Research Article

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Journal of Emergency and Trauma Care

2020
Vol.5 No.2:21

DOI: 10.36648/trauma-care.5.2.21

Respiratory Muscle Strength Performance in Assessment of COVID-19 Patients Following Infectiong

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Citation: Agrawal A, Nalgirkar V (2020) Respiratory Muscle Strength Performance in Assessment of COVID-19 Patients Following Infection. J Emrg Trauma care. Vol.5 No.2:21

Abstract

Background: The respiratory muscle performance can be an important factor from the perspective of COVID 19 infection. It is a factor which is not appreciated much for contributing to poor outcomes during the corona virus pandemic. The primary aim of this study is to discuss the potential role of respiratory muscle performance followed by corona virus infection.

Aim: In this paper, we have tried to use the outcome of our study on chronic lung disease on the respiratory muscle strength of COVID 19 patients following infection.

Methods: This work was done at a Premier Medical Institute of Mumbai. After proper diagnosis from the Chest Physician and labelled as COPD patient, the Maximal Inspiratory Pressure (MIP) measurements, which is an index of respiratory muscle strength, was conducted.

Results: The analysis of variance (ANOVA) showed significant difference for maximal inspiratory pressure (p=0.003) between different stages of COPD. The MIP results showed that there was a statistically significant difference between mild and very severe (p=0.0019) as well as between moderate and very severe (p=0.002). A significant positive correlation among maximal static pressure and FEV1 % (r= 0.5) was also observed. MIP thus is an effective technique to measure reduced performance of respiratory muscle strength.

Conclusion: MIP can be the test of choice to test the impaired respiratory muscle performance following COVID 19 infection. It may be advantageous to screen for respiratory muscle impairment in patients with dyspnea or characteristics associated increased risk of severe respiratory complication due to viral infection. Being non-invasive, simple, and inexpensive; measurement of the MIP in COVID-19 patients especially with high-risks elderly would for sure be noteworthy.

Keywords: COVID 19; MIP; ROC

Received: June 26, 2020; **Accepted:** July 06, 2020; **Published:** July 13, 2020

Introduction

According to the current guidelines in the healthcare system, the pulmonary function testing should be limited to tests that are only essential for immediate treatment decisions. It is advised that the type of pulmonary function testing be limited to the most essential tests when possible, and that measures to protect both the staff and individuals being tested should be put in place [1].

The role of a type of pulmonary function test is Maximal Inspiratory Pressure (MIP) which depicts the Respiratory muscle strength is very well reviewed by Severin and coworkers recently [2], wherein they have evaluated all aspects of the treatment based on respiratory muscle testing and training. Through their vast experience, they have reviewed and hypothesised a model following COVID infection to improve outcomes and reduce the burden of future viral pandemics. We in this study have tried to use the outcome of our study on chronic lung disease involving dysnea on the COVID 19 patients following infection.

Another group [3] have recently published that grip strength is inversely associated with the most common global measures of maximal strength of respiratory muscles (i.e., maximal inspiratory pressure (MIP). Most pulmonary function tests including Respiratory muscle strength (MIP) were inversely associated with the diagnosis of sarcopenia and its indicators including grip strength.

Coronavirus (COVID-19) pandemic has shown how a single highly infectious virus can affect healthcare systems of developed as well as developing nations so drastically [4-8].

It is noticed that COVID-19 and other viral infections can cause significant damage to the lungs and air ways potentially resulting in acute respiratory distress syndrome and, if severe enough, respiratory failure [9]. Many patients with comorbidities as well as elderly population is at higher risk to developing severe respiratory complications from COVID-19 and require intensive care unit admission and mechanical ventilation [5-10]. Not only older age it also includes smoking as well as cardio metabolic and lung disease.[5-8] Patients with these characteristics are at higher risk for serious complications from seasonal flu [9-11].

As such, there are other, less appreciated factors contributing to the risk for poor outcomes resulting from the COVID-19 pandemic observed in admitted patients beyond the risk factors.

We hypothesize that one of the ignored aspect of COVID pandemic management is impaired respiratory muscle performance. While impaired respiratory muscle performance is considered to be rare [12,13] it is more frequently seen in patients possessing poor health characteristics, in particular chronic lung diseases. Measures of respiratory muscle performance are also not routinely performed in clinical practice, even in patients presenting with dyspnea [14]. Yang and coworkers [15] have investigated pulmonary rehabilitation for patients with COVID-19 having complications, such as chronic pulmonary disease, especially COPD patients. According to them, patients with COVID-19 having chronic pulmonary diseases often have excessive airway secretions, expiration exercises should be performed in addition to general airway clearance exercises to facilitate sputum excretion and reduce the exhaustion due to coughing. Chen and coworkers [16] have reported that due to chronic lung disease and reduced activity, the respiratory muscles of patients with COVID-19 are weakened.

More studies are needed to indicate whether respiratory muscle performance influences outcomes following a viral infection of any kind. There is some preliminary work that does suggest this is a plausible hypothesis, and Severin and co-workers [2] are currently working on developing studies to test this. The purpose of this paper is to discuss the potential role of testing respiratory muscle performance. It can be utilised for large population following COVID-19 infection.

Respiratory muscle physiology and the maximum mouth pressures

In healthy adults, the pressure needed for both full breaths and quiet breathing represents a small fraction of the respiratory muscles maximal pressure generating capacity [12]. In healthy individuals with normal total respiratory system compliance, the opening pressure required to fully inflate the alveoli is approximately 40 cm H_2O. Tidal breathing in healthy individuals only requires ≈5-10 cm H_2O [15]. The average maximal inspiratory pressure generated by a healthy adult aged 18-29 years is 128 cm H_2O (116.3-139.5 cm H_2O) for males and 97 cm H_2O (88.6-105.4 cm H_2O) for females. By comparison, the average maximal inspiratory pressure for a healthy adult aged 70-83 years is 76.2 cm H_2O (66.1- 86.4 cm H_2O) for males and 65.3 cm H_2O (57.8-72.7 cm H_2O) for females [12]. In India where the stature of a normal man is small as compare to the western world, the MIP values (according to the present study) are lower as compared to them (59.47 ± 14.94 cm H_2O).

Research Methodology

Recruitment

We planned this cross-sectional study which included 90 COPD patients (Age group 45-75 years) from PFT Lab of Chest Medicine Department, attending the outpatient department of chest medicine and were diagnosed to have mild to very severe Chronic Obstructive Pulmonary Disease (FEV_1/Forced Vital Capacity (FVC)<0.7) by a chest physician. Age matched healthy controls were also tested who denied any respiratory complaints. Participation in the study was voluntary. Oral and written information was given, and informed consent was obtained from all study subjects prior to enrolment. Ethics committee approval was taken before commencement of the study.

Statistical analysis

SPSS version 23 and Microsoft Excel software was used for statistical analysis. Data is represented as mean+/-SD. Z test was done, as the study is quantitative in nature and sample size was large. Statistical analysis to calculate sensitivity and specificity was done using Receiver Operating Characteristic Curve (ROC Curve). *P* value (z value) <0.05 is kept as significant for all statistical analysis. Confidence interval was calculated as 95%. Sample size was calculated by using n-Master 2.0. Repeatability of the parameters was assessed. Comparisons between the groups have been made by analysis of variance (ANOVA).

All patients were in clinically stable condition and mean age was 60.3±14.7 COPD patients showing obstructive pattern, that is FEV_1/Forced vital capacity (FVC)< 0.7 were recruited. Patients who have FEV_1 improvement after taking bronchodilator (≥ 12%) were excluded from the study. Patients suffering from Asthma, Interstitial Lung Disease, Lung Cancer, tuberculosis and neuromuscular disease were also excluded. Some patients were excluded because of lack of cooperation during spirometry and MIP manoeuvres.

Maximal inspiratory pressure measurements were performed and carried out with a computerized machine SPIRO AIR by MEDISOFT (Germany). The patient is asked to maximally inspire during MIP at the level of RV. The measurements were made in sitting position only. Subjects were encouraged continuously to achieve maximal strength. MIP measurements were repeated until three values varying by less than 5% were obtained.

We divided COPD patients into four groups on the basis of airway obstruction: mild (FEV_1 <80%), moderate (FEV_1 between 70% and 50%), severe (FEV_1 between 50% and 30%) and very severe (FEV_1 < 30%) with FEV_1/FVC <70% in all groups. The control group included 60 ages matched normal subjects, free of any respiratory complaints and symptoms and with normal functional parameters.

Results

As regard the maximal mouth pressures, MIP was significantly lower at all stages of COPD than in the control group. Mean MIP of COPD and Control group was 41.43 ± 16.30 and 59.47 ± 14.94 respectively. Average MIP was significantly higher in Control group than COPD. (z=-7.78).

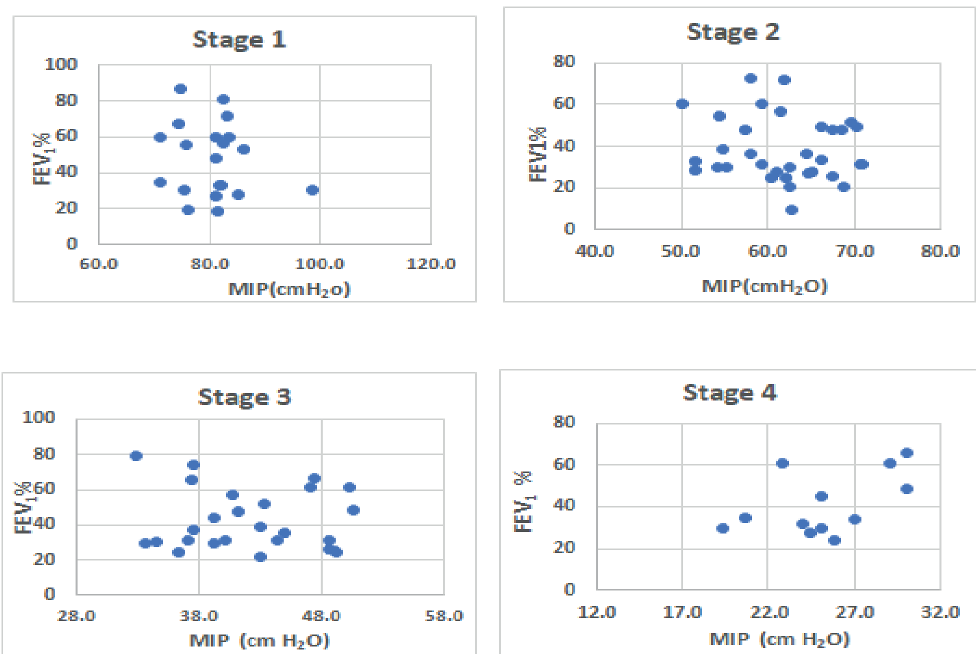
Moreover a possible correlation between COPD stages and respiratory muscular strength was evaluated. The analysis of variance (ANOVA) showed significant difference for maximal inspiratory pressure (p=0.003) between very severe, severe, moderate and mild stage. Within the different stages, the level of significance was tested using post hoc test. For FOT, the analysis of variance (ANOVA) showed no statistically significant difference between mild and moderate patients while the difference between mild and very severe (p= 0.0019) was significant as well as between moderate and very severe (p=0.002). The MIP results showed that there was a statistically significant difference between mild and very severe (p=0.0019) as well as between moderate and very severe (p=0.002).

A significant positive correlation among maximal static inspiratory pressure for stage 4 and FEV_1% (r= 0.5) was observed **(Figure 1)**. SPSS version 23 was used to plot Receiver operating curve to find out the sensitivity and specificity of MIP **(Figure 2)** shows ROC curve for of this techniques.

Discussion

One of the primary objectives of this study was to determine whether the decrease in Maximal inspiratory pressure is closely associated with different stages of airway obstruction. MIP values were lower in patients with different severity in obstruction than in normal patients. In fact, MIP values were decreased in patients with mild and moderate obstruction; this could suggest that even in early stage of COPD, there is deterioration of respiratory muscles. Thus using MIP, periodical evaluation of respiratory muscle strength seems to be a helpful tool in monitoring the disease severity.

In COVID patients, the respiratory muscle deterioration due to invasion of virus will lead to reduction in respiratory muscle strength. We propose to do MIP testing using a MIP measuring capsule after the recovery of the patient from COVID 19 infection.



a) Stage 1-mild COPD (FEV_1 % <80%), b) Stage 2- moderate (FEV_1 50%-70%), c) Stage 3 – severe (FEV_1 30%-50%), d) Stage 4 – very severe (FEV_1<30%)

Figure 1 Relationship between MIP and FEV1 (%).

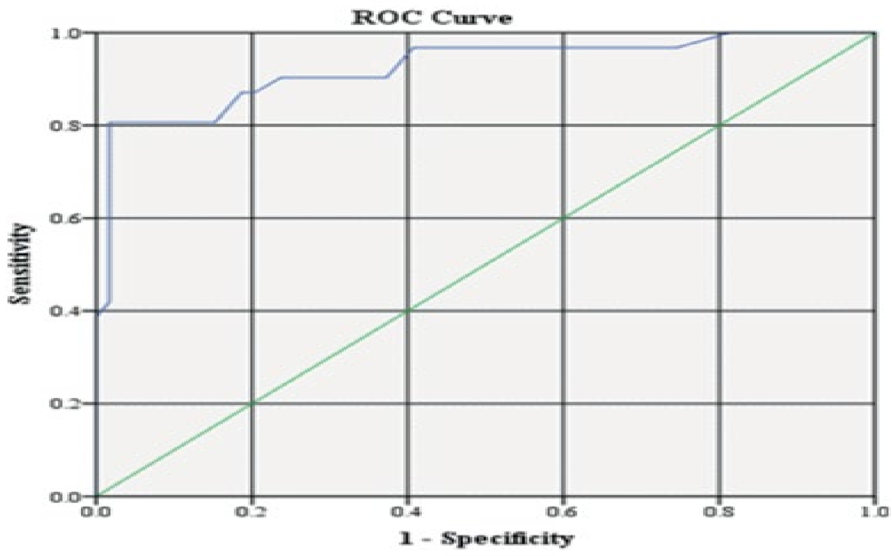


Figure 2 ROC Curves for MIP parameters in COPD patients.

Also if the respiratory muscle weakness is observed, such patients can be sent for respiratory muscle training programme [2].

Several factors like aging, physical inactivity, smoking and chronic lung diseases decrease respiratory muscle performance [17-21]. In patients with chronic lung diseases, in addition to a reduction in respiratory muscle strength, the demand imposed on the respiratory muscle also increases due to changes in airway resistance and chest wall mechanics [17-22]. Quiet breathing accounts for 1-3% of total oxygen consumption in normal weight, healthy individuals [18-22]. In an acutely diseased lung (e.g., acute respiratory distress syndrome), the pressure required to breathe further increases [23].

The respiratory muscle weakness is rare in the general population [24]. The threshold for respiratory muscle weakness in a younger healthy adult is also fairly low. However, respiratory muscle weakness is associated with dyspnea, and there are certain populations where respiratory muscle weakness is more likely. The maximal inspiratory pressure produced by the respiratory musculature decreases in healthy older individuals [12]. However, due to the normal age-related changes in lung compliance and muscle strength the threshold for respiratory muscle weakness with aging is also lower (i.e., >80 years: 42 cm H_2O) [13]. It is important to acknowledge that these age-related reductions are in reference to healthy individuals. As described earlier, in patients with multimorbidity, the risk of respiratory muscle weakness may increase or potentially compound these age related reductions in respiratory muscle performance [18-21].

While routinely screened measures of lung volume and flow rate are associated with respiratory muscle performance [19,20] changes in respiratory muscle performance may occur independently of these values and may be detected prior to changes in lung volume [19-20].

The capsule-sensing pressure gauge (CSPG-V) is a new tool that measures the strength of inspiratory muscles; it is easy to use, non-invasive, inexpensive and lightweight [25]. It is a small, handheld, portable, no battery-powered, device with a mouth pressure manometer attached to a flexible tube with a plastic rigid flanged mouthpiece and a small monitor that displays the test results in cm H_2O. With these new types of tools it is very easy to measure MIP. We strongly recommend the use of newly type's tools so that it is not at all inconvenient to a patient who has spent 15 days already under hospitalisation to recover from COVID-19 infection.

As regard the ROC curve for MIP, the cut off value of MIP of 83 gives sensitivity of 80.6% and specificity of 93.5% **(Figure 2).** As both sensitivity and specificity are above 80%, MIP can be used as a diagnostic tool for assessing the respiratory muscle weakness in patients. Since it is a good diagnostic tool, it can be test of choice in COVID patients following infection.

In times of crisis, it is important to remember our experiences and lessons learned from COVID -19. We need to be better prepared moving forward from a healthcare perspective. This preparation for the future entails exploring and testing possible solutions that have not been considered. As described in this paper, it appears diminished respiratory muscle performance, in conjunction with other disconcerting characteristics (e.g., chronic diseases), may contribute to the overwhelming burden imposed on healthcare systems due to viral pandemics. It is really of great concern that the frequency of viral pandemics and the prevalence of the global population at poor health associated with impaired respiratory muscle performance are potentially both at the tipping point.

We plan to use this hypothesis on COVID 19 patients following infection at our hospital, which is at present declared COVID Hospital and has huge inflow of patients. The increase in number of recovered patients is very encouraging. It may be of help to regain their respiratory muscle strength after following this protocol of MIP testing and MIP training by the therapists of the institute. Use of newer type of MIP measuring capsule sensing measure gauge can be very handy.

Conclusion

With so many factors which may be behind the viral pandemic scene, we propose that screening for respiratory muscle impairment in patients with dyspnea or characteristics associated increased risk of severe respiratory complication due to viral infection may be advantageous. Our research work done on COPD patients using MIP, strongly suggest the use of this technique in COVID 19 patients following infection. Use of relatively newer device may lead to better patient care and management pertaining to known and unknown causes of dyspnea requiring inspiratory muscle training.

Acknowledgements

We are grateful to Dr. Amita Athavale, Professor and Head, Chest Medicine Department for permitting us to use PFT lab. We are grateful to the technical team of pulmonary function laboratory of Department Of Chest Medicine for assisting us while collecting data. We are thankful to Dr. D.N. Shenvi, Professor and Head, Department of Physiology, for allowing us to use departmental facilities and help us in discussions regarding the results. We are thankful to our statistician Mr. P. Jadhav for helping us with the data.

Conflict of Interest

There is no conflict of interest.

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