Original article:

Eminence of non invasive ventilation in a mixed ICU setup

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Abstract

Objective: Non Invasive Ventilation is a type of ventilatory support, used for treating acute respiratory failure(ARF). The efficacy of NIV depends on several factors like the experience of medical personnel, adequate selection of patient and inter-face and appropriate ventilator settings. NIV has an established role in treatment of chronic obstructive pulmonary disease (COPD). However in Indian scenario efficacy of NIV in other etiologies causing ARF is incompletely understood due to paucity of data. Our objective is to analyse NIV utilisation factors, success rate & outcome in patients of ARF due to pulmonary and non pulmonary causes, including the type of respiratory failure associated with them.

Method: A retrospective single centre study (D.Y.Patil Hospital & Research centre, India). All patients admitted consecutively in the Intensive Care Unit (ICU) over a period of 4 months having ARF and receiving NIV were included in the study. Indications for application were based on clinical radiological assessment and arterial blood gas analysis before NIV application.

Result: 60 patients received NIV support during the study - 61.66% in Type 1 and 35% in Type 2 ARF and 3.33% patients without ARF. Most common etiology for Type 1 and type 2 ARF was cardiogenic pulmonary edema (CPE) and COPD respectively. The success rates of NIV applications were 75% with COPD and 74% with CPE, 50% with pneumonia and 16.66% with ARDS. NIV failure occurred in 31.66% patients.

Conclusion: NIV application can be an alternative modality of ventilator support particularly in type 1 ARF due to CPE and both type 1 and 2 ARF in COPD patients. Mild ARDS can be given NIV trial if hemodynamically stable. NIV applicability in other etiologies can be propitious.

Keywords: Acute Respiratory failure, COPD, Invasive Ventilation, ARDS

Introduction:

Respiratory failure is one of the most common reasons for which patients are admitted to the ICU. It can be categorized based on pathophysiologic derangements in respiratory function[1].Type I or Hypoxemic respiratory failure is characterized by oxygen arterial pressure (PaO_2) less than 60 mmHg with normal or lower carbon dioxide arterial pressure ($PaCO_2$)[2]. Type1 ARF can occur due to alveolar collapse or alveolar flooding which may be a consequence of pulmonary edema, pneumonia, or alveolar haemorrhage. Pulmonary edema can be further categorized as occurring because of elevated intravascular pressures seen in heart failure and intravascular volume overload or because of low pressure edema as seen in ARDS[1]. Type II or Hypercapnic failure is characterized by PaCO2 higher than 50 mmHg, accompanied with hypoxemia [2]. Type 2 ARF can occur due to increased load on the respiratory system which can be caused by increased resistive loads (e.g., bronchospasm), by reduced lung compliance [e.g., alveolar edema, atelectasis, intrinsic positive end-expiratory pressure], by reduced chest wall

compliance (e.g., pneumothorax, pleural effusion, abdominal distension), and by increased minute ventilation requirements (e.g., pulmonary embolus with increased dead space fraction, sepsis). An impaired central nervous system can give rise to decrease drive to breath (eg.,drug overdose, brainstem injury, sleep-disordered breathing) or impaired neuromuscular function of the respiratory muscles (eg.,myasthenia gravis, Guillain-Barre syndrome, amyotrophic lateral sclerosis, myopathy, phrenic nerve injury) leading to ARF[1]**.** Treatment of ARF is aimed at treating the underlying cause and based on the condition of the patient providing ventilatory assistance in form of oxygen supplementation or mechanical ventilatory support-invasive or noninvasive.

The application of NIV has decreased the need for endotracheal intubation hence averted incidence of Ventilator Acquired Pneumonia and complications like barotrauma and volutrauma. NIV use is indicated in hypoxia refractory to mask oxygen or acute hypercapnia due to air flow obstruction[3]**.** NIV improves alveolar gas exchange, arterial oxygenation and reduces work of breathing[4]. It increases alveolar size and recruitment[5]It increases cardiac output by decreasing inspiratory efforts and with maintaining optimum myocardial oxygen consumption[5]. NIV is contraindicated in patients who have a Glasgow Coma Scale < 10, post upper abdominal surgery, facial trauma, pneumothorax without a chest tube and who are severely sick and hemodynamically unstable[4]. Delay in recognising NIV failure has been related to increased post intubation mortality[6]. NIV (Continuous Positive Airway Pressure-CPAP mode) has been an established treatment for obstructive sleep apnea[4]. For COPD patients' coming in exacerbation NIV (Bilevel positive Airway Pressure-BIPAP mode) has deterred the need for invasive ventilation[7]. NIV also has come in to play in using it for weaning off COPD patients who are intubated[8]. NIV used in cases of congestive heart failure, post cardiac sugery cases and post myocardial infarction cardiogenic pulmonary edema (CPE) has promising outcomes in hypoxemic ARF while there is insufficient evidence to recommend its use in hypercapnic ARF[9]. The success of NIV in ARDS and pneumonia is questionable with many factors influencing its end result.

Aims & objectives: 1.To identify NIV indication in an ICU setting, 2.To study success rate of NIV, 3.To assess outcome of NIV in different etiologies

Methodology:

A retrospective single centre study conducted over a period of four months which included 60 patients that were admitted in the ICU and given NIV therapy.Inclusion criteria were based on Clinical condition of patient; Radiological assessment (chest xray) & Type 1 or type 2 acute respiratory failure seen on ABG. Exclusion criteria were patients under the age of 18 years. NIV was administered through critical care ventilators using oronasal mask secured with head strapping. All patients of ARF were put on the BIPAP mode of NIV with inspiratory pressures ranging from 12 to 20 cm of H_2O and expiratory pressures ranging from 5 to 12 cm of H_2O. The ventilator settings were adjusted by the attending physician. ABG and chest Xray at the time of NIV application were noted. Number of days on NIV for each case was also noted. The outcome of the patients was studied- improvement or worsening and shift to invasive ventilation. NIV **success** defined as improvement of ABG, and clinical condition, removal of NIV. NIV **failure** defined as conversion to invasive ventilation. The cases of CPE were diagnosed with BNP (Brain natriuretic peptide) levels and confirmed with 2D echo. COPD patients were diagnosed based on history of exposure to offending agent and chest xray. Relevant

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investigations were done for diagnosing other etiologies. All statistical analysis was done using program SPSS 16.

Result:

Out of 60 patients there were 58.33% male patients (n=35) and 41.66% females (n=25) with a mean ± SD age of 48.65 ± 16.33 with maximum 25% (n=15) of the patients were in age group 41-50 years.[**FIGURE 1,TABLE 1]**

- NIV success occurred in 68.3 % (41/60) while 19 patients required endotracheal intubation.
- 37 patients of **type 1 ARF** were treated with NIV, out of which 26 (70.27 %) patients improved on NIV whereas 11 were intubated. **[TABLE 2,4 FIGURE 2,3,4]**
- 21 patients of **type 2 ARF** were put on NIV out of which 13 (62 %) patients improved on NIV and 9 required invasive ventilation. **[TABLE 2,4 FIGURE 2,3,4]**
- Based on Chest Xrays maximumpatients (n=28) requiring NIV were those developing **cardiogenic pulmonary edema (CPE)** or bilateral pleural effusion or unilateral pleural effusions secondary to acute myocardial infarction or post cardiac surgery like CABG, MVR,AVR, etc. **[FIGURE 3]**
- Amongst these patients those with type 1 ARF (80%) had a better improvement with NIV than those with type 2 ARF(57%) but overall success rate was 74% with average number of days on NIV being 2.62 **[FIGURE 3,4 TABLE 3,4]**
- Out of the cases of CPE, there were 2 such cases who were put on NIV, post extubation after a cardiac surgery for purpose of weaning. These patients weaned of perfectly on NIV and therefore did not develop hypoxemia post extubation.

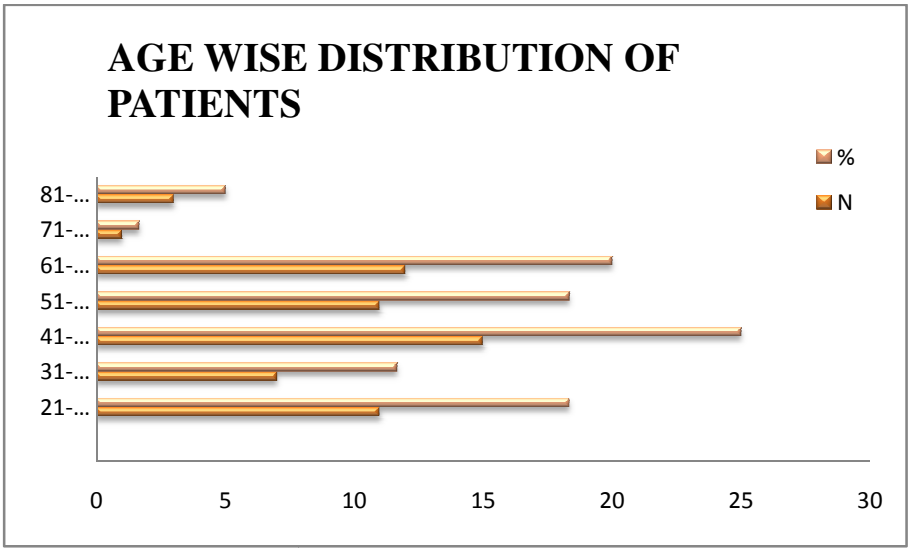

FIGURE 1: AGE- WISE DISTRIBUTION OF PATIENTS

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	NUMBER OF PATIENTS	%
MALES	35	58.33
FEMALES	25	41.66

TABLE 1: GENDER- WISE DISTRIBUTION OF PATIENT

RESPIRATORY FAILURE	NUMBER OF PATIENTS	%
TYPE 1	37	61.66
TYPE 2	21	35
NONE (NORMAL ABG)	2	3.33

TABLE 2: TYPES OF RESPIRATORY FAILURE

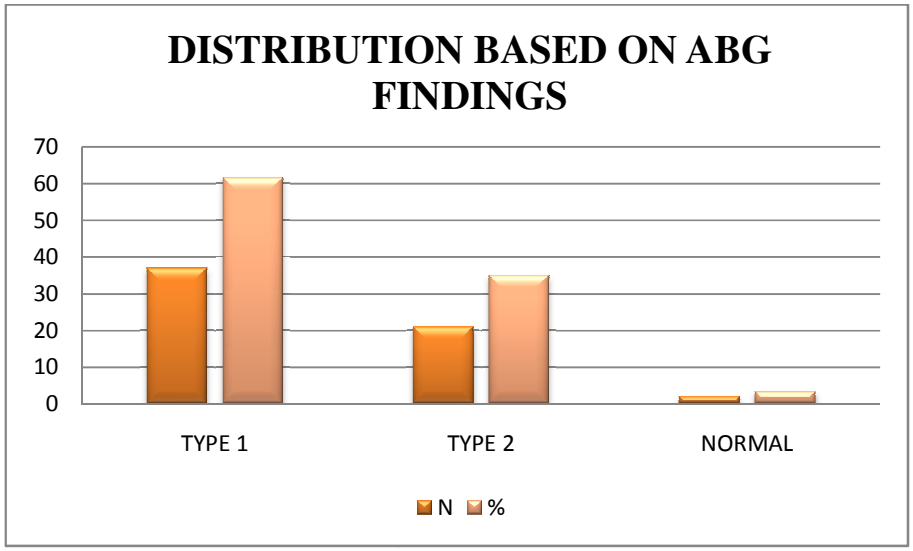

FIGURE 2: DISTRIBUTION BASED ON ABG FINDINGS

- 2nd most common chest Xray finding was **COPD**, followed by ARDS and pneumonia. **[FIGURE 3,4]**
- In cases of COPD, 3 who presented with type 1 ARF improved with NIV only.
- Out of 12 COPD patients of type 2 ARF, 8 improved NIV, whereas 4 required intubation **[FIGURE 3,4, TABLE 4]**
- Average number of days of NIV therapy required was 4 days. **[TABLE 3]**

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- The COPD patients requiring intubation had high baseline PCO2 (>60 mm Hg) levels and/or pH < 7.26
- In cases of **ARDS**, 1 out of 6 patients survived on NIV, rest required intubation. The NIV success rate was correlating with the grade of ARDS according to PaO2/FiO2 ratio (Berlins definition[10]) , in that it being a case of mild ARDS (PaO2/FiO2 between 300 and 200) **[FIGURE 3,4, TABLE 4]**
- Cases of pneumonia (n=6) presenting both with Type 1 and type 2 ARF had only 50 % success rate each, on NIV. **[TABLE 4]**
- Cases with **pneumonia (CAP/VAP)** requiring endotracheal intubation had associated comorbidities and general condition was already poor due to comorbidities (in cases of systemic sclerosis, alcohol liver disease, COPDs and Post abdominal surgery)
- 2 cases of **post abdominal surgery** developing pleural effusion improved with NIV application
- 1 cases of **ILD** improved on NIV. **[FIGURE 3,4, TABLE 4]**
- 2 cases of bilateral pleural effusion due to other etiologies such as **chronic kidney disease** also given an NIV trial had a positive outcome.
- 3 cases (Post CABG, seizure disorder, GuillaneBarre syndrome) with a **normal chest xray** but ABG showing Type 1 ARF improved with NIV. **[TABLE 4]**

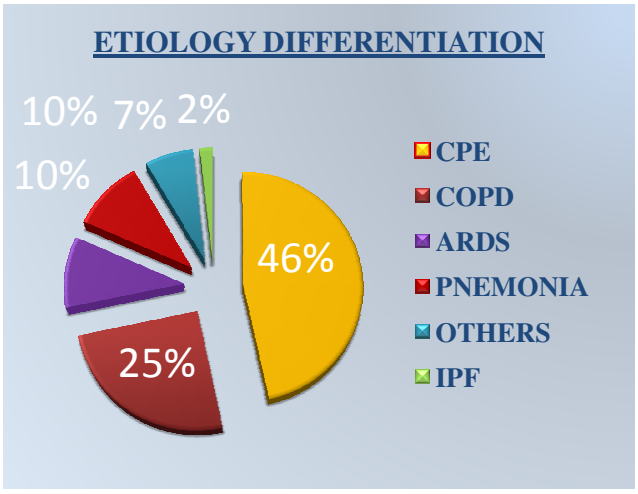

FIGURE 3: ETIOLOGICAL DIFFERENTIATION

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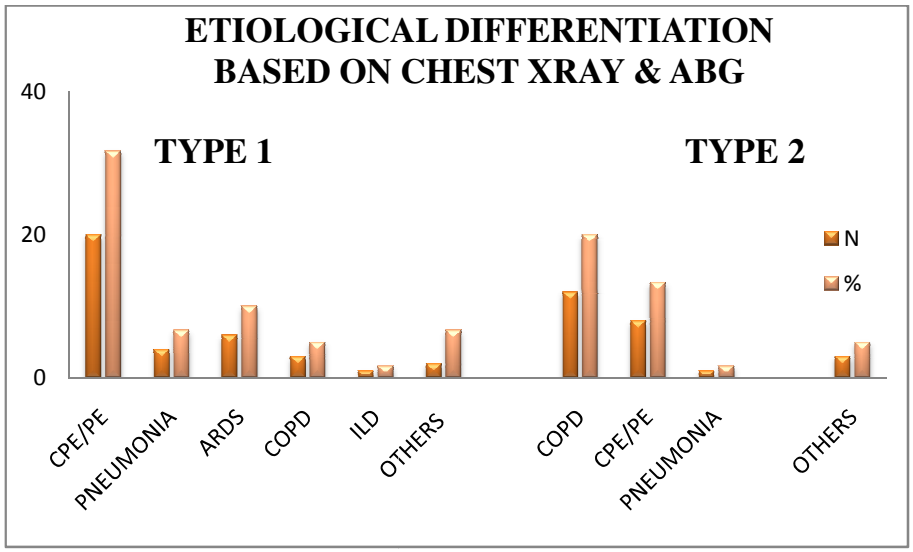

FIGURE 4: ETIOLOGICAL DIFFERENTIATION BASED ON CHEST XRAY & ABG

ETIOLOGY ON CHEST XRAY	AVERAGE DAYS OF BIPAP
COPD	3.87
ARDS	2.16
CPE/PE	2.62
PNEUMONIA	3.5

TABLE 3: AVERAGE DAYS ON NIV TREATMENT FOR EACH MAJOR DISEASE GROUP

ETIOLOGY	NUMBER OF PATIENTS	%	SUCCESS RATE (%)	FAILURE RATE (%)
TYPE 1 ARF				
CPE/PE	20	33.33	16(80)	4(20)
PNEUMONIA	4	6.66	2(50)	2(50)
ARDS	6	10	1(16.66)	5(83.33)
COPD	3	5	3(100)	0
ILD	1	1.66	1(100)	0
OTHERS[1]	3	5	3(100)	0
TYPE 2 ARF				

COPD	12	20	8(66.66)	4(33.33)
CPE/PE	7	11.66	4(57.14)	3(42.85)
PNEUMONIA	2	3.33	1(50)	1(50)
OTHERS[2]	2	3.33	2(100)	0

TABLE 4: SUCCESS AND FAILURE RATES ON NIV THERAPY BASED ON ETIOLOGY

OTHERS[1]: TYPE 1 RESPIRATORY FAILURE WITH NORMAL CXR

OTHERS[2] : NO RESPIRATORY FAILURE ON ABG, NORMAL CXR

Discussion:

The beneficial effects of NIV on hypoxemic, non hypercapnic respiratory failure (Type 1) patients is unclear in etiologies other than CPE and COPD [4] . The reported success of NIV in hypoxemic respiratory failure is 50% while in hypercapnic respiratory failure it is 75% [11]. In our study 37 patients had PaCO2< 45 mm Hg, NIV was applied due to desaturation. Out of these 70 % patients had improvement with NIV, hence implying otherwise.

Recent studies have shown to reduce intubation rate and mortality with NIV(CPAP) use in acute hypoxemic respiratory failure due to **CPE**[9].NIV increases the intrathoracic pressure and reduces venous return, thus decreasing the right and left ventricular preload; in diastole, NIV increases the pericardial pressure thus decreases afterload[12]. NIV(CPAP) also causes a decrease in the heart rate secondary to lung inflation and resultant increased parasympathetic tone[9]**.** NIV prevents fluid filling, re-expands flooded alveoli, counteracts intrinsic PEEP and prevents microatelectasis[9]. In our study 80% patients with type 1 RF improved with NIVhowever only 57% of patients with type 2 ARF in CPE improved on NIV. The reason for hypercapnia and associated NIV failure in patients of CPE may be underlying an COPD which would require evaluation after the patient stabilizes. Retention of carbon dioxide not previously associated with chronic obstructive pulmonary disease is a common finding in patients presenting with CPE and is associated with a poor prognosis.[13] Recent studies have revealed that in patients with acute respiratory failure, early extubation with immediate application of NIV has a positive impact on important outcomes, turning to advantage when compared with continuous invasive weaning. Its use decreases the occurrence of ventilator-associated pneumonia, length of ICU and hospital stay, total duration of mechanical ventilation and risk of re intubation [14]. In our study there were two such cases who were subjected to NIV post extubation following a cardiac surgery, having a 100% success rate**.** However NIV is not indicated in cases that develop acute respiratory failure after extubation. In this situation, patients should be reintubated and mechanically ventilated [14].

Chronic obstructive pulmonary disease is characterised by increase in airway resistance, decrease in expiratory flow rates, and hyperinflation leading to respiratory muscle fatigue[15].Studies have shown that NIV provides rest to the respiratory muscles, proven by reduction in diaphragmatic EMG activity [16]. It also reverses nocturnal hypoventilation and increases the sensitivity of the central receptors to carbon dioxide [17]**.** In our study we had an overall success rate of 75% in COPD patients. All patients(3) presenting with type 1 hypoxemic ARF treated with NIV improved completely. We would like to

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highlight this as until recently there was data of NIV being useful in only hypercapnic COPD patients. 25% (4) of patients of type 2 ARF in COPD required invasive ventilation. Patients requiring intubation had either a high baseline $PaCO_2$ (> 60 mm Hg) or pH< 7.26. In a retrospective study, Ambrosino *et al* found that patients in whom NIV treatment failed were significantly more acidaemic at baseline than those successfully treated (pH 7.22 versus 7.28) [18]. Our results were in conjuncture with their findings. Also the patients who were intubated, had NIV failure after more than 48 hours of NIV use, this is known as late failure. A study by Moretti*et al* showed that late failure is a bad prognostic factor, with over half the patients dying even with invasive ventilation[19]. This is more likely in patients with severe acidosis, poor functional status, and other complications[19].

In cases of **ARDS,** NIV success rates are related to the degree of disease severity, such that mild to moderate ARDS may respond to NIV, in hemodynamically stable patients[20]**.** In our study only 1 out 6 patients survived with NIV, it was a case of mild ARDS. All other 5 cases required invasive ventilation within a few hours of NIV trial (<12 hours) due to minimal improvement in ABG. Most ARDS patients die of multi-organ failure rather than irreversible respiratory failure[10] Moreover, the lungs may play an important role in the development of non-pulmonary organ failure[10]. Hence identification of NIV failure and immediate intubation should be borne in mind in patients of ARDS due to its high mortality rate.

In cases of **pneumonia**, a worsening chest Xray within 24 hours and low PaO_2 after an hour of NIV with higher heart rate can be predictors for NIV failure [21]. In our study there was a 50% success rate of NIV trial in cases of pneumonia with both type 1 and 2 ARF each. The patients requiring intubation had an unresolving pneumonic opacity on chest xray and/or associated comorbidities. Guidelines are still required to determine which cases of pneumonia can be given an NIV trial.

In our study, since we had only 1 case of **ILD**, it is difficult to comment on credibility of NIV in ILD exacerbations. Not many studies are there to determine the same, but since invasive ventilation carries a higher risk of mortality, NIV can be tried in selected patients[5]. 2 cases of **post abdominal surgery**who developed ARF associated with pleural effusion improved on NIV. Post surgery there is a reduction in tidal volume, with atelectasis and diaphragmatic dysfunction, causing hypoxia in 30-50 % post op patients [22]. Hence NIV should be used for treatment and prophylaxis of ARF in post abdominal surgery patients to prevent prolonged recovery and ICU stay.[23]

Conclusion:

NIV is found to be useful in patients of COPD and CPE maximally. All hemodynamically stable patient of COPD with type 1 and 2 ARF should be given NIV trial, and results be monitored via serial blood gas analysis. In CPE patients with just hypoxemic ARF, NIV can be of excellent use. For Type 2 ARF with CPE NIV can be tried with caution. It is important to identify associated or underlying diseases and hemodynamic instability as one of the reasons of NIV failure in hypercapnic CPE, in order to prevent mortality despite intubation. NIV has promising results with post extubation weaning and post surgeryhypoxemia, guidelines should be formulated to integrate it in the treatment plan, such that it can be used judiciously in these cases. In patients of ARDS and pneumonia, recognising NIV failure early is important to prevent mortality, therefore prompt intubation should be planned. Overall NIV has a more favourable outcome in cases of Type 1 ARF than type 2 ARF. Our study had a limited number

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of patients, and the application of NIV and withdrawal was the decision of the attending physician. Hence there would be variability of our outcome in relation to other studies. However it delineates the success and failure of NIV in various etiologies and the precaution with which it should be used in certain cases, giving us a better understanding of its application.

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