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PREDICTING THE NEED OF VENTILATOR SUPPORT FOR ACUTE EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE PATIENTS USING RAPID SHALLOW BREATHING INDEX

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Abstract:

Acute exacerbation of COPD is a frequent reference to the intensive care unit (ICU) due to respiratory failure, which often requires mechanical ventilation (MV).

Aim: *In this study, the rapid shallow respiratory rate (RSBI) was assessed as a predictor of the need for ventilation support in patients with acute COPD exacerbation.*

Study Design: *A prospective study.*

Place and Duration: *In the Medicine Unit II and Anesthesia Department of Jinnah Postgraduate Medical Center Karachi for one year duration from January 2019 to January 2020.*

Methods: *The study was conducted on 115 patients with acute exacerbation of COPD who went to the intensive care unit at the Jinnah Postgraduate Medical Center Karachi. All enrolled patients measured RSBI every 30 minutes at admission and for the first 2 hours.*

Results and Conclusion: *The RSBI cutoff value, which made the best distinction between non-invasive and invasive MV requirement using recipient operational characteristics (ROC), was> 241 breaths / minute / liter, showed 88.33% of sensitivity and 100% specificity. RSBI may be a good predictor of the need for ventilation assistance in acute COPD exacerbations.*

Keywords: *critical, pneumatic, fast and shallow breathing rate, ventilation.*

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INTRODUCTION:

COPD is a communal disease that usually progresses and is categorized by tenacious restriction of airflow related with a chronic inflammatory reaction to harmful gases or particles in the lungs and airways. Exacerbations and concomitant diseases subsidize to the general severity in patients[1-3]. COPD is one of the main causes of mortality and causes significant and increasing economic and social burdens. The COPD characteristic symptoms are progressive and chronic coughing, sputum secretion and dyspnea. Acute exacerbation of COPD is an acute incident characterized by deterioration of respiratory symptoms, leading to a change in normal COPD medication that goes beyond the patient's daily symptoms[4-5]. Treatment of acute COPD exacerbations along with treatment of the cause includes supplemental oxygen, bronchodilators, corticosteroids, antibiotics and, if necessary, support ventilation. The rapid shallow respiratory rate (RSBI) is definite as the respiratory rate to tidal volume (f / VT) ratio. It is widely used to foresee dissuading from mechanical ventilation[6-8]. This study aim was to evaluate the role of RSBI as a predictor of the need for ventilator support in patients with acute exacerbation of COPD who referred to the ICU.

MATERIALS AND METHODS:

This prospective study was conducted in 115 adult COPD patients admitted to the ICU with acute exacerbation in the Medicine Unit II and Anesthesia Department of Jinnah Postgraduate Medical Center Karachi for one year duration from January 2019 to January 2020. All enrolled patients were adults of both sexes. All patients with respiratory arrest or hemodynamic instability were excluded from the study. In addition, patients who did not cooperate were excluded from the study. Pregnant women were excluded from the study. All patients employed during the application were subject to a complete medical history, full physical examination and routine laboratory tests. During the first 2 hours after entering the intensive care unit, the following parameters were monitored every 30 minutes: vital signs, Glasgow coma (GCS), arterial blood gas (ABG) and rapid shallow respiration (RSBI). Acute physiology and chronic health evaluation (APACHE II) were calculated for all patients. Then, according to mechanical ventilation (MV), patients were divided into 2 groups that require non-invasive MV (NIMV) and require invasive MV (IMV).

Statistical analysis: The SPSS version 24.0 was used for data analysis. Quantitative data is articulated using mean, range, median and standard deviation, while qualitative data is expressed as percentage and frequency. The Chi-square test was used for qualitative data analysis and Fisher's exact test was used to compare both groups' data. While Student's t test is used for normally distributed quantitative data analysis, quantitative data that is not normally distributed was analyzed using the Mann Whitney test for 2 group's comparison. In addition, ROC was used to determine the sensitivity of various variables in predicting the need for mechanical ventilation. 0.05 equal or less P value was taken significant.

RESULTS:

In terms of demographic data, there was no gender alteration among the two groups studied. In the NIMV group there were 25 women (35%) and 45 men (65%), 17 women (37.7%) and 28 men (63.3%) in the IMV group. The NIMV group age fluctuated from 42–73 years with 52.40 ± 7.90 years mean value, and 46-88 years with 61.89 ± 9.60 years mean in IMV group, viewing a substantial alteration among the two groups (p=0.004). Regarding the symptoms of acute COPD exacerbation, no significant alteration was noted among the 2 groups. 48 patients (68.6%) in the NIMV group suffered from 4 cardinal symptoms, and only 22 patients (32.5%) did not experience an increase in purulent sputum, but 36 patients (80%) in the IMV group suffered from 4 cardinal symptoms and no purulent sputum rise was observed among 9 patients (20%). There was no substantial alteration between the 2 groups in symptoms of COPD exacerbation. Regarding the causes of acute exacerbation, most patients in both groups had chest infections and there was no significant difference between them. The average APACHE II result showed a statistically substantial variance among the 2 groups in favor of the IMV group. (p <0.001) (Table 1).

	NIMV (n = 70)	**IMV (n = 45)**	**test**	***p value***
Age	42–73	45-87		
Min. – Max.				
Mean ± SD.	52.40 ± 7.90	61.89 ± 9.60	t = 1.418	0.004*
Median	54	60		
Sex				
Male	45 (65%)	28 (63.3%)	χ^2=0.083	pFE = 0.5
Female	25(35%)	17 (37.7%)		
APACHE II score Min. – Max.	7.0 – 20.0	18.0 – 39.0		
Mean ± SD.	11.70 ± 2.46	25.10 ± 4.40	t = 1.584	<0.001*
Median	11	25		

Regarding vital signs measured at 5 stages (every 30 minutes during hospitalization and for the first 2 hours), heart rate during hospitalization and respiratory rate at each stage were significantly higher in the IMV group. When the respiration rate values after 30, 60, 90 and 120 minutes are compared with the respiration rate at hospitalization, both groups show a statistically significant difference (p = 0.001) and compare repeated heart rate measurements with the admission, only values at 90 and 120 minutes showed a statistically significant difference in NIMV group (p<0.05 and the values at 60, 90 and 120 minutes showed a statistically substantial change in the IMV group (p <0.05). The GCS assessment in five stages showed a significantly higher result in the NIMV group (p = 0.001). Comparing GCS after 30, 60, 90 and 120 minutes with GCS at the time of hospitalization, a statistically momentous alteration was shown in both groups (p = 0.001). In terms of routine laboratory tests, there was no significant alteration among the two groups in terms of hematocrit, electrolytes, white blood cell count, blood urea nitrogen, and serum creatinine, D-dimer or C - reactive protein. It was found to be significant in favor of the NIMV group in terms of platelet count between the two groups (p <0.05). As for the ABG input, the average pH was 7.28 ± 0.02 in NIMV, while it was 7.16 ± 0.09 in IMV (Fig. 1). ABG results in patients with NIMV were significantly better than in the IMV group. There was only a noteworthy alteration among the two groups in pH and blood pressure in carbon dioxide ($PaCO_2$) (p <0.05). Comparing the values of pH and $PaCO_2$ after 30, 60, 90 and 120 minutes with pH and $PaCO_2$ at the time of application, a significant statistic change was found in both groups (p <0.05).

The tidal volume comparison among 2 studied groups given in Table 2

Tidal Volume(Liter)	**0 min**	**30 min**	**60 min**	**90 min**	**120 min**
NIMV(n=70					
Min-max	0.13-0.25	0.13-0.25	0.13-0.26	0.13-0.25	0.16-0.28
Mean± *SD*	0.18±*0.04*	0.19±*0.04*	0.19±*0.04*	0.20	0.23
Median	0.17	0.18	0.20	0.21	0.22
P1 value		‹.001	‹.001	‹.001	‹.001
IMV(n=45)					
Min-max	0.09-0.21	0.10-0.23	0.10-0.23	0.11-0.24	0.10-0.27
Mean± *SD*	0.16±*0.04*	0.14±*0.05*	0.15±*0.03*	0.16±*0.04*	0.17±*0.06*
Median	0.13	0.13	0.14	0.15	0.16
P1 value		‹.001	‹.001	‹.001	‹.001
t	6.49	6.18	6.42	6.16	5.71
P value	‹.001	‹.001	‹.001	‹.001	‹.001

In terms of tidal volume and minute volume measured in five stages, the outcomes showed a significant statistic alteration among the 2 groups, they were worse in the IMV group (p <0.05) (Table 2). Regarding the main concept of the study, the RSBI measured in 5 stages showed a statistically substantial variance between the two groups (p <0.001). RSBI was higher in group B, and RSBI values after 30, 60, 90 and 120 minutes showed a significant statistic modification in both groups compared to RSBI on admission (p <0.001) (Table 3).

The rapid shallow breathing index among 2 studied groups given in Table 2

RSBI	**0 min**	**30 min**	**60 min**	**90 min**	**120 min**
NIMV(n=70					
Min-max	131-242	116-234	107-292	93-171	89-152
Mean± *SD*	190.12±*30.2*	169.02±*28.20*	143.95±*29.25*	124.95±*18.15*	114.95±*14.05*
Median	188.10	167.0	142.10	125.25	110.10
P1 value		‹.001	‹.001	‹.001	‹.001
IMV(n=45)					
Min-max	158-688	138-556	131-510	130-460	110-350
Mean± *SD*	355.90±*119.10*	*304.50±107.06*	259.04±*97.10*	229.30±*84.94*	147.45±*59.32*
Median	0.13	0.13	0.14	0.15	0.16
P1 value		‹.001	‹.001	‹.001	‹.001
t	7.60	6.80	6.18	6.60	6.90
P value	‹.001	‹.001	‹.001	‹.001	‹.001

The RSBI cut-off value that best differentiated the NIMV requirement from the IMV requirement was> 241 breaths / minute / liter, showing 100% specificity to determine the deterministic IMV requirement. 100% positive (PPV) and 90.9% negative predictive value (NPV) (Fig. 2).

DISCUSSION:

Evidence supporting the role of RSBI in mechanically ventilated patients has not yet been fully proven, but RSBI has been tested in many cases, such as weaning mechanically ventilated patients, patients with heart surgery and acute respiratory failure. In addition, it was compared with many forecast indicators. Various criteria have been established for determining the indications for mechanical ventilation, many of which require ABG analysis to accurately indicate the requirements for mechanical ventilation[9-10]. Few studies have been conducted to eliminate invasive interventions to determine ventilation needs, including the Crawford study in which various parameters are tested, for example: pH, RSBI, minute volume, lactate, CO2 production and APACHE II result. In this test using receiver performance characteristics (ROC), the sensitivity index estimated by RSBI at the time of use was 83.33% and the specificity value was 100%. In the next 4 stages, the rated sensitivity ratios were 73.33% and the specificity values were 98%. Cut-off points in five stages were over 241, 223, 188, 164 and 147, respectively, and were associated with high sensitivity and specificity to determine the need for IMV. RSBI> 241 was related with the highest specificity and sensitivity to determine the necessity for IMV. RSBI ≤ 241, 223, 188, 164 and 147 were related with high specificity and sensitivity to determine NIMV requirements[11-12]. RSBI ≤ 241 was associated with the highest sensitivity and specificity to determine NIMV requirements[13-14]. According to this study on the RSBI's ability to predict demand for MV, Hassan Soleimanpour et al tested the hypothesis that the RSBI may predict the need for NIMV in exacerbating COPD. The Hassan study was conducted on 98 patients divided into 2 groups requiring NIMV and not NIMV. Statistical logistic regression testing revealed that RSBI before treatment one hour and two hours after treatment showed high diagnostic sensitivity in patients requiring NIMV, as well as significant predictive capacity for admission in patients requiring NIMV. As with all measurements, the rated sensitivity ratios were 95.08%, 93.1%, 98.6%, respectively, and the specificity values were 95.2%, 93.81% and 96.5%, respectively[15]. In this study, the average APACHE II score in the IMV group was advanced than in the NIMV group (p <0.001). The Putinati study was conducted in a group of 59 COPD patients with acute respiratory failure and high APACHE II result.

CONCLUSION:

The cut-off value of the shallow breathing rate, which was better distinguished between non-invasive and invasive MV requirements by receiver Operating characteristics (ROC), was> 241 breaths / minute / liter, 88.33% sensitivity and 100% specificity. RSBI may be a good predictor of the need for ventilation assistance in acute COPD exacerbations. The limitation of this study is the small sample size. Further research is recommended to assess the serial use of RSBI and the RSBI factor together.

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