

Correlation of body mass index, degree of airflow obstruction, dyspnea scale, and exercise index with pulmonary hypertension

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ABSTRACT

Introduction: Cardiovascular disease is major comorbidity and most frequent disease coexisting with chronic obstructive and pulmonary disease (COPD). BODE (body mass index, degree of airflow obstruction, dyspnea scale and exercise) index is a multi-dimensional tool to assess severity of COPD. This study was undertaken to assess the BODE index as a predictor of development of pulmonary hypertension (PHT) in COPD patients.

Aims: The aim of the study was to assess the correlation between the BODE index and PHT as diagnosed by 2DEcho.

Materials and Methods: We conducted a prospective study over a period of 2 years on 60 stable COPD patients by evaluating the BODE index and categorizing into mild, moderate, and severe COPD cases on the basis of spirometry and into 4 quartiles on the basis of BODE index value (scores 0-2, 3-4, 5-6, and 7-10). PHT was defined in this study as pulmonary artery systolic pressure ≥ 30 mmHg. We investigated the prognostic value of BODE quartiles for prediction of development of PHT in COPD patients.

Results: In our study, spirometry showed mild obstruction in 16.7%, moderate obstruction in 26.7%, severe obstruction in 38.3%, and very severe obstruction in 18.3% of patients. According to BODE score, 52% of patients were quartile 1, 21% quartile 2, 15% quartile 3, and 12% were quartile 4. In this study group, 46.7%, 31.7%, 11.7%, and 10.0% patients were with no, mild, moderate, and severe PHT, respectively.

Conclusion: COPD patients with higher BODE index should also be looked for other causes of developing PHT, and such patients should undergo 2DEcho on regular intervals.

Key words: Body mass index; degree of airflow obstruction; dyspnea scale and exercise index, chronic obstructive and pulmonary disease, pulmonary hypertension, spirometry

INTRODUCTION

Chronic obstructive and pulmonary disease (COPD) is defined as a common preventable and treatable disease, characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airway and the lung to noxious particle or gases. Exacerbations and comorbidities contribute to the overall severity in individual patients.^[4] Globally, COPD has emerged as the major cause of morbidity and mortality expected to become the 3rd most leading cause of death and the 5th leading cause of loss of "disability-adjusted life years" as per projection of the global burden of disease study.^[2]

We conducted a prospective study over a period of 2 years on 60 stable COPD patients by evaluating the BODE index and categorizing into mild, moderate, and severe COPD cases on the basis of spirometry and into 4 quartiles on the basis of BODE index value (scores 0-2, 3-4, 5-6, and 7-10).^[1,3]

Pulmonary hypertension (PHT) secondary to COPD is placed in Group 3 of the Dana Point, 2008^[5] classification of PHT, that is, PHT associated with lung diseases and/or hypoxemia. The prevalence of PHT in stable COPD varies from 20% to 91% depending on the definition of PHT (mean pulmonary artery pressure [mPAP] >20 vs. >25 mmHg), the severity of COPD (forced expiratory volume in the first second [FEV¹]), and the method of measuring the pulmonary artery pressure (PAP) (echocardiography vs. right heart catheterization).^[6-11] In severe COPD patients with or without resting PHT, steady-state exercise may raise PAP to about twice the level of its resting value.^[12] In severe COPD activities of daily living such as climbing stairs or walking can induce transient PHT. In patients with severe COPD, oxygen saturation may fall during REM sleep by 20-30%^[13,14] and PAP may rise by as much as 20 mmHg.^[15] During an acute exacerbation of COPD, PAP may rise by as much as 20 mmHg and return to its baseline after recovery.^[16,17] However, many patients with COPD have systemic manifestations that are not reflected by FEV¹ alone.^[18]

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The development of PHT in COPD adversely affects survival, exercise capacity and is associated with increased morbidity and mortality and increased risk of acute exacerbations.

PAP depends on cardiac output, pulmonary vascular resistance, and pulmonary artery wedge pressure [Figure 1].

Body mass index, degree of airflow obstruction, dyspnea scale and exercise (BODE) index: Body mass index (B), degree of airflow obstruction (O), dyspnea (D), and exercise capacity (E), measured by 6 minute walk test (6MWT) is a validated, simple, multidimensional 10 point grading system predicting the risk of death from any cause and from respiratory causes among patients with COPD.^[19] Quartile 1 is defined by a score of 0–2, quartile 2 by a score of 3–4, quartile 3 by a score of 5–6, and quartile 4 by a score of 7–10.^[19] BODE index is useful because it includes one domain that quantifies the degree of pulmonary impairment (FEV1), one that explains the patient (the Modified Medical Research Council [mMRC] dyspnea scale), and two independent domains (the distance walked in 6 min and the body mass index [BMI]) that express the systemic consequences of COPD.

MATERIALS AND METHODS

This was a prospective study involving 60 stable COPD patients conducted at a tertiary care center over a period of 2 years, started after Institutional Ethical Committee approval.

Already diagnosed and newly diagnosed cases of COPD who meet the global obstructive pulmonary disease (GOLD) criteria of spirometry diagnosis with a post-bronchodilator FEV¹ to forced vital capacity (FVC) ratio <70% were included in the study. Asymptomatic patients visiting the health check-up were also included. Exclusion criteria were patients with a diagnosis of bronchial asthma, bronchiectasis, or other chronic lung disorder requiring treatments, interventions, or diagnosis. Any other severe systemic comorbidities such as congenital or ischemic heart diseases, neoplasm, chronic kidney disease, and stroke except hypertension and diabetes mellitus were excluded. Detailed history including age, smoking status was taken as per the pro forma. Detailed general and physical examination were done. BMI, mMRC, FEV¹ %, and 6MWT were calculated when the patient was stable, i.e., not in exacerbation. BMI was calculated as per the body weight in kg and square of height in meters. Patients were asked to do spirometry to calculate post-bronchodilator

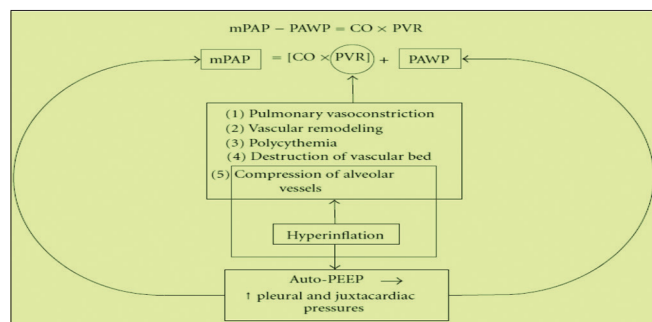


Figure 1: Pathophysiology of PH in chronic obstructive and pulmonary disease. mPAP: Mean pulmonary artery pressure, PAWP: Pulmonary artery wedge pressure, CO: Cardiac output, PVR: Pulmonary vascular resistance, PEEP: Positive end-expiratory pressure

FEV¹ to FVC ratio (desired value was FEV¹/FVC<70%) and post-bronchodilator FEV¹% to grade COPD as mild, moderate, severe, and very severe. mMRC scoring system was used on each patient to grade the degree of breathlessness experienced by the patient. Patient’s exercise capacity was measured with the help of 6MWT. Patients are asked to walk with their normal pace till they get tired, or till 6 min, whichever is early, oxygen saturation is measured with the help of pulse-oximetry at the start and end of walking. Distance walked in meters is calculated.

PHT was defined in this study as pulmonary artery systolic pressure (PASP) ≥30 mmHg (PASP) as assessed by 2Decho. PHT was classified into mild, moderate, and severe category as PASP 30–50, 50–70, and >70 mmHg, respectively.^[20]

BODE index was calculated as mentioned above and patients were divided into 4 quartiles. BODE index was then correlated with the development of PHT in COPD patients. The data were analyzed systematically.

Statistical Analysis

Association between qualitative variables was assessed by Chi-square test, with continuity correction for all 2 × 2 tables and by Fisher’s exact test for all 2 × 2 tables where Chi-square test was not valid due to small counts. In the presence of small counts, in tables with more than two rows and/or columns, adjacent row and/or column data was pooled and Chi-square test reapplied. Continuity correction was applied for all 2 × 2 tables after pooling of data. Fisher’s exact test was applied for all 2 × 2 tables where P-value of Chi-square test was not valid due to small counts, in spite of pooling of data. Correlation between BODE index and various variables was done using Spearman rank-order correlation.

RESULTS

In our study, patients belonged to the age group 35–70 years with a mean age of 56.07 ± 7.6 years. In our study, among the 60 patients, 47 (78.3%) patients were smoker in comparison to 13 (21.7%) patients who were non-smoker [Table 1]. The mean and median number of pack-years was 20.65 ± 11.55. BMI of all 60 patients was calculated, minimum BMI was 15.43 kg/m²

Table 1: Distribution of smoking among the study group

Smoking	n (%)
Yes	47 (78.3)
No	13 (21.7)
Total	60 (100.0)

Table 2: Distribution of mMRC among the study group

mMRC	n (%)
0	6 (10.0)
1	34 (56.7)
2	8 (13.3)
3	11 (18.3)
4	1 (1.7)
Total	60 (100.0)

mMRC: Modified medical research council

and the highest being 34.77 kg/m² with a mean of 22.29±4.63 and 50% of patients had BMI >21. In our study, percentage of mMRC grade 0, 1, 2, 3, and 4 is 10%, 56.7%, 13.3%, 18.3%, and 1.7%, respectively [Table 2]. Maximum patients belonged to Grade 1. Mean mMRC is 1.45 ± 0.96. Spirometry showed mild obstruction in 16.7%, moderate obstruction in 26.7%, severe obstruction in 38.3%, and very severe obstruction in 18.3% of patients [Figure 1]. In this study group, 46.7%, 31.7%, 11.7%, and 10.0% patients were with no, mild, moderate, and severe PHT, respectively [Figure 2]. In our study, Quartile 1, 2, 3, and 4 had 23.3% (14 patients), 36.7% (22 patients), 30% (18 patients), and 10% (6 patients), respectively [Figure 3], maximum patients belonged to quartile 2 (BODE score 3–4). Minimum and maximum BODE score observed in our study was 1, present in 13.3%^[8] patients, and 9, present in 1.7%^[1] patients, respectively [Figure 4]. Mean BODE index in our study is 4.03. Mild PH is seen in 80% cases of mild COPD whereas severe PH is seen in 54.5% cases of very severe COPD [Tables 3 and 4].

DISCUSSION

Identification of comorbidities is an integral part of the assessment of COPD patients. Calculating BODE index can be helpful to predict the risk of development of comorbidities. In our study, patients belonged to the age group 35–70 years with a mean age of 56.07 ± 7.6 years. In a study conducted by Grabicki^[21] mean age group was 63 ± 8.3 years and in a study conducted by Sarioglu^[22] mean age group was 63.6 ± 10.5. COPD is more common in elderly people.

In our study, among the 60 patients, 47 (78.3%) patients were smoker in comparison to 13 (21.7%) patients who were non-smoker. The mean and median number of pack-years was 20.65 ± 11.55. In a study conducted by Grabicki,^[21] mean number of pack-years was 33 and in a study conducted by Sarioglu,^[22]

median (25th–75th and 15, respectively, percentile) 40 (20–60) pack/year. Marin *et al.* conducted a prospective cohort study on 275 COPD patients^[23] the mean number of pack-years was 56.23 ± 25.37.

BMI of all 60 patients was calculated, minimum BMI was 15.43 kg/m² and the highest being 34.77 kg/m² with a mean of 22.29 ± 4.63. In a study conducted Grabicki,^[21] mean BMI was 27.6 ± 6.4 and in a study conducted by Celli,^[24] mean BMI was 27.5 ± 4.5.

In our study, percentage of mMRC Grade 0, 1, 2, 3, and 4 is 10%, 56.7%, 13.3%, 18.3%, and 1.7%, respectively. Maximum patients belonged to Grade 1. mMRC is 1.45 ± 0.96. In a study conducted by Celli *et al.*^[25] mean mMRC was 2.7 ± 0.89 and in a study conducted by Marin *et al.*^[26] mean mMRC was 1.73 ± 1.09.

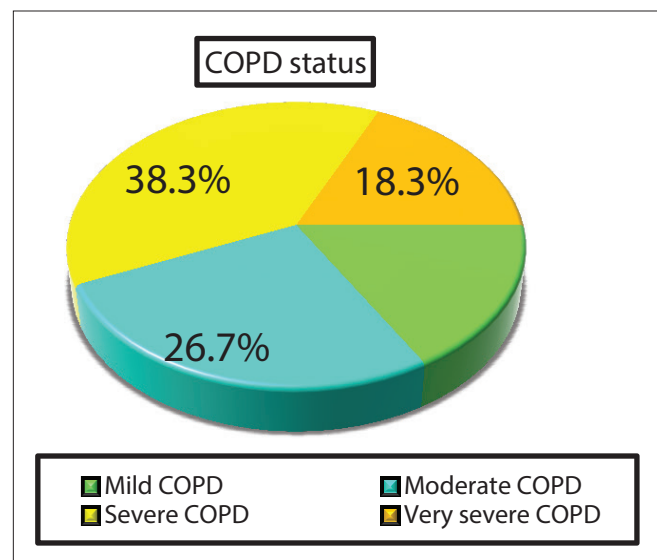


Figure 2: Distribution of chronic obstructive and pulmonary disease among the study group

Table 3: Distribution of quartile of BODE index among the study group

Quartile of BODE index	n (%)
Quartile 1	14 (23.3)
Quartile 2	22 (36.7)
Quartile 3	18 (30.0)
Quartile 4	6 (10.0)
Total	60 (100.0)

BODE: Body mass index, degree of airflow obstruction, dyspnea scale, and exercise

Table 4: Association among the cases between COPD and PHT

COPD	PHT				Total
	No PH	Mild	Moderate	Severe	
Mild n (%)	8 (80.0)	2 (20.0)	0 (0.0)	0 (0.0)	10 (100.0)
Moderate n (%)	8 (50.0)	8 (50.0)	0 (0.0)	0 (0.0)	16 (100.0)
Severe n (%)	10 (43.5)	9 (39.1)	4 (17.4)	0 (0.0)	23 (100.0)
Very severe n (%)	2 (18.2)	0 (0.0)	3 (27.3)	6 (54.5)	11 (100.0)
Total n (%)	28 (46.7)	19 (31.7)	7 (11.7)	6 (10.0)	60 (100.0)

COPD: Chronic obstructive and pulmonary disease, PHT: Pulmonary hypertension

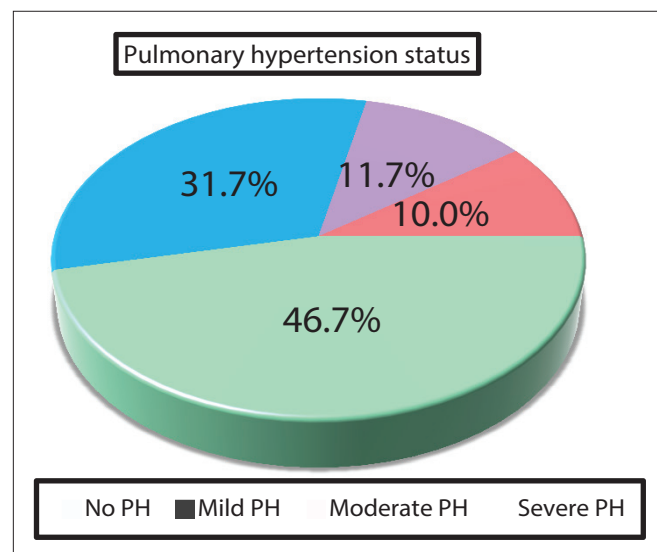


Figure 3: Distribution of pulmonary hypertension among the study group

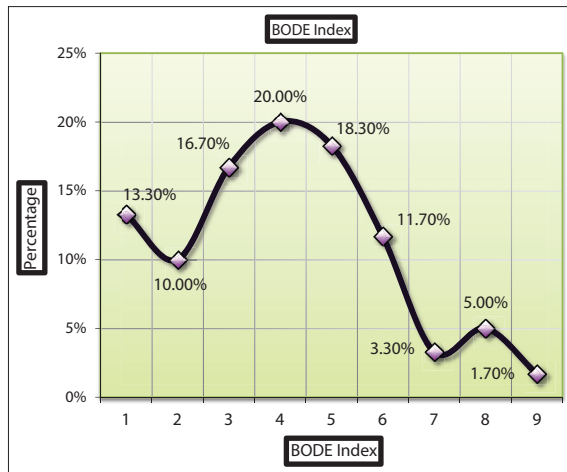


Figure 4: Distribution of body mass index, degree of airflow obstruction, dyspnea scale, and exercise index among the study group

BODE index is a better predictor than its individual components.

In our study, spirometry was done before current episode of exacerbation. Spirometry showed mild obstruction in 16.7%, moderate obstruction in 26.7%, severe obstruction in 38.3%, and very severe obstruction in 18.3% of patients. In this study, maximum patient belonged to severe COPD group (38.3%) as compared to study conducted by Celli *et al.*^[24] among 625 patients, recruited between 1997 and 2003, which showed maximum patients belonged to very severe COPD, 235 among 625 patients (38%).^[27]

In this study group, 46.7%, 31.7%, 11.7%, and 10.0% patients were with no, mild, moderate, and severe PHT, respectively. In a study conducted by Chaouat *et al.* on PHT in COPD, it was observed that mild (mPAP 26–35 mmHg), moderate (36–45 mmHg), and severe (>45 mmHg) PH was present in 36.7, 9.8, and 3.7%, respectively, of the 215 patients.^[28] In both studies, mild PH patients are more in number in comparison to moderate and severe PH.

Our study group was divided among quartiles according to BODE index; Quartile 1 is defined by a score of 0–2, quartile 2 by a score of 3–4, quartile 3 by a score of 5–6, and quartile 4 by a score of 7–10. Quartile 1, 2, 3, and 4 had 23.3% (14 patients), 36.7% (22 patients), 30% (18 patients), and 10% (6 patients), patients, respectively. In our study, maximum patients belonged to quartile 2 (BODE score 3–4), this result is in accordance with the data in the study performed by Celli *et al.*^[22] Minimum and maximum BODE score observed in our study was 1, present in 13.3% (8) patients, and 9, and present in 1.7% (1) patients, respectively. Mean BODE index in our study is 4.03.

On applying Spearman’s rho correlation coefficient between BODE index and pack-years, $P = 0.10$; the correlation is not significant. This result is not in accordance with a study conducted by Shivakumar and Krishna^[29] who suggested that BODE score was significantly associated with the number of pack-years of smoking [Table 5]. The difference in the result can be due to the difference in mean age, pack-years and difference in the distribution of mild, moderate, and severe COPD cases among both the studies.

Table 5: Association between pack-years and COPD severity

Studies	Present study	Shivakumar and Krishna ^[29]
Mean age (years)	56.07	56.91
Mean pack years	20.65	7.36
Mild COPD (%)	16.7	34.44
Moderate COPD (%)	26.7	32.22
Severe COPD (%)	38.3	33.33

COPD: Chronic obstructive and pulmonary disease

When correlating BODE index with PASP with the help of Spearman’s rho correlation coefficient, $P < 0.05$, i.e., significant. This shows that BODE index is a significant predictor development of PHT in COPD patients. BODE index can be utilized to predict the risk of development of PHT and helps in assessment of COPD.

On applying Pearson Chi-square test between severities of COPD as per GOLD guidelines and degree of PHT $P < 0.05$; hence, the association is observed to be significant. Mild PH is seen in 80% cases of mild COPD whereas severe PH is seen in 54.5% cases of very severe COPD. This shows that the degree of PHT is related to the severity of COPD. This result was in accordance with the findings of studies conducted by Shivakumar^[29] and Stevens *et al.*^[30] Thus, our study concludes that BODE index is a reliable method to predict the development of PHT in COPD patients.

CONCLUSION

BODE index is a multidimensional staging system consisting of simple physiological and clinical variables which are easy to calculate and FEV¹ % which can be calculated with a simple device called spirometer. This can be helpful in better understanding of the outcome of COPD for individual patients. Similarly, severity of COPD is related to degree of PHT. It is very rare to find sever PHT in patients with mild COPD having no other risk factors of developing PHT. Patients are having severe COPD should also be looked for other causes of developing PHT, and such patients should undergo 2DEcho on regular intervals.

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