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To Evaluate the Role of Non - Invasive Ventilation in the Management of Type 2 Respiratory Failure - A Clinical Study

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Abstract: ***Type 2 respiratory failure, also known as hypercapnic respiratory failure, is characterized by elevated PaCO2 and reduced PaO2 levels, often arising from conditions like COPD, bronchial asthma, pneumonia, and ARDS. This study evaluates the efficacy of non - invasive ventilation (NIV), particularly BiPAP, in managing acute type 2 respiratory failure in 120 patients at PRS Hospital, Trivandrum. Key findings reveal an 83.3% improvement rate with significant reductions in PaCO2, stabilization of pH, and enhanced oxygenation (SpO2). Most patients responded well to NIV, with COPD being the most prevalent condition. The study underscores the importance of tailored NIV protocols based on diagnosis and highlights the need for continuous monitoring of arterial blood gases (ABG) to optimize treatment. While NIV proved effective in most cases, a 16.7% failure rate was observed, suggesting the need for alternative strategies for certain patients. These findings support NIV as a critical intervention for managing type 2 respiratory failure, emphasizing its role in reducing intubation rates and improving patient outcomes.***

Keywords: Type 2 respiratory failure, COPD, non - invasive ventilation, BiPAP, ABG

1. Introduction

Type 2 respiratory failure, or hypercapnic respiratory failure, is defined by a PaO2 below 8 kPa (<60 mmHg) and a PaCO2 over 6 kPa (>45 mmHg). This may manifest as acute, chronic, or acute - on - chronic, and distinguishing among these forms is essential for identifying the optimal therapeutic approach and the most suitable setting for patient care. Acute hypercapnic respiratory failure often manifests in persons with little or no prior respiratory conditions, characterized by arterial blood gas analysis showing elevated PaCO2, decreased pH, and normal bicarbonate levels. Conversely, chronic hypercapnic respiratory failure is often linked to prolonged respiratory disorders, characterized by raised PaCO2, normal pH, and increased bicarbonate, reflecting the body's long - term compensatory mechanisms. Acute - on - chronic hypercapnic respiratory failure is an acute exacerbation in a patient with pre - existing chronic respiratory failure, characterized by blood gas analyses revealing higher PaCO2, decreased pH, and increased bicarbonate levels.

Common conditions that precipitate Type 2 respiratory failure include acute exacerbations of chronic obstructive pulmonary disease (COPD), bronchial asthma, obstructive sleep apnoea, pneumonia, and acute respiratory distress syndrome (ARDS). In such instances, the lungs' capacity to eliminate carbon dioxide is impaired, resulting in its buildup in the bloodstream. The pathophysiology differs based on the underlying aetiology, although the therapy focusses on enhancing breathing and oxygenation. Non - invasive ventilation (NIV), especially bilevel positive airway pressure (BiPAP), is crucial in these situations, since it reduces the need for invasive breathing, enhances gas exchange, and aids patients' recovery from the acute phase of respiratory failure. This therapeutic approach is especially significant for patients experiencing COPD exacerbations, since non - invasive ventilation has shown a reduction in mortality and intubation rates.

In the management of Type 2 respiratory failure, meticulous and ongoing assessment of arterial blood gases (ABG) is essential to monitor disease progression and inform medication modifications. Monitoring changes in PaCO2 and pH assists doctors in determining the continued efficacy of non - invasive techniques such as BiPAP or the need for invasive breathing. The treatment strategy must include a thorough evaluation of complications and comorbidities to guarantee optimum patient outcomes.

Indications of NIPPV	
As therapeutic trial before tracheal intubation	Hypoxemic respiratory failure
Hypercapnic respiratory failure	Cardiogenic pulmonary edema
Acute exacerbation of COPD	Community acquired pneumonia
Post extubation	Post traumatic respiratory failure
Post surgical respiratory failure	ARDS
Thoracic wall deformities	Weaning difficulties
Asthma	
Acute respiratory failure in obesity hypoventilation syndrome	
Chronic respiratory failure	
Immunocompromised patients	
Do not intubate patients	

Contraindications of noninvasive ventilation	
Absolute	Relative
Respiratory arrest	Medically unstable (hypotensive shock, uncontrolled cardiac ischemia, or arrhythmia
Patient decline	Multiple (two or more) organ failure. Recent upper airway or upper gastrointestinal surgery, Progressive severe respiratory failure, Pregnancy
Uncontrolled vomiting or copious upper gastrointestinal bleeding	Unable to protect airway
Unable to fit mask	Agitated, uncooperative

Application of NIV

Patient is put in semi - recumbinent position >30^0. An appropriate sized interface is selected. The Non invasive ventilator is turned on and set in spontaneous timed mode. IPAP of 8 – 12 cm H2O and EPAP of 3 - 5 cm with a back up rate of 8 breaths is set and started. The face mask kept on the patients face lightly so that he gets adjusted to the pressure effects and once the patient is comfortable it is applied to the patient using the head gear tightly and checking for leaks. The O2 is connected to the mask and the flow is adjusted to keep SPO2 > 90%. Once the patient settles with the initial setting and depending on improvement and tolerance the IPAP support can be increased by 2 cm every 2hourly till a tidal volume of 5 – 7 ml/Kg is achieved or signs of respiratory distress improve. ABG is obtained after 1 hour. The patient is constantly monitored to assess for leaks, respiratory rate, vital parameters, SPO2, use of accessory muscle and patient comfort. If there are signs of deterioration change in setting or intubation should be considered immediately

Problems with non - invasive ventilation

Non - invasive ventilation seems to be mostly devoid of significant problems and adverse consequences. The main drawback of non - invasive ventilation is its dependence on a spontaneously breathing patient capable of safeguarding their airway against aspiration risks.

Complications of NIV	
Common complications	Rare complications
Nasal – congestion /dryness /rhinorrhea Nose bridge - erythema /ulceration Conjunctival irritation Sinus pain /earache Nasal /oral dryness	Gastric distension Aspiration Nosocomial pneumonia Pneumothorax

Objectives:

This study aimed to assess the efficacy and outcome of NIV in management of acute type 2 respiratory failure and to study the incidence of treatment failure of NIV

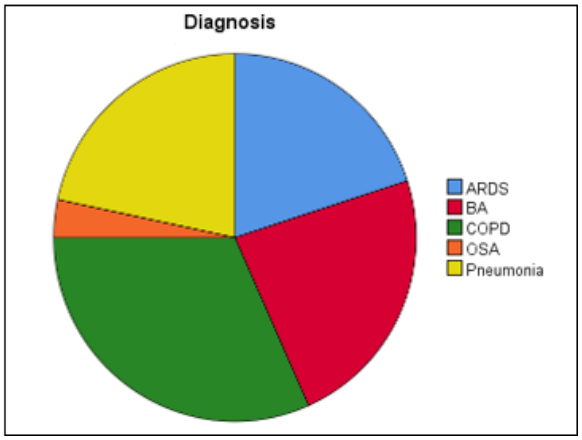
2. Methodology

120 patients with acute type 2 respiratory failure who presented to the Emergency department of PRS Hospital Trivandrum who fulfilled the criteria were included in the study. A well fitted BiPAP mask was affixed to the patient's face. Bedside arterial blood gas (ABG) analysis was conducted at admission (0 hours) and thereafter at 1, 2, 4, and 24 hours, with settings modified based on ABG findings and clinical condition. From the obtained data the frequency distribution of categorical variables was established. Chi - square tests for proportions were conducted to compare the causes of type II respiratory failure and the outcomes of NIV at 4 hours and 24 hours. Repeated assessments Variance analysis of metrics such as PCO2 and SPO2 across time for aetiologies of type II respiratory failure, including bronchial asthma, COPD, ARDS, OSA, and pneumonia.

3. Results and Discussion

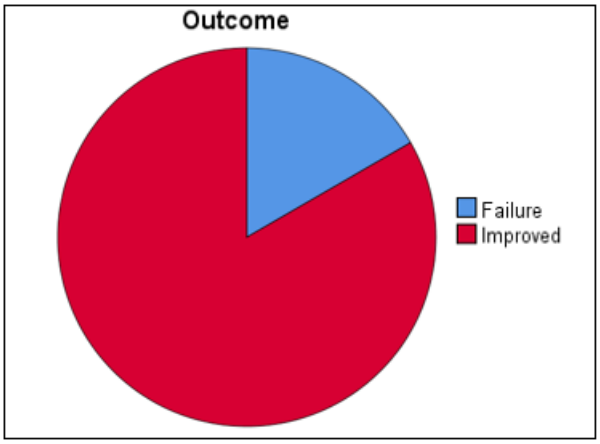
The distribution of subjects among diagnosis is as follows:

Diagnosis	Frequency	Percent
ARDS	24	20.0
BA	28	23.3
COPD	38	31.7
OSA	4	3.3
Pneumonia	26	21.7
Total	120	100.0



Outcome findings among the group:

Outcome	Frequency	Percent
Failure	20	16.7
Improved	100	83.3
Total	120	100.0



NIV settings at baseline (0 hour), 1st, 2nd, 4th and 24th hour:

NIV Settings	0 - hour N (%)	1st hour N (%)	2nd hour N (%)	4th and 24th hour N (%)
12/6	120 (100%)	116 (97%)	90 (75%)	90 (75%)
14/7	0 (0%)	4 (3%)	30 (25%)	30 (25%)

NIV outcome at 4th and 24th hour:

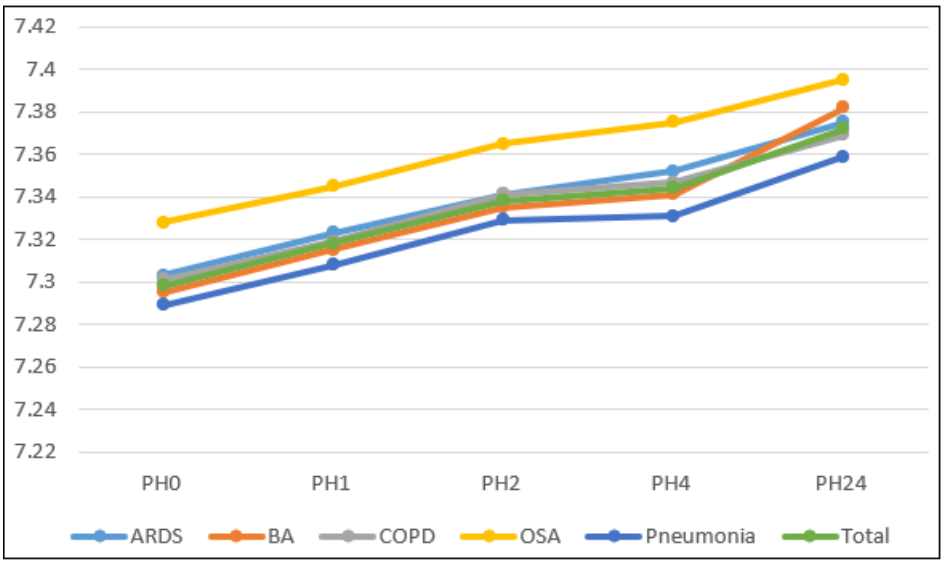
NIV Outcome	NIV Outcome at 4th hour N (%)	NIV Outcome at 24th hour N (%)
Failure	20 (16.67%)	20 (16.67%)
Improved	100 (83.33%)	30 (83.33%)

Comparison of causes of type II respiratory failure with NIV outcome at 4th and 24th hour:

	Outcome		Total
Diagnosis	Failure	Improved	
ARDS	3	21	24
BA	4	24	28
COPD	9	29	38
OSA	0	4	4
Pneumonia	4	22	26
Total	20	100	120
Pearson chi - square = 9.592, p - value = 0.028			

Changes in PH values over time in all groups:

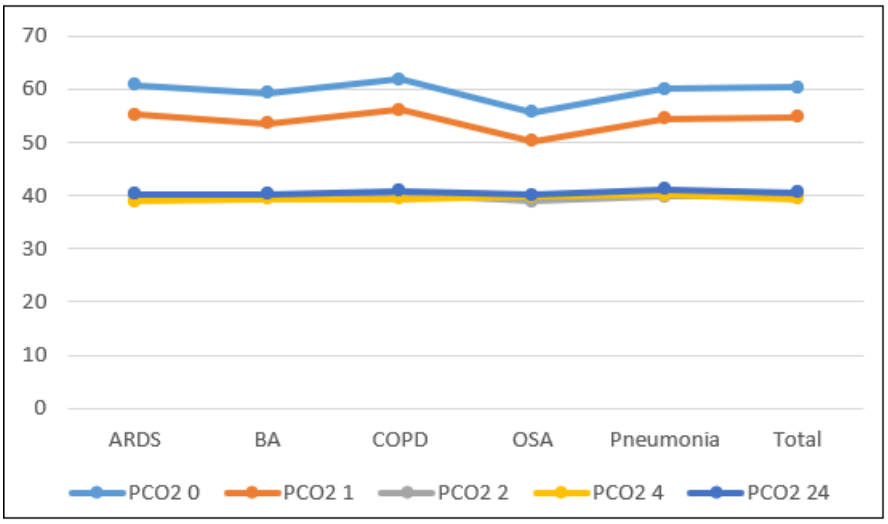
Condition	PH0 Mean ± SD	PH1 Mean ± SD	PH2 Mean ± SD	PH4 Mean ± SD	PH24 Mean ± SD	F value	P value
ARDS	7.303 ± 0.0317	7.323 ± 0.0325	7.341 ± 0.0318	7.352 ± 0.0318	7.375 ± 0.0292	1.460	0.219
BA	7.295 ± 0.0394	7.315 ± 0.0385	7.335 ± 0.0397	7.341 ± 0.0395	7.382 ± 0.0470	1.348	0.256
COPD	7.301 ± 0.0314	7.319 ± 0.0317	7.341 ± 0.0294	7.347 ± 0.0310	7.369 ± 0.0307	1.254	0.292
OSA	7.328 ± 0.0150	7.345 ± 0.0173	7.365 ± 0.0238	7.375 ± 0.0173	7.395 ± 0.0173	2.173	0.076
Pneumonia	7.289 ± 0.0348	7.308 ± 0.0348	7.329 ± 0.0355	7.331 ± 0.0364	7.359 ± 0.0347	2.148	0.071
Total	7.298 ± 0.0342	7.318 ± 0.0342	7.338 ± 0.0339	7.344 ± 0.0349	7.372 ± 0.0360	1.872	0.120



Changes in PCO2 values over time in all groups:

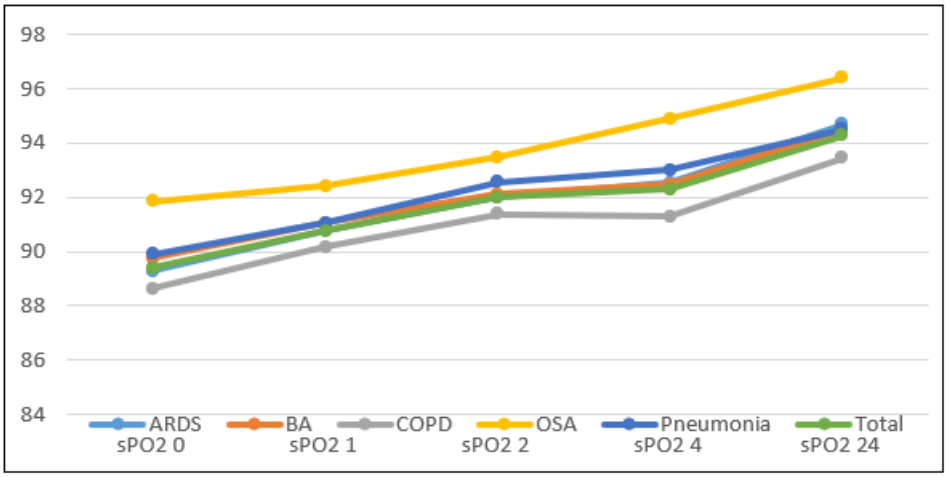
There was a significant decrease in PCO2 levels over time on repeated measures ANOVA for ARDS, pneumonia and overall (All P's <0.001)

Condition	PCO2 0 Mean ± SD	PCO2 1 Mean ± SD	PCO2 2 Mean ± SD	PCO2 4 Mean ± SD	PCO2 24 Mean ± SD	F value	P value
ARDS	60.762 ± 3.8284	55.187 ± 3.8608	40.152 ± 2.6710	38.888 ± 3.1523	40.287 ± 2.0357	4.953	<0.001
BA	59.254 ± 4.4517	53.646 ± 4.5159	40.207 ± 2.9332	39.396 ± 2.8070	40.241 ± 2.5965	2.751	0.031
COPD	61.868 ± 4.7608	56.137 ± 4.6680	40.079 ± 2.4647	39.365 ± 2.7555	40.821 ± 4.2254	4.254	<0.001
OSA	55.725 ± 2.3315	50.225 ± 2.3315	38.946 ± 2.5515	39.787 ± 3.1971	40.125 ± 4.0837	3.576	0.021
Pneumonia	60.050 ± 3.6873	54.415 ± 3.6657	39.830 ± 2.5194	40.101 ± 2.9409	41.183 ± 3.3419	5.395	<0.001
Total	60.438 ± 4.3765	54.796 ± 4.3466	40.032 ± 2.6032	39.451 ± 2.8822	40.634 ± 3.2855	5.949	<0.001



Changes in SPO2 values over time in all groups:
There was a significant increase in SPO2 levels over time on repeated measures ANOVA for bronchial asthma, COPD, overall (All P's <0.001) and OSA (P=0.004)

Condition	sPO2 0 Mean ± SD	sPO2 1 Mean ± SD	sPO2 2 Mean ± SD	sPO2 4 Mean ± SD	sPO2 24 Mean ± SD	F value	P value
ARDS	89.29 ± 3.353	90.80 ± 2.657	92.01 ± 3.125	92.54 ± 3.599	94.68 ± 2.862	4.898	<0.001
BA	89.75 ± 3.588	91.04 ± 3.088	92.11 ± 3.155	92.47 ± 3.960	94.47 ± 3.246	6.629	<0.001
COPD	88.62 ± 4.662	90.17 ± 3.952	91.37 ± 4.243	91.28 ± 4.838	93.46 ± 3.923	4.683	<0.001
OSA	91.85 ± 1.100	92.40 ± 0.400	93.48 ± 0.350	94.90 ± 0.000	96.40 ± 0.000	3.120	0.013
Pneumonia	89.89 ± 4.045	91.06 ± 3.559	92.55 ± 2.766	93.01 ± 2.790	94.50 ± 3.064	5.318	<0.001
Total	89.40 ± 3.975	90.76 ± 3.360	92.00 ± 3.409	92.30 ± 3.957	94.26 ± 3.339	5.688	<0.001



With an improvement rate of 83.3%, the results affirm NIV's efficacy in stabilizing patients and reducing the need for invasive mechanical ventilation. Most patients requiring NIV were middle - aged, particularly between 51 - 60 years, and the majority were male. COPD was the most prevalent diagnosis, followed by bronchial asthma and pneumonia, highlighting the importance of tailored NIV protocols based on underlying conditions. Key physiological improvements were observed with NIV treatment. Stability in pH levels and significant reductions in PCO_2 levels demonstrated NIV's effectiveness in alleviating hypercapnia, a characteristic of type 2 respiratory failure. Additionally, decreases in respiratory and heart rates indicated enhanced cardiovascular stability, while increased SpO_2 levels confirmed improved oxygenation. These findings align with existing research, supporting NIV's role in improving respiratory function and patient outcomes across a range of conditions. The study also reported a 16.7% failure rate, suggesting that while NIV is generally effective, certain patients may require alternative interventions or more intensive monitoring. The correlation between diagnosis and treatment outcome emphasizes the need for diagnosis - specific NIV protocols to optimize efficacy.

4. Conclusion

In summary, this study reinforces NIV as a vital intervention for type 2 respiratory failure, offering a less invasive, effective, and versatile treatment option. By preventing intubation, NIV minimizes associated risks and improves patient comfort. Future research should focus on refining personalized NIV settings and exploring adjunct therapies to further enhance outcomes, especially for patients at higher risk of treatment failure. This approach will ensure that NIV

continues to provide substantial benefits across diverse patient populations experiencing type 2 respiratory failure.

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