



Non-Invasive Ventilation in a Pediatric Intensive Care Unit: An Experience of Tertiary Care Hospital Over 4 Years in Oman

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Authors' contributions

This work was carried out in collaboration between all authors. Author AAAA designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors AMAA and NRD were managed the literature searches. Author AAS was analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Background: Noninvasive ventilation (NIV) has now become an integral tool in the treatment of both acute and chronic respiratory failure, and at the same time reducing the need for invasive ventilation.

Aim: To determinate the efficacy of NIV in pediatrics whom admitted to Pediatric intensive care unit (PICU) with respiratory failure (Short term evaluation).

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Subjects and Methods: Based on a retrospective review of electronic medical records (EPR) of patients who underwent NIV in the period between January 2007 and December 2010, 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).

Results: 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, 40.9%), 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.

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.

Keywords: Respiratory failure; noninvasive ventilation; PICU; pediatric patients.

1. INTRODUCTION

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].

The frequency of acute respiratory failure is higher in pediatric than adults and often precedes cardiopulmonary arrest. However, in adults primary cardiac disease is often responsible. Therefore, prompt recognition and treatment of pediatric patients with pending respiratory failure is life saving [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 4 year period

requiring respiratory support in form of NIV, and assess the possible correlative factors with response to NIV.

2. MATERIALS AND METHODS

This retrospective observational study allowed the accumulation of sufficient number of patients from reviewed electronic patients records (EPR) of the PICU at Sultan Qaboos University Hospital (SQUH) from January 2007 to December 2010 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 2007 and December 2010. 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 into 2 main groups according to primary diagnoses:

1. Respiratory causes; included bronchial asthma, bacterial/viral pneumonia aspiration pneumonia, acute bronchiolitis and recurrent apneas.
2. Non respiratory causes; included 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. Patient's clinical response was assessed by respiratory rate, oxygen saturation, heart rate and blood gas analysis (PO_2 & PCO_2). We collected data from EPR 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 (O_2 saturation <90%), pH <7.2, $PaCO_2$ >50 or continuum of apnoeic episodes after one hour of initiation of NIV.

2.1 Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS version 19), which was used for data entry and analysis. P value was used to test the significance of the results at the 5% level.

2.2 Ethical Approval

Ethical approval for the study was waver by ethical approval of research involving humans, Sultan Qaboos University, Sultanate of Oman as the study was retrospective.

3. RESULTS

A total of 61 patient were admitted to the PICU and ventilated using NIV between January 2007 to December 2010 with mean age of $46.6 \pm (27.6)$ 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 (14.7%) were ventilated using a biphasic

positive airway pressure (BIPAP). More than two third 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 (see Table 1).

The clinical diagnosis as in Table 2 showed respiratory diseases were the most frequent indication for NIV ($n = 44$, 72.13%). Among them pneumonia was the commonest indication for NIV ($n=25$, 40.9%).

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 ($P=0.000$), O_2 concentration improved from 88.1 ± 1.8 to 96.5 ± 0.7 ($P=0.000$), and the CO_2 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.

4. DISCUSSION

The current study showed our experience in NIV in SQUH tertiary care hospital over 4 years in PICU from January 2007 to December 2010 in Oman.

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 (PO_2 and PCO_2).

Pneumonia was the major cause for the NIV among the primary respiratory diseases 40.9%, and bronchiolitis 9.8%. Compared with non respiratory diseases, our results were comparable to the percentages in the study which was done by Clara Abadeso et al. [12] in which Main diagnoses were bronchiolitis in 102 (67.5%), and pneumonia in 44 (29%) patients [13].

Table 1. Demographic and clinical characteristics of pediatrics whom required NIV

Characteristics	No (n=61)	Percentage (100.0)
Sex : Boys	34	55.73
Girls	27	44.26
Age : < 12 months	32	52.5
12 months - < 5 years	20	32.8
≥ 5 years	09	14.7
Types of NIV: CPAP	52	85.2
BIPAP	09	14.7
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 were expired

Table 2. The clinical diagnosis of pediatrics whom admitted to PICU and required NIV

Characteristics	No (n=61)	Percentage (100.0)
Respiratory diagnoses		
- Pneumonia	25	40.9
- Bronchopneumonia	6	9.8
- Bronchiolitis	6	9.8
- Aspiration pneumonia	4	6.5
- Recurrent apnea	2	3.2
- Asthma	1	1.6
Non respiratory diagnoses		
- Hematology†	6	9.8
- Immunology	2	3.2
- Neurology††	8	13.1
- Postoperative	1	1.6

†eg: SCD & leukemia

††eg: myopathy & GBS

Table 3. The physiological parameters that were used as criteria to monitor response before and after one hour of start NIV

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

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 PaO₂ was 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. [14] 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) [15].

Our study showed early improvements in the HR and PCO₂ in comparison with a study done by Muñoz-Bonet JI et al. [15] in the Predictive factors for the outcome of NIV in pediatric acute respiratory [12].

Another study was done by Essouri S et al. [13] and concluded that NPPV was able to improve clinical outcome in young patients admitted to the

PICU for acute moderate hypercapnic respiratory insufficiency [16,14].

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. [12].

Limitation 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 points time.

5. 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.

CONSENT

As this is a retrospective study of data that already exist in Electronic Patients Records, and the patients consent were not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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