Original research article

A study to determine Cardiopulmonary reserve and Vital capacity by Breath-holding test in Covid -19 patients in a Tertiary Care Hospital

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Abstract

Background & objectives: The most common clinical presentation of COVID 19 is acute respiratory distress syndrome. Due to its rapid and risky course of transmission and limited medical facilities, it is important to identify the patients with hampered lung function with minimal chance of aerosol spread. As conventional spirometry increases the chances of infection transmission, a breath-holding test can be used to determine vital capacity and cardiopulmonary reserve. Methods: From May 11 to June 4, 2020, a randomly sampled study was conducted in a tertiary care hospital, Ahmedabad. Patients aged between 18-65 years with mild to moderate COVID 19 infection and who were vitally stable were included in the study. In all participants, the breath-holding test was performed and vital capacity and cardiopulmonary reserve were measured. Results: 16 females and 34 males, with a mean age of 45.82±12.08, were included in the study. Average Breath-holding time was 28.56 - 15.20 seconds, vital capacity was 3400±892.142 liters. Patients had 32%, 56% and 12% grade 0, 1 and 2 cardiopulmonary reserves respectively. Interpretation & conclusion: From our study, we concluded that vital capacity and cardiopulmonary reserve are compromised in patients with mild to moderate covid 19 infections. No Patients with more than two comorbidities had normal cardiopulmonary reserve and even vital capacity was lowest in them, when compared to patients with no comorbidities.

Keywords: breath-holding test, cardiopulmonary reserve, Covid 19, vital capacity

Introduction

Coronaviruses (CoVs), which are large enveloped non-segmented positive-sense RNA viruses, generally cause enteric and respiratory diseases in animals, and human research into their behavior is nearly a century old. (1) In late 2019, a novel coronavirus emerged in Wuhan, China, and then spread worldwide. In February 2020, the World Health Organization designated coronavirus disease 2019 (COVID-19) as the name of the human disease caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), which was previously known as 2019-nCoV (2019 novel coronavirus). (2) Viral pneumonia is the most frequent and serious clinical manifestation of COVID-19, prominently featuring fever, cough, dyspnoea, weakness, hypoxemia, and bilateral infiltrates on chest radiography. Dry cough is more common than a productive cough. Dyspnea appears after a median time of 5 to 8 days. (2) In light of the widely documented lung injuries related to COVID-19, concerns have been raised regarding the assessment of lung injury for discharged patients. Ground-glass opacities in bilateral, peripheral and lower lobe distribution appear to be the most common pattern on computed tomography (CT) scanning. A study showed that discharged patients with COVID-19 pneumonia still have residual

abnormalities in chest computed tomography (CT) scans such as ground-glass opacities in bilateral, peripheral, and lower lobe distribution, which appear to be the most common pattern. (3,4) As COVID-19 is extremely contagious and is transmitted quickly, it’s virtually important to adhere to infection control measures as outlined by the hospital and health department policies to avoid transmission of COVID-19. Serious cases of Covid 19 lead to fibrosis as late changes. (3,5) Monitoring and targeting physiological levels of breathing effort is important for optimizing lung protection and potentially preventing diaphragm dysfunction, but this poses new challenges at the bedside and it remains uncertain whether such a strategy can be implemented effectively. (2)
The vital capacity may assist in the diagnosis of underlying lung disease. It may also assist in differentiating between the various causes of lung disease. (6) Underlying lung disease can easily be diagnosed with pulmonary function testing but a conventional way of doing pulmonary function tests is not possible due to the high chances of spreading infection, but many studies concluded that breath-holding test can be used to determine vital capacity and cardiopulmonary reserve. (7) However, until now, there is no report regarding breath-holding capacity and cardiopulmonary reserve in the patients. Thus, the aim of this study is to measure vital capacity and cardiopulmonary reserve as there is no chance of aerosol spread, and which will help to categorize the patient and more attention can be given to those who have less BHT. Breath holding test can be used as a vital sign in covid patients, and as an easy and safe method to determine pulmonary function

Materials and Method
The study to determine cardiopulmonary reserve and vital capacity by the breath-holding test was done in patients aged between 18-65 years and with mild to moderate covid-19 infection. The severity of COVID-19 was determined by the following category:
1) Mild Disease - Symptomatic patients meeting the case definition for COVID 19 without evidence of viral pneumonia or hypoxia.
2) Moderate disease (Pneumonia) - Adolescents or adults with clinical signs of pneumonia (fever, cough, dyspnea, and fast breathing) but no sign of severe pneumonia and SPO2 greater than or equal to 90% on room air.
3) Severe disease (Severe Pneumonia) - Adolescents or adults with clinical signs of pneumonia (fever, cough, dyspnea, and fast breathing) + one of the following: Respiratory rate greater than 30bpm, severe respiratory distress or SPO2 less than 90% on Room Air.

In BHT respiration can be voluntarily inhibited for some time but eventually, this voluntary control is overridden. The point at which the breathing can no longer be voluntarily inhibited is called the “breaking point”. Breaking is due to the rise in the arterial PCO2 and fall in PO2. (8) After obtaining written informed consent, information regarding Demographic data and onset of symptoms and comorbidities was taken. Examination of vital signs was done prior to the testing as only vitally stable patients on room air were included in the study. One familiarization session was held before the beginning of data collection. The breath-holding test was performed as follows: In all participants, the breath-holding test was performed in the morning before breakfast. After inhalation of atmospheric air volume, which was equal to approximately two-thirds of the subject's vital capacity, a voluntary maximal inspiratory breath-holding was performed. The counting of the duration of the breath-holding was made by a stopwatch from the beginning of the inspiration to the appearance of reflex contractions of the diaphragm, which were determined by the palm of the researcher located in the epigastric region of the subject. The test was performed three times with an interval of 10 minutes. The mean value of the three samples was recorded as a result of BHT. (5,8) Permission from the Ethical Committee was taken. Written informed consent was obtained from the participants.

Study design
Sampling design and sample size: A Purposive sampling method was used. A sample size of 41 was calculated by keeping an error (%) 5 percent and a design effect of 0.667.

Inclusion criteria
Age criteria: 18 - 65 years.
Patients with **Mild to Moderate Covid-19** (4) infection will be included.
Stable ward patients.

Exclusion criteria
Unstable ward patients.
Patients on high flow nasal cannula, Bi-PAP, or Mechanical Ventilator.
Patients with Lung conditions like COPD, Tuberculosis, Asthma, ILD, etc.
Chronic smoker
The study was conducted from May 11 to June 4, 2020.

Statistical analysis: The Statistical analysis was performed using Statistical Package for Social Science (SPSS) Version 16.0.

Results:
The Demographic and clinical characteristics of the study population are reported in the Table given below. 50 patients, both male and female, were included in the study. Measurement data were expressed as mean ± standard deviation. The data in the Table:1 indicates demographic data, vital signs, duration of hospitalization (days), breath-holding capacity (seconds) and vital capacity (CC).

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	SD
AGE (Years)	50	24.0	65.0	45.820	12.0808
PR (beats /min)	50	58.0	122.0	86.320	14.2320
Systolic BP (in mm Hg)	50	100.0	150.0	125.040	9.3218
Diastolic BP (in mm Hg)	50	70.0	90.0	80.400	6.2857
RR (breaths /min)	50	11.0	20.0	15.480	2.4431
SPO2 (% on RA)	50	93.0	99.0	96.960	1.4702
DURATION (in days)	50	1.0	19.0	5.560	3.8447
DAYS OF HOSPITALISATION (in days)	50	1.0	19.0	7.160	4.0525
BHC (BEST)	50	11.0	105.0	28.560	15.2063
VC (IN CC)	50	2000.0	4500.0	3400.000	892.1426
Valid N (listwise)	50				

SBP - Systolic blood pressure, DBP - Diastolic blood pressure, RR – respiratory rate, SPO2 – Oxygen Saturation, RA – Room air, BHC – Breath Holding Capacity, VC – Vital Capacity, CC – Cubic centimetre, SD – Standard Deviation.

The data in Table 2a represents the cardiopulmonary reserve grades and their frequency among patients.

The data in Table 2b represents the number of comorbidities among individuals.

Table 2a and 2b:

No of comorbidities	frequency	Percentage	Cardiopulmonary reserve	frequency	Percentage
0	25	50.0	0	16	32.0
1	15	30.0	1	28	56.0
2	10	20.0	2	6	12.0
Total	50	100.0	Total	50	100.0

The data in Table:3 represents the cross-tabulation between the number of comorbidities and Cardiopulmonary reserve.

Table 3: of Co-morbidities and Cardiopulmonary Reserve Cross tabulation

		CARDIOPULMONARY RESERVE			Total
		0	1	2	
No Of Co-morbidities	0	8	14	3	25
	1	3	9	3	15
	2	5	5	0	10
Total		16	28	6	50

Table 4: Correlation between vital capacity, breath hold capacity and days of hospitalization.

		Vital Capacity (In Cc)	BHC (Best)	Days Of Hospitalisation (In Days)
Days of Hospitalisation (In Days)	Correlation Coefficient	-.055	-.064	1.000
	Sig. (2-Tailed)	.705	.660	
	N	50	50	50
**. Correlation is significant at the 0.01 level (2-tailed).				

Discussion
Breath-holding time (BHT) may be considered as one of the indicators of efficiency of breathing function. The maximal breath-holding time (BHT) has been used in respiratory physiology as a measure of ventilatory response.[9] [8] The breath-hold test is the length of time until the first urge to breathe. This easy breath-hold provides information on how soon the first sensation of breathlessness takes place and was noted to be a very

useful tool for the evaluation of dyspnoea. (5) Normal voluntary breath-holding time is 45-55 seconds. Respiration can be voluntarily inhibited for some time, but eventually, the voluntary control is overridden. BHT is directly proportional to the lung volume at the onset of breath-holding, partly because this has a major influence on oxygen stores. (9)

The lack of physical movement, on top of the infection and inflammation, leads to severe muscle loss. The muscles for breathing are also affected, which weakens the breathing capacity. The result of our study shows that the Breath hold duration was significantly affected in patients with mild to moderate COVID 19 when compared to normal population findings. Patients with comorbidities have lesser breath holding time when compared with the patients who have no comorbidities. Results of our study state that out of the 10 patients who had 2 or more comorbidities, 5 of them had grade 0 cardiopulmonary reserve and 5 of them had grade 1 cardiopulmonary reserve but none of them had a normal cardiopulmonary reserve.
Also, no significant correlation was found between breath holding capacity and days of hospitalization. It might occur because patients with mild to moderate covid were included in our study.

A study done by Whitelaw et al., 1987 demonstrated a positive correlation between the duration of breath-holding and vital lung capacity. Nikita Trembach and Igor Zabolotskikh did study on Influence of Age on Interaction between Breath-Holding Test and Single-Breath Carbon Dioxide Test. The results indicate a positive correlation between the duration of breath-holding and vital lung capacity. (7) Trembach Nikita did a study on Breath-holding test in evaluation of peripheral chemoreflex sensitivity in healthy subjects and found a positive correlation between the breath-holding duration and vital lung capacity ($r = 0.64$, $p < 0.05$) and they noted that increasing age has no effect on this pattern. (10) Though the direct Patho-physiological mechanisms of covid affecting BHT is not clear, patients with covid have reduced BHT and vital capacity. The lack of physical movement, on top of the infection and inflammation, leads to severe muscle loss. The muscles for breathing are also affected, which weakens the breathing capacity. Pulmonary rehabilitation, which involves physical exercises and advice on managing symptoms, including shortness of breath and post-traumatic stress disorder, is crucial for helping patients to recover fully.

Conclusion

The present study determines cardiopulmonary reserve and vital capacity by maximal breath-holding time (BHT) which can be used in respiratory physiology as a measure of ventilatory response.

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