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Non-Invasive Ventilation (NIV) in Infants and Children: Observational Study

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ABSTRACT

To assess use of noninvasive ventilation in infants and children requiring respiratory support in Pediatric Intensive care unit. Children between age group 1 month to 16 years with respiratory distress who were treated with NIV support were included. This was prospective observational study was conducted in pediatric Intensive care unit (PICU) at Ch. Sambhajinagar. NIV success and NIV failure criteria were defined. NIV used was in form of CPAP (bubble or ventilator) and NIPPV with ventilator (oronasal mask or Rams cannula as interface) with NIV mode. HFNC use was not included in study. Patients were monitored by respiratory rate, work of breathing, FiO2 need and blood gas analysis. Predictors of NIV failure recorded. Total 44 children were included in study of which 33(75%) improved with NIV while 11(25%) failed to respond and treated with invasive ventilation. Most common indication was acute severe bronchiolitis followed by pneumonia. Thirteen patients had primary disease other than respiratory but had respiratory distress. Most common illness with such scenario was dengue hemorrhagic fever with capillary leak. In patients with persistence tachypnea, no decrease in work of breathing, no decrease in FiO2 need and severe ARDS and shock NIV failure was observed. Pressure injury was most commonly observed complications (22.7%). NIV is effective form of respiratory support in children with respiratory distress. Careful selection of cases, proper interface, trained and supportive nursing staff with close clinical monitoring to pick up failure of response earlier are crucial for success of NIV. No clinical improvement, no decrease in FiO2 need and severe ARDS were associated with NIV failure.

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Key Words
ARDS, NIV, PICU, PaO2/FiO2 ratio

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INTRODUCTION

Breathing difficulties are common symptoms in pediatric age group and one of the common reasons for visiting emergency department. Acute or impending respiratory failure remains the leading diagnosis for admission to pediatric intensive care unit (PICU)[1]. Traditionally, until recently endotracheal intubation and mechanical ventilation has remained mainstay of treatment for such children. Invasive ventilation is associated with complications like upper airway trauma, ventilator associated pneumonia (VAP) and need of sedation so increasing cost of treatment. Noninvasive ventilation (NIV) is delivery of respiratory support without use of invasive artificial airway like endotracheal tube. NIV is done through use of interface with aim of adequate ventilation, improving gas exchange and decreasing respiratory muscle fatigue and work of breathing[2]. NIV has advantage in avoiding complications associated with invasive ventilation like VAP, need of sedation and upper airway trauma[3]. Use of NIV in adults is well established and recommended. In developed nations NIV use for children has increased recently[4]. There are many controlled trials for adults in developing countries but there is paucity of literature in children with exception of CPAP in newborns[5]. In Pediatric age group it is important to conduct new studies about NIV use due to lack of specific guidelines and heterogenicity of diseases found in PICU. Present observational prospective study is carried out to assess NIV use in pediatric age group in terms of indication, outcome and factors associated with failure of NIV.

MATERIALS AND METHODS

This prospective observational study was carried out at PICU of tertiary care center Ch. Sambhajinagar, Maharashtra. Those children between age >one month and till 16 years having respiratory distress on NIV in PICU were included in study.

Inclusion Criteria:

- Patients with increased work of breathing, tachypnea, tachycardia and chest signs.
- Spo2 less than 90% on nasal O2(Low flow system).
- PaO2<60 or PaCO2 >50 .

Exclusion Criteria:

- Altered sensorium with GCS<8.
- Hypotensive Shock.
- Children with facial injury and abdominal surgeries.
- Inability to maintain airway.
- Age <one month.
- Cardiac or respiratory arrest.

Demographic details, provisional diagnosis, vitals, SPO2, ABG parameters , past significant history, type of NIV used, NIV duration, complications and outcome was recorded. Patients were divided in 2 groups according to primary diagnosis.

- **Primarily Respiratory Disease:** Bronchiolitis, pneumonia, asthma exacerbations, ARDS.
- **Secondary Respiratory Involvement:** Dengue hemorrhagic and rickettsial fever with respiratory distress and neuromuscular disorders.

Following Types of NIV Used:

- **CPAP:** CPAP with nasal mask as interface (make-Medin) was used as our unit staff was used to it. We could use it till 10 months or up to 8 kg as properly fitting mask was available only to these sized babies. CPAP was started with 5 then gradually increased to 8 and FiO2 initially >60% then gradually tapered depending up on response. CPAP was delivered by bubble CPAP machine (Medin)or by Ventilator (Macquet-servo i).
- **NIPPV with Oronasal Mask:** Proper fitting oronasal mask was selected with its upper end at nasal bridge and lower part covering chin. Ventilator with dedicated NIV mode were used to have good leak compensation (Macquet servo I and Newport 360). For first few minutes to make child comfortable and to get acceptance, mask was hold with hands without strapping then afterwards properly fixed to allow only minimal leak. Initial ventilator settings-PIP above PEEP around 10-12, PEEP 5-7 and FiO2 >60%. Then depending upon response settings changed.
- **NIPPV with Rams Cannula:** Those children afraid and noncooperative for oronasal mask proper sized Rams cannula (make-Neotech) was used which looks like simple nasal cannula. Acceptance was excellent for it as patient were able to communicate and take orally as they improved with no claustrophobic feeling. Same ventilators with NIV modes and initial setting were used.

For all three types of NIV used infant feeding tube/Ryles tube was put to have enteral feeding and to take care of gastric distension. High flow nasal cannula (HFNC) was not used as NIV device in current study as it is an open system and pressure delivered is variable and not easily measurable which depends upon leakage around nasal prongs[6].

- **Monitoring:** Heart rate, RR, work of breathing, SPO2, level of sensorium, ABG parameters were recorded on admission. Patients were closely monitored after starting NIV. After one hour all parameters were recorded and NIV continued only if there is improvement.
- **NIV Failure:** Deterioration in clinical condition, no decrease in HR, RR, work of breathing or O2 requirement >60%, hypotensive shock or and deteriorations in sensorium. Nonacceptance of interface with agitation is also labeled as NIV failure. NIV failed patients were intubated and ventilated.

NIV Success: Was Defined as:

- HR, RR settling with in 1-2 hours.
- Decrease in work of breathing.
- FiO2 requirement <50% with SpO2 >93%.
- Along with patients comfort and acceptance with interface.

RESULTS AND DISCUSSIONS

Total 44 patients fulfilling inclusion criteria were included in study. Out of it 31 patients had primarily respiratory condition and 13 had other primary diseases. Most common respiratory condition needing NIV was acute severe bronchiolitis (15 cases) followed by pneumonia (13 cases) Three cases were previously diagnosed as bronchial asthma presented as acute severe asthma. Ten patients were having dengue hemorrhagic fever with respiratory distress and 3 patients having rickettsial fever with respiratory distress. Twenty eight patients were less than one year of age and 16 patients were more than one year age. Twenty-six patients were male and 18 were females. One infant had neuromuscular disorder with pneumonia. One child with congenital agammaglobulinemia and one child on chemotherapy for AML with pneumonia improved with NIPPV with oronasal mask. Thirty-three cases (75%) shown improvement with NIV and recovered completely. Eleven (25%) patients had NIV failure so has to be intubated and given invasive ventilation. Most common factors associated with NIV failure was progressive pneumonia with deteriorating Xray and PaO2/FiO2 ratio not improving or deteriorating with NIV use. Other causes were shock and altered sensorium with inability to maintain airway during course of treatment. Most of the patients with acute lung injury (PaO2/FiO2 ratio <300) recovered with NIV while those with severe ARDS (PaO2/FiO2 ratio less than 100) did not respond to NIV and needed invasive ventilation. Most common complication observed was pressure sore in 10 cases (22.7%). It was picked in stage 1 or 2 so complete healing was seen in all cases. Gastric distension was observed in 5 cases (11%) which was easily relieved by keeping Ryles tube open and hanged above head level.

Fig. 1: Properly Fitting Oronasal Mask for NIPPV

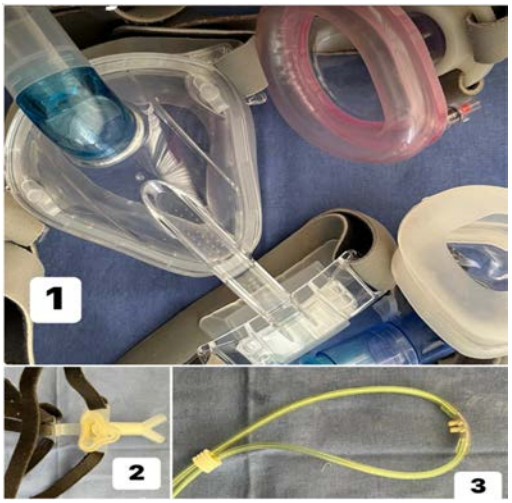

Fig. 2: Interface Used

- Different Size Oronasal Mask for NIPPV
- Nasal Mask for CPAP
- Rams Cannula for NIPPV

Though PICU care is well developed in high income countries, it remains in its early stages in low-and middle-income countries due to lack of well-equipped PICUs, trained staff and easy and free availability of supplies. In resource limited situations as in developing countries NIV offers the advantage as overall cost of treatment is less. Also NIV avoids complications of invasive ventilation like upper airway trauma, nosocomial infections and VAP[7]. Use of NIV in children has been increasing significantly worldwide[8]. A study by Ganu *et al.* evaluated the impact of intubation rates over the last decade related to the increasing use of NIV in infants with severe bronchiolitis. Over ten-year period use of NIV rose by 2.8% per year and invasive ventilation fell by 1.4% per year[5]. But there is paucity of literature regarding use of NIV in children from developing countries. In present study NIV use was successful in 75% of cases and only 25% needed invasive ventilation. Similar results were observed by previous studies[9]. In our study most of the children with acute lung injury (Pao2/FiO2 ratio <300) recovered with NIV while those with severe ARDS failed to improve with NIV and needed invasive ventilation. Similar observations were noted by Essouri[10]. In 2015, the Pediatric acute lung injury consensus conference group published recommendations on pediatric ARDS[11]. It said NIV should be delivered in unit with trained staff that offers close monitoring and should be used in early in the disease process improve gas exchange and work of breathing. Continues and systematic bedside clinical monitoring with help of blood gases analysis helped to label someone as having NIV failure and proceed to provide higher support (invasive ventilation with sedation) timely. NIV failure was apparent with in first 6 hours of starting so we should not wait too long as

delay will lead to crash intubation associated with higher mortality[12]. Acceptance and adherence of interface was one of the most important aspects in success of NIV. Taking parent and child into confidence, well trained supportive nursing staff were observed to be key in success of NIV. Poor adherence of interface could contribute to poor outcomes related to respiratory insufficiency and may need invasive support. Interface adherence may be enhanced by desensitization efforts, role playing with creative thinking by the physicians[13]. Two immuno compromised patients with pneumonia improved with NIV. Immunodeficient patients are at a greater risk of complications from invasive ventilation and may benefit from early intervention with NIV. As per Pancera CF *et al*. NIV can be used as first line treatment in children with malignancies who developed acute respiratory failure except those with severe hemodynamic compromise[14]. Given the evidence from SCARF study, NIPPV remained as a reserved ventilation method for more distressed population with malignancy or immune deficiency who possess greater risks for endotracheal intubation[15]. In present study, most common complication observed was pressure injury (22.7%). The bridge of the nose was the most involved area of pressure injury. Assessment of the presence of pressure injury and its severity was evaluated by using the National pressure ulcer advisory panel guidelines[16]. NIV interface was removed, the skin was assessed every 4 hours by trained staff. All patients with pressure injury had stage 1 or 2 injury so recovered fully. Pressure ulcerations have been reported in 4-27% patients[17]. High mask leak was significantly associated with developing pressure injury. High humidity has been linked with development of pressure injury as observed by Visscher[18]. Pressure injuries can be minimized by careful repeated observation and having units' protocol for its prevention. We found decrease in tachycardia and tachypnea with in first hour of NIV use and these patients recovered with NIV. This result was similar to the study done by Yanez[19] which showed that heart rate and respiratory rate were significantly lower after one hour of treatment with NIV compared with admission. We could successfully treat 3 children with acute severe asthma with NIV, invasive ventilation becomes very challenging in such children. Early initiation of NIV along with short acting beta 2 agonists and systemic steroids can be safe, well tolerated and effective in children with status asthmaticus[20]. In present study, we observed NIV failure in 25% cases. Most common predictors of failure were no reduction in respiratory rate, work of breathing in first 1-2 hours of use, FiO2 requirement of >60% after 6 hours of use, severe ARDS and MODS .Patients with metabolic acidosis of pH <7.35 had higher NIV failure rate compared to patients with normal pH value[21]. A multi centered study on efficiency of NIV, a <10% decline in respiration with in an hour, FiO2 need >55% at 6 th hour and PRISM-3 score >8 were three independent risk factors related to NIV failure[22].

CONCLUSION

NIV is an effective form of respiratory support in PICU with advantage of avoiding complications of invasive ventilation. Careful selection of cases and interface, trained and supportive staff, close clinical monitoring to timely detect failure are critical for success of NIV.

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