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Predictors of Success of Noninvasive Ventilation in Patients with COPD Exacerbations (Role of Clinical Parameters and Arterial Blood Gases)

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ABSTRACT

Background: Noninvasive mechanical ventilation (NIV) decreases the need for endotracheal intubation (ETI) and also decreases mortality in severe acute exacerbation of COPD (AECOPD). **Objective:** The aim of the current study is to assess determinants of NIV effectiveness in patients with COPD exacerbation.

Patients and methods: Our study was a cross-sectional comparative study. A total 100 patients with AECOPD were included in this study. Patients were admitted to the Respiratory Intensive Care Unit (RICU) in Minia Cardiothoracic University Hospital. All patients were evaluated at the time of admission, at the start of NIV, after 1 hour (hr) of NIV and at the end of NIV. This evaluation included heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure, and arterial blood gases (ABG) which include PaO2, PaCO2, PH, HCO3, as well as PaO2 /FiO2 ratio.

Results: Patients were divided into 2 groups; 85 (85%) patients improved with NIV (success group, *Group I*) and 15 (15%) patients failed NIV and were intubated (*Group II*). PH, PO2, as well as PCO2 revealed significant improvement after 1 hr, which persisted till the end of the study in the success group. Clinical data including heart rate, respiratory rate, systolic blood pressure, and diastolic blood pressure showed significant difference between the two groups at time of hospital admission and the initiation of NIV. After 1 hr, these variables showed significant improvement in the success group that continued till the and at the end of the study. Also, PaO2/FiO2 ratio showed a significant improvement in the success group after 1 hr of NIV. Multivariate analysis showed PH <7.26 and RR ≥ 35 (at hospital admission) are predictors of failure of NIV. **Conclusion**: Clinical parameters including HR, RR and blood pressure, as well as ABG, could predict success of NIV in patients with AECOPD. Improvement in these parameters within 1 hr of NIV could be a good predictor of success.

Keywords: COPD exacerbation, Clinical parameters, NIV, ABG.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a substantial contributor to chronic morbidity and death globally and is one of the top three killers in the globe [(1)]. AECOPD is a well-known, typical COPD consequence with a high mortality and morbidity rate that might result in hospitalization [(1)].

Bronchodilators, corticosteroids, antibiotics, and regulated oxygen therapy are common treatments for AECOPD [(2)].

Patients with acute respiratory failure and hypercapnia will require less endotracheal intubation (ETI) and experience lower mortality when non-invasive ventilation (NIV) is added to this therapy [(3)].

Inappropriate patient selection increases mortality by delaying ETI, with documented failure rates ranging from 9 to 50%, whether at the time of admission or by under-recognition of NIV failure [(4)].

Lack of qualified workers, concomitant conditions, and a lack of clear recommendations for the ideal NIV settings and timing are the main contributors to NIV failure [(5)].

The aim of the current study is to assess determinants of NIV effectiveness in patients with COPD exacerbation.

PATIENTS AND METHODS

Our study was a cross-sectional comparative study. A total of 100 patients with AECOPD were included in this study. They were admitted to Respiratory Intensive Care Unit (RICU) in Minia Cardiothoracic University Hospital, during the period from June 2021 to December 2021.

Inclusion criteria: Patients with AECOPD who required NIV according to gold criteria [(2)].

Exclusion criteria:

- Patients who did not tolerate NIV or in whom NIV was contraindicated [(2)].
- All patients were evaluated at the time of admission, at the start of NIV, 1 hour after start of NIV and at the end of NIV.

The evaluation of patients included:

A) Clinical evaluation; including monitoring of heart rate, respiratory rate, systolic blood pressure (SBP), diastolic blood pressure (DBP) and temperature.

B) ABG; includes PaO2, PaCO2, PH, and HCO3.

C) PaO2 /FiO2 ratio.

The patients were divided into 2 groups; 85 patients showed clinical improvement (successes NIV Group, *Group I*) and 15 patients failed NIV and needed intubation (*Group II*).

Ethical approval:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Minia University. Written informed consent was obtained from all participants. This study was executed according to the code of ethics of

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the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 18 for Windows was used to code, process, and analyze the obtained data (IBM SPSS Inc., Chicago, IL, USA). Qualitative data were defined as numbers and percentages. Chi-Square test and Fisher's exact test were used for comparison between categorical variables as appropriate. Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as means and SD, and independent sample t-test was used for comparison between groups. P value ≤0.05 was considered to be statistically significant.

RESULTS

There was no significant difference between *Group I* and *Group II*, as regard PH at baseline and at start of NIV (**Tables 1 and 2**) with P value 0.225 and 0.21, respectively, after 1 hour significant difference between the two groups existed (**Table 3**) and continued till the end of NIV (**Table 4**). P values were 0.0001 and 0.0001, respectively.

As regards PaCO2 changes during the course of the study, there was a significant difference after 1 hour (**Table 3**) and at the end of the study (**Table 4**) with P values 0.001 and 0.0001, respectively.

Regarding oxygen status, there was a significant difference between both groups in PaO2 (P values 0.0001 and 0.0006, respectively) after one hour and at the end of study. And the same goes for PaO2/FiO2 with P values 0.0001 and 0.0001, respectively, after one hour and at the end of study. The failure group had considerably greater cardiac and respiratory rates, but their systolic and diastolic blood pressures were lower at the time of hospital admission and at the beginning of NIV, according to an analysis of their clinical data (**Tables 1 and 2**).

One hour after initiation of the NIV, the aforementioned variable showed significant improvement in the success group, with decrease in both the RR and HR, and the improvement continued till discontinuation of the NIV (**Tables 3 and 4**).

Univariate analysis of several hospital admission data in the success and failure groups revealed a statistically significant difference between the two groups in terms of: PH7.26, RR>35. The results of a multivariate analysis of the various hospital admission data in the success and failure groups revealed that PH 7.26 and RR>35 are predictors of NIV failure.

Table 1 demonstrates comparison between the two studied groups regarding clinical data, ABG and oxygenation parameters at time of hospital admission.

Table (1): Comparison between the two groups at time of hospital admission.

Variable	Group I Base	Group II Base	P-value
pH	7.3 ± 0.1	7.3 ± 0.1	0.225
$PaCO_2$	67.1 ± 12.4	69.4 ± 14.2	0.712
PaO_2	67.1 ± 11.3	59.6 ± 12.7	0.167
HCO_3	30.6 ± 4.9	29.1 ± 2.5	0.451
PaO_2/FiO2	186.8 ± 39.1	168.1 ± 16.4	0.214
RR	28.6 ± 7.1	35.1 ± 7.0	0.05
HR	91.9 ± 17.6	112.9 ± 12.6	0.002
SBP	118.4 ± 21.1	97.1 ± 29.3	0.013
DPB	77.2 ± 13.3	65.7 ± 20.7	0.034

(*) P <0.05: Significant.

Table (2): Comparison between the two groups at time of initiation of NIV.

Variable	Group I	Group II	P-value
pH	7.3 ± 0.1	7.3 ± 0.1	0.21
$PaCO_2$	72.8 ± 10.4	78.1 ± 16.4	0.211
PaO_2	56.3 ± 14.01	53.4 ± 13.1	0.156
HCO_3	30.9 ± 4.9	30.6 ± 4.9	0.829
PaO_2/FiO2	194.3 ± 53.1	175.0 ± 13.2	0.34
RR	27.4 ± 6.76	34.1 ± 7.0	0.015
HR	91.3 ± 17.5	111.4 ± 15.8	0.004
SBP	116.7 ± 20.1	95.7 ± 22.4	0.01
DPB	75.1 ± 13.3	62.9 ± 14.9	0.024

(*) P <0.05: Significant.

Table (3): Comparison between the two groups one hour after initiation of NIV.

Variable	Group I	Group II	P-value 1 hr
pH	7.3 ± 0.1	7.2 ± 0.1	0.0001*
$PaCO_2$	67.8 ± 11.6	85.9 ± 18.8	0.0001*
PaO_2	67.9 ± 8.5	44.4 ± 11.1	0.001*
HCO_3	31.8 ± 4.4	30.3 ± 6.9	0.397
PaO_2/FiO2	231.6 ± 38.7	178.9 ± 44.4	0.001*
RR	24.3 ± 6.01	33.1 ± 8.2	0.0001*
HR	86.3 ± 13.9	104.7 ± 14.6	0.001*
SBP	116.8 ± 17.4	94.2 ± 22.7	0.002*
DPB	75.3 ± 10.6	61.4 ± 15.2	0.002*

(*) P <0.05: Significant.

Table (4): Comparison of full data between the two studied groups at the end of NIV.

Variable	Group I	Group II	P-value end
pH	7.4 ± 0.1	7.2 ± 0.1	0.0001*
$PaCO_2$	57.4 ± 5.8	84.1 ± 20.8	0.0001*
PaO_2	67.8 ± 7.1	40 ± 9.6	0.006*
HCO_3	33.8 ± 4.4	31.1 ± 7.2	0.145
PaO_2/FiO2	250.8 ± 36.4	200.1 ± 41.6	0.001*
RR	21.7 ± 3.8	33.0 ± 8.1	0.0001*
HR	81.2 ± 10.0	104.1 ± 24.9	0.0001*
SBP	117.1 ± 13.8	85.7 ± 21.1	0.0001*
DPB	75.0 ± 8.7	55.7 ± 12.8	0.0001*

(*) P <0.05: Significant.

Table (5): Univariate analysis of the different parameters in the success and failure groups at baseline.

Variable	Success (N. 85)	Failure (N. 15)	Relative risk	95% CI	P-value
pH <7.26	21 (24.7 %)	11 (73.3%)	0.36	0.12-1.21	0.015*
PaO2/FiO2 < 146	15 (17.6 %)	0 (0 %)	0.9	0.9-0.9	0.296
RR ≥35	15 (17.6%)	11 (73.3%)	12.34	2.2-6.8	0.004*

(*) P <0.05: Significant. Univariate analysis of different parameters showed significant statistical difference between the two groups regarding: PH<7.26, RR>35.

Table (6): Multivariate analysis of the different parameters in the success and failure groups at base line.

Variable	Success (N. 85)	Failure (N. 15)	Relative risk	95% CI	P-value
pH <7.26	21 (24.7 %)	11 (73.3 %)	0.36	0.12-1.21	0.022*
PaO2/FiO2 <146	15 (17.6 %)	0 (0 %)	0.2	0.07-0.64	0.330
RR ≥35	15 (17.6 %)	11 (73.3 %)	0.34	0.11-1.07	0.004*

(*) P <0.05: Significant.

Multivariate analysis showed PH <7.26 and RR>35 are predictors of failure of NIV.

DISCUSSION

In our patients with AECOPD, the NIV failure rate was 15%. This number is lower than those seen in several trials, where the failure rate for NIVs varied from 9 to 50% [(4)].

A number of studies of AECOPD have demonstrated that acidosis and PCO2 level are indications of the degree of decompensation in acute and chronic respiratory failure and can predict death [(6,7)]. Improvements in pH, PCO2, and level of awareness during the first hour or two following NIV commencement are excellent indicators of effectiveness, according to several writers [(8)].

We found a significant difference between the two groups in terms of pH levels at the beginning of the study and at the end of the study (P values 0.0001 and 0.0001, respectively), with the success group having higher pH levels. The pH levels in patients with AECOPD have been identified to be an important critical prognostic factor [(9)] and this agrees with the findings in our study. Baseline PH 7.26 was identified by multivariate analysis as a potential indicator of NIV failure.

Ambrosino *et al.* [(10)] observed that pH levels following 1 hour of NIV have shown to be a potent indicator of how NIV will turn out. Additionally, **Agarwal *et al.*** [(11)] recommended that intubation be taken into consideration if NIV does not improve pH and RR during the first 2 hours.

In addition, **Soo Hoo *et al.*** [12] showed that NIV failure was more likely when respiratory acidosis and respiratory rates did not improve within the first several hours of NIV. According to **Confalonieri *et al.*** [13], a pH of less than 7.25 after 1 hour of NIV usage was linked to a higher probability of NIV failure.

Our findings concur with those of **Soliman *et al.*** [14] who believed that the degree of acidemia was a predictor of NIV success in COPD subjects.

Miller *et al.* [15] demonstrated that an improvement in pH within 1 hour after NIV predicted survival until hospital discharge, with a sensitivity of 82%, in a study of 240 unselected patients undergoing ward-based noninvasive positive pressure ventilation (NIPPV), which is consistent with the results of another study [16]. Similar to this, **Ahmad *et al.*** [17] discovered that 1 hour after beginning NIPPV, arterial blood pH and pCO2 had significantly improved. BiPAP causes CO2 to leave the lungs, which lowers blood PCO2 levels and raises arterial blood pH.

Our results found that PaO2 and PaO2/FiO2 were higher in the success group than in the failure group at the time of hospital admission and initiation of NIPPV; however it is of no statistical significance. But one hour after the initiations of NIPPV, the above two parameters showed improvement in the success group with a statistically significant difference between the success and the failure groups (P values 0.001 and 0.006 for PaO2 respectively and 0.001 for PaO2/FiO2).

Our results are in agreement with **Nava and Hill** [18] who showed that failure to improve oxygenation is the main cause for NIV failure.

On the other hand, several investigations have failed to demonstrate any connection between the response to NIV and the initial arterial blood gas tensions [8,12].

In the current study, there was no significant difference between studied groups regarding HCO3 level (P values 0.397 and 0.145) after 1hr and at the end of the study. In contrast **Corrêa *et al.*** [19] noticed that lower arterial bicarbonate levels were one of the markers that may predict NIV failure.

The current study demonstrated that RR was significantly higher at time of hospital admission and initiation of NIV in the failure group. Moreover, the success group showed significant decreases in the RR one hour after the initiation of NIV and continued till the discontinuation of NIV. Multivariate analysis showed that base line RR ≥35 is considered a predictor of NIV failure. NIV increases tidal volume, which in turn increases the minute ventilation and RR fall with off-loading of the respiratory muscle, which will be translated into improvement in the patient's clinical condition. Failure of improvement of RR after start of NIV could reflect patient ventilator asynchrony; however, it may also be a marker of a marked intrinsic respiratory drive. Because of the effect of NIV on unloading of the respiratory muscle, the RR can fall [20,21].

Our results are in agreement with **Bastiansen** [22], who found that an increased RR was associated with NIV failure. Also our findings are supported by **Soliman *et al.*** [14] who reported a significant difference in the RR (P-value <0.001), between the failure and the success group. Similarly **Lin *et al.*** [23] reported improvements of RR during the first 30 minutes of NIV application and it is considered as one of the parameters that can predict the outcome of NIV.

Similarly **Ahmad *et al.*** [17] reported that RR is an important clinical parameter that could predict the outcome. Improvement in RR is also reported in other trials [24,25]. Respiratory rate >24 bpm, one hour after start of NIV, was independently correlated with the necessity of endotracheal intubation. **Chakrabarti *et al.*** [26] recorded that after multivariate logistic regression, the baseline respiratory rate predicted outcome in the Patients on NIV.

Our results showed a significant statistical difference between the success and failure groups regarding: HR, SBP and DBP, where both systolic and diastolic BP was significantly higher in the success group, while HR was significantly higher in the failure group at time of hospital admission. The aforementioned variable showed significant improvement one hour after initiation of NIV and till the end of the study in the success group.

Our results are in accordance with **Moretti *et al.*** [27] where they showed that hemodynamics variables are one of the indicators of NIV failure. Also our results are supported by the finding of **Chawla *et al.*** [28].

In contrast to our finding; **Çelikel *et al.*** [29] found that heart rate and blood pressure did not change significantly at any time during NIV.

CONCLUSION

Clinical data such as respiratory rate, heart rate, blood pressure, as well as ABG and oxygenation parameters are good predictors of success of NIV in patients with AECOPD. Early improvement of the aforementioned parameters within one hour of start of NIV could predict NIV success in those patients.

RECOMMENDATIONS

We recommend longitudinal studies that include large sample size to verify our results.

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