical ventilation. The NIV is a useful tool for treatment of respiratory failure in pediatrics, especially under the age of one year. Pneumonia was the commonest indication for the use of the NIV. More investigation is needed to fully evaluate the ramifications of increased use of this technology in the PICU.

Introduction:

The use of noninvasive ventilation (NIV) has become increasingly popular in the pediatric intensive care unit (PICU) over the last decade. Breathing difficulties are common symptoms in pediatrics and one of the common reasons for visiting the emergency department,[1] invasive mechanical ventilation is still widely used in PICU for treatment of respiratory failure but with high risk sequel. The NIV has become a standard treatment of acute and chronic respiratory failure in children.[2] The advantages of NIV are widely reported in scientific literature. It is much safer than invasive mechanical ventilation. Compared to invasive ventilation, NIV lowers the risk of laryngeal swelling, post extubation vocal cord dysfunction, barotrauma/volutrauma, ventilator-associated pneumonia. One can communicate with the patient and does not require deep sedation.[3-6]

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The frequency of acute respiratory failure is higher in children than adults and often precedes cardiopulmonary arrest.

However, in adults primary cardiac disease is often responsible. Recent studies endorse the use of this therapy in the pediatric intensive care setting. NIV appears to be associated with a decrease in the intubation rate in children. Children who are responsive to NIV will usually show improvement in their physiologic parameters shortly after the initiation of this therapy and this improvement is often sustained. NIV is proving to be a well-tolerated alternative to endotracheal intubation, in particular in those patients with primary respiratory failure, postsurgical patients or with post-extubation respiratory distress. Most studies represent single-center experience and therefore caution must be exerted when attempting to generalize their results. Therefore, prompt recognition and treatment of pediatric patients with pending respiratory failure is lifesaving.[7,8]

Respiratory failure is a syndrome in which the respiratory system fails in one or both of its gas exchange functions: oxygenation and carbon dioxide elimination. Patients with respiratory failure can be classified into two groups, depending on the component of the respiratory system that is involved: hypoxemic respiratory failure and hypercapnic respiratory failure.[9-11]

The aim of our study was to determinate the efficacy of NIV in pediatrics admitted to PICU with respiratory failure (PCO2 >50mmHg or oxygen saturation <90%) over a 3 year period requiring respiratory support in form of NIV, and assess the possible correlative factors with response to NIV.

Materials and method:

This retrospective observational study allowed the accumulation of sufficient number of patients from reviewed hospital patients' records of the PICU at Dhaka Shishu (Children) Hospital, Dhaka, Bangladesh from January 2017 to December 2019 to select patient who required NIV. During their course of admission they assess initially and after one hour from initiation. In our PICU registry 416 patients were admitted from January 2017 and December 2019. Assisted ventilation was used for 177 (42.5%) patients, among them 61 patients (14.7%) required NIV for respiratory support. The extracted data included demographic characteristics of the patients, type of respiratory failure, clinical diagnosis and the indication of NIV. The decision of instituting the NIV was made by a PICU physician. NIV was considered as a treatment when the patient presented with acute hypercapnia (PCO2>50 mmHg) or hypoxemia (oxygen Saturation <90%) or both. The uses of CPAP versus BIPAP depend on age and weight. CPAP use for small patients less than 8 kg during the first year of life (mostly neonates).

Exclusion criteria were Glasgow Coma Scale (GCS) of less than 8 or altered mental status in previously normal patients and cardio circulatory instability. Patients were divided in to 2 main groups according to primary diagnoses: 1) respiratory causes; bronchialasthma, bacterial/viral pneumonia aspiration pneumonia, acute bronchiolitis and recurrent apneas, and 2) non respiratory causes; hematological/oncological (acute chest syndrome, and leukemia with septic shock), neurological (neuromuscular disease), post-operative extubation.

The collected data included demographic variables like age and sex, primary and secondary clinical diagnoses.

The type and duration of NIV required during that illness. The progress included need for intubation. Patients' clinical response was assessed by respiratory rate, oxygen saturation, heart rate and blood gas analysis (PO2 & PCO2). We collected data from clinical records before and after one hour from initiation of NIV (short-term effects).The criteria for failure of NIV were determined by persistence of severe respiratory distress without improvement in oxygenation (O2 saturation <90%), pH <7.2, PaCO2>50 or continuum of apnoeic episodes after one hour of initiation of NIV.

Statistical Analysis:

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS version 21.0), which was used for data entry and analysis. P value was used to test the significance of the results at the 5% level.

Results:

A total of 177 patients received assisted ventilation during January 2017 to December 2019 at the PICU, among them 61 (34.5%) patients were ventilated using NIV. The mean age was 46.6±(27.6) months, males to female ratio 1:1.26. Median weight was 3kg.According to the types of NIV, 52 patients (85.2%) were ventilated using CPAP and 9 patients (14.8%) were ventilated using a biphasic positive airway pressure (BIPAP). More than two-thirds of the cases (n=42, 68.9%) required NIV for 1-5 days. The mean duration of NIV for the 61 patients was 8±7.2 days.(Table 1)The clinical diagnosis as in Table 2 showed respiratory diseases were the most frequent indication for NIV (n=44, 72.1%). Among them pneumonia was the commonest indication for NIV (n=25, 41.0%).

Table I: Demographic and clinical characteristics of patients who required NIV (N=61)

Characteristics		Frequency (n=61)	Percentage
Sex	Boys	34	55.7
	Girls	27	44.3
Age	<12 months	32	52.5
	12 months - <5 years	20	32.8
	≥5 years	09	14.8
Types of NIV: CPAP		52	85.2
BIPAP		09	14.8
Duration of NIV: <1 day		14	22.9
1–5 days		42	68.9
> 5 days		05	08.2
Outcome : Successful wean NIV:		56	91.8
Failed NIV*		05	08.2

*Failed NIV shifted to mechanical ventilation. Three were improved and successfully extubated, while two expired.

Table II: Clinical diagnosis of patients who required NIV (N=61)

Characteristics	No (n=61)	Percentage
Respiratory diagnoses		
Pneumonia	25	41.0
Bronchopneumonia	6	9.8
Bronchiolitis	6	9.8
Aspiration pneumonia	4	6.6
Recurrent apnea	2	3.3
Asthma	1	1.6
Non respiratory diagnoses		
Hematology*	6	9.8
Immunology	2	3.3
Neurology**	8	13.1
Postoperative	1	1.6

* Sickle cell disease & leukemia, **myopathy & GBS

Table III: Physiological parameters that were used as criteria to monitor response before and after one hour of start NIV (N=61)

Characteristics	Before NIV	After NIV	Percentage of difference	P value
Heart rate	141.9±3.7	132.6±3.4	–9.2±2.9	0.002
Respiratory rate	48.4±2.2	35.0±1.5	–13.3±1.9	0.000
O_2 concentration	88.1±1.8	96.5±0.7	8.3±1.7	0.000
CO_2 concentration	61.4±6.1	48.7±3.7	–12.6±3.7	0.002

Table 3 reveals the physiological parameters that were used as criteria to monitor response before and after one hour from the start of NIV. The majority of patients showed significant improvement after one hour from application of NIV. The mean respiratory rate decreased from 48.4±2.2 to 35.0±1.5 (P=0.000), Oxygen concentration improved from 88.1±1.8 to 96.5±0.7 (P=0.000), and the CO2 concentration improved from 61.4±6.1 to 48.7±3.7 (P = 0.002).Patients were monitored closely for signs of NIV failure and promptly intubated. Five patients were failed to respond to NIV after the initial one hour of monitoring, and were shifted to mechanical ventilation. Three had pneumonia with respiratory failure were improved and successfully extubated, while two were expired, first one has prematurity and recurrent apnea and the other one had immunodeficiency with pneumonia. They died due to progress of their primary disease and no delay concerning respiratory support.

Discussion:

The current study showed our experience in NIV in Dhaka Shishu (Children) Hospital, Dhaka, Bangladesh over 3 years in PICU from January 2017 to December 2019 in Bangladesh. Acute respiratory insufficiency/distress in pediatric patients admitted to PICU can improve with NIV. The clinical evidence of the response was determined by improvement in physiological parameters (RR and HR) as well as biochemical indices in the blood gases (PO2 and PCO2). In our study pneumonia was the major cause (41.0%) for the NIV among the primary respiratory diseases, and bronchiolitis 9.8%. In one study the main primary respiratory diseases were bronchiolitis in 102 (67.5%), and pneumonia in 44 (29%) patients, here bronchiolitis was much higher than pneumonia.[12]

Compared with non-respiratory diseases, our results were comparable to the percentages in the study which was done by Clara Abadesso et al.[13]

13 From the first hours of use of the NIV, the improvement was evident, and statistically significant, the mean difference in the respiratory rate was -13.3±1.9 breaths per minute (P=0.000), in PaO2was 8.3±1.7 mmHg (P =0.000) and in PaCO2 was 12.6±3 mmHg (P =0.002).This result was similar to the study done by Yañez LJ et al. which found that heart rate and respiratory rate were significantly lower after 1 hour of treatment using NIV compared with admission (p=0.0009 and p=0.004, respectively).[14]

Our study showed early improvements in the HR and PCO2 in comparison with a study done by Muñoz-Bonet JI et al. in the predictive factors for the outcome of NIV in pediatric acute respiratory failure.[15]

15 In this study, independent risk factors for NIV failure were apnea, pneumonia and septic shock. These factors were also identified in previous studies done by Clara Abadesso et al.[13]

13 Essouri S et al. showed that NIV decreased inspiratory muscle effort in children with acute moderate hypercapnic insufficiency, measured by esophageal and diaphragmatic pressure time product.[16]

Another study was done by Essouri S et al. and concluded that NPPV was able to improve clinical outcome in young patients admitted to the PICU for acute moderate hypercapnic respiratory insufficiency.[17]

The use of positive end expiratory pressure (PEEP) enhances the patients´ functional residual capacity allowing better gas exchange. Other studies have identified different predictive factors of NIV failure:

ventilation–perfusion impairment, higher Pediatric Risk of Mortality score (PRISM), lower respiratory rate decrease,[18]
presence of ARDS, higher Pediatric Logistic Organ Dysfunction score,19 and FiO2> 80%20. The majority of patients showed significant improvement after one hour from application of NIV. The mean respiratory rate decreased from 48.4±2.2 to 35.0±1.5 (P=0.000), O2 concentration improved from 88.1±1.8 to 96.5±0.7 (P=0.000), and the CO2 concentration improved from 61.4±6.1 to 48.7±3.7 (P=0.002). Patients were monitored closely for signs of NIV failure and promptly intubated. Five patients were failed to respond to NIV after the initial one hour of monitoring, and were shifted to mechanical ventilation. The diversity of predictors results from different study populations and from different factors chosen for evaluation. Although the number of patients was relatively low, we could report convincing efficacy of NIV in this pediatric patient population. Although there are numerous studies determining the factors predicting failure of NIPPV in acute respiratory failure and due to other causes, there is none from the Bangladeshi subcontinent and this study provides the Bangladeshi perspective on this issue. The strength of this study is the prospective nature of the study and the fact that robust statistical methods have been used for analysis of the data so that the results can be interpreted with confidence.

Limitations of this Study

In this study, we chose one hour time as crucial point to decide whether to continue on NIV or to escalate to invasive ventilation. This needed an extended study with further point's time.

Conclusion:

The NIV is a useful tool for treatment of respiratory failure in pediatrics, especially under the age of one year. Pneumonia was the commonest indication for the use of the NIV. NIV appears to be a well-tolerated alternative to invasive ventilation for use in the pediatric population. Its use is associated with decreased intubation rates, which may lead to a decrease in the intubation-related complications. More investigation is needed to fully evaluate the ramifications of increased use of this technology in the PICU.

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