Original Research Article

International Physiology
Volume 7 Number 2 May - August 2019
DOI: https://dx.doi.org/10.21088/ip.2347.1506.7219.2

Correlation Between Rate Pressure Product and Severity of Chronic Obstructive Pulmonary Disease

Bharti Bhandari[1], Abhinandan Kumar[2], Bharati Mehta[3]

Author Affiliation

[1]Associate Professor, Department of Physiology, Government Institute of Medical Sciences, Greater Noida, Uttar Pradesh 201310, India, [2]Final year MBBS Student, [3]Additional Professor, Department of Physiology, All India Institute of Medical Sciences, Jodhpur, Rajasthan 342005, India.

Corresponding Author

Bharti Bhandari, Associate Professor, Department of Physiology, Government Institute of Medical Sciences, Greater Noida, Uttar Pradesh 201310, India.

E-mail: drbhartibhandari@yahoo.co.in

Received on: 03.07.2019

Accepted on: 22.08.2019

Abstract

Objectives: Cardiac co-morbidities add to the overall morbidity and mortality of patients with COPD. Rate Pressure product is the product of systolic blood pressure and heart rate and is indicative of increased myocardial oxygen demand or the cardiac workload. The objective of the study was to assess cardiovascular status of Chronic Obstructive Pulmonary Diseasepatients, by determining rate pressure product (RPP). The study was performed with the hypothesis that RPP would be increased in COPD patients and may be used to detect cardiovascular complications in these patients. *Methods and materials:* Thirty COPD patients of more than 18 years age without frank cardiovascular symptoms were selected. Patients with pulmonary co-morbidities, diabetes mellitus, hypertension, thyroid disorders, any heart disease or other diseases that may affect cardiovascular system were excluded from the study. They were divided into different stages of severity (GOLD classification), based on FEV1. Their RPP was calculated. *Outcomes:* The results showed RPP to be above normal range in all the patients. Spirometry was abnormal (decreased FVC, FEV1, FVC/FEV1 below predicted) in all the patients. A negative correlation was observed between FVC/FEV1 and FEV1 and RPP, however it was not statistically significant. *Conclusion:* The study emphasises the implication of RPP in detecting early and imperceptible cardiovascular morbidity in COPD patients.

Keywords: COPD; Rate pressure product; Cardiovascular morbidity.

How to cite this article:

Bharti Bhandari, Abhinandan Kumar, Bharati Mehta, Correlation Between Rate Pressure Product and Severity of Chronic Obstructive Pulmonary Disease. International Physiology. 2019;7(2):61-65.

Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible. The systemic involvement in patients with COPD, as well as the interactions between COPD and its comorbidities, better describes COPD as a chronic systemic inflammatory syndrome.[1] The pathogenesis of COPD is closely linked with aging, as well as with cardiovascular, endocrine, renal, and other systemic pathologies, decreasing the quality of life of patients with COPD and, furthermore, complicating the management of the disease.[2,3] Among these, cardiovascular complications are a major cause of morbidity and mortality in COPD patients, which include systemic hypertension, dyslipidaemia, ischemic

heart disease, chronic heart failure, vasculopathies etc.[4,5]

Higher prevalence and incidence of cardiac comorbidities are observed in patients with COPD than in matched controls.[2] Presence of COPD may be an independent risk factor for the development of these cardiovascular diseases above that associated with the most widespread factor these diseases have in common, namely smoking.[6] Autonomic impairment primarily sympathetic over-activity has been implicated as a cause of cardiovascular complications in these patients.[7,8] In addition, recurrent hypoxemia, hypercapnia, increased intrathoracic pressure swings due to airway obstruction, increased respiratory effort, systemic inflammation and the use of beta-sympathomimetics may also lead to associated cardiovascular symptoms in COPD patients.[7]

The efficiency of the myocardium to perform work can be represented by the myocardial oxygen consumption (MVO2), which is the most important indicator of the load on the heart.[8–10] Rate Pressure Product (RPP) is a non-invasive method of estimating MVO2 and can be calculated by multiplying HR by SBP and dividing by 1000 (RPP = [(HR × SBP)/1000]).[8–10] According to Fletcher *et al*. (1979), under resting conditions, safer RPP should range between 7.00 and 9.00,[9] RPP more than 10.00 is a clear indicator of increased risk for heart disease.[9,11] RPP, also referred to as double product, has been recognized as a relevant parameter in evaluating ventricular function and is used as a predictor of cardiovascular morbidity.[12–14]

Keeping in mind the association between COPD and cardiovascular complications, we hypothesised that the rate pressure product may be deranged in COPD patients even before the onset of cardiovascular symptoms. So we have planned the current study to evaluate cardiovascular status in COPD patients by measuring RPP and further to correlate the same with the severity of COPD.

Materials and Methods

This Cross-sectional study was commenced after approval from the Institutional Ethics Committee. It was conducted in the Autonomic Function Laboratory of the institute on thirty COPD patients.

The sample size was calculated with reference to the work by Sembulingam P *et al*., 2015; using Master 2.0 software (CMC, Vellore).[11]

Men and women of more than 18 years attending the outpatient Pulmonary Medicine Clinic and diagnosed of COPD as per GOLD 2015 guidelines were selected for the study.

Patients with pulmonary comorbidities or Patients with diabetes mellitus, hypertension, thyroid disorders, any heart disease or other diseases that may affect cardiovascular system and those who were unwilling to participate, were excluded from the study.

Written informed consent was obtained from the participants after explaining them the importance of the project, their role in the project and the procedural part of the project. Detailed history, including any present medical complaints, duration of disease, past history of any illness pertaining to cardiovascular, respiratory and musculoskeletal system, history of chest pain or breathlessness and history of smoking, alcohol or tobacco intake was also recorded. Clinical examination and other investigations was done between 9:00 am - 12:00 pm to avoid confounding effects of circadian rhythm on spirometry and cardiovascular parameters.

The GOLD staging system was used which classifies people with COPD based on their degree of airflow limitation.[15] Airflow limitation was assessed by Spirometry; which is a simple, non-invasive technique. It was carried out in all the patients by single trained technician following standard protocol to assess the severity of COPD. The spirometric parameters on which diagnosis of COPD is based were forced vital capacity (FVC) and forced expiratory volume in one second (FEV1). The total, forcefully exhaled breath, following deep inspiration is called the forced vital capacity (FVC), measured in liters. The volume of FVC in first second of forced exhalation is called the forced expiratory volume in one second (FEV1), also measured in liters. In patients with FEV1/FVC < 0.70, GOLD classification was used to describe the severity of the obstruction or airflow limitation. The worse a person's airflow limitation is, the lower their FEV1. As COPD progresses, FEV1 tends to decline. GOLD staging uses four categories of severity for COPD, based on the value of FEV1.[16]

Stage I	**Mild COPD**	**FEV1 ≥ 80% of predicted**	
Stage II	Moderate COPD	FEV1	50–79% of predicted
Stage III	Severe COPD	FEV1	30–49% of predicted
Stage IV	Very Severe COPD	FEV1	< 30% of predicted, or < 50% normal with chronic respiratory failure present

The blood pressure (BP) and heart rate (HR) was recorded in all patients using an oscillometric sphygmomanometer. Since oscillometric devices are declaredly unreliable in persons with arrhythmias and those with mid-upper arm circumference >42 cm, such subjects were not included in this study. BP measurements were done in conformity with the updated American Heart Association guidelines for office BP measurement.[17] To stabilize the blood pressure, subjects were made to take rest for 5 min before starting the measurement. Rate pressure product (RPP) was calculated using the formula: RPP = (HR × SBP)/1000).[9]

Statistical analysis was done using SPSS for windows (Version 21; Chicago, IL, USA). The distribution of variables was assessed by means of Kolmogorov-Smirnov normality test. Correlation between two parameters was analyzed using Pearson's correlation test.

Results

The basic characteristics of the patients are given in Table 1.

Table 1: General characteristics of the COPD patients

Parameters	Values
Age (years)	64.75 ± 6.12
Height (cm)	166.8 ± 6.13
Weight (kg)	61.8 ± 14.64
BMI (kg/m^2)	22.29 ± 4.54

All the values are Mean ± SD. BMI: Body mass index.

Cardiovascular (Systolic blood pressure and heart rate) and important spirometric (FVC, FEF1, FEF1/FVC) findings are given in Table 2. The percentage predicted values of the above-mentioned spirometric parameters in all the patients were below normal. The mean RPP was more than the normal range.

Table 2: Cardiovascular and Spirometric parameters

Parameters	Values
FVC (L)	2.6 ± 0.72
FEV1 (L)	1.53 ± 0.61
FEV1/FVC (%)	56.6 ± 13.4
SBP (mmHg)	129 ± 17.9
HR (bpm)	82.35 ± 11.9
RPP (SBP*HR)/1000 (mm Hg• bpm)	10.7± 2.5

All the values are Mean ± SD. BMI: Body mass index. FVC: Forced Vital Capacity; FEV1: Forced Expiratory Flow in 1 second; SBP: Systolic Blood Pressure; HR: Heart Rate; RPP: Rate Pressure Product.

Table 3: Correlation of spirometric parameters with Rate Pressure Product.

Spirometric parameters	*r*	*p* value	
FVC/FEV1		–0.42	0.06
FEV1		–0.12	0.64
FEV1 (Stage I & II)	RPP	-0.25	0.48
FEV1 (Stage III)		-0.26	0.62
FEV1 (Stage IV)		-0.74	0.26

$p < 0.05$ were considered statistically significant. Non-significant negative correlation was observed.

Similarly, non-significant negative correlation was observed between FEV1 and RPP irrespective of the severity of disease (Table 3).

Discussion

COPD and chronic cardiac diseases share common risk factors like old age, smoking, sedentary life style, persistent low-grade pulmonary and systemic inflammation.[1–3] With this background, we proceeded with the hypothesis that the rate pressure product, which is an index of myocardial oxygen consumption and reflects hemodynamic stress, may be deranged in COPD patients even before the onset of cardiovascular symptoms.[8,10,14] In this study, we evaluated the cardiovascular status in COPD patients by measuring RPP and further correlated the same with the severity of COPD.

The rate pressure product was found to be more than the prescribed normal range of 7–9, indicating increased myocardial oxygen consumption and hence increased hemodynamic stress in COPD patients. Similar to our study, many researchers have found RPP to increase in patients of COPD.[18–20] Tzani and co-authors showed that COPD patients with dynamic hyperinflation have a poor cardiovascular response to exercise, supporting the view that in COPD patients, dynamic hyperinflation may affect exercise performance not only by affecting ventilation, but also cardiac function.[18] J. Travers *et al*., 2007 reported improved cardiac as well as pulmonary function with Tiotropium during exercise in COPD. The increased RPP in COPD patients due to exercise was found to decrease with tiotropium.[19] Vengatasubramani M and Vikram M, 2015 observed that the increased RPP in COPD patients decreased with specifically designed physical activity, thus improving the cardiovascular fitness in these patients.[20] As expected, the predicted values of FVC, FEV1 and FEV1/FVC were below normal. We could not detect significant correlation

between spirometric findings and RPP, though a non-significant negative correlation was observed between these parameters, irrespective of the stage of the disease. On literature search, we were not able to retrieve any study correlating these two parameters. Negative correlation is suggestive of increased myocardial workload in patients of COPD, however statistical non-significance makes its clinical importance questionable. We need to extend the study further with increased sample size and consider the duration of disease as well.

Conclusion

Our results were suggestive of increased rate pressure product in all stages of COPD. This indicates increased myocardial workload in these patients. Though a negative correlation was detected between spirometric records and RPP, but was statistically non-significant. Our sample size was small and very few patients were included in each stage of COPD. To confirm the cause, we need to extend the study further, with bigger sample size, taking into consideration duration along with the severity of COPD. We conclude by saying that this simple non-invasive procedure may help in early recognition of the cardiovascular comorbidity in these patients and may help doctors in making better treatment recommendations for people with COPD.

Conflicts of Interest: The authors declare no conflict of interest.

Financial Support: ICMR STS

Research Grant: STS project grant from ICMR

Ethical Issues: None to be declared.

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