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ORIGINAL RESEARCH

EVALUATION OF RIGHT VENTRICULAR DYSFUNCTION AND ITS ASSOCIATION WITH MULTIDIMENSIONAL SCORING SYSTEM (BODE INDEX) IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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Abstract

Aim: To evaluate right ventricular dysfunction and its association with multi-dimensional scoring system (BODE Index) in Chronic Obstructive Pulmonary disease (COPD).

Material and methodology: It was a prospective observational hospital based research, conducted in TMMC & RC, TMU, Moradabad, U.P. It was a time bound research & all the cases (n=76)confirming inclusion criteria were enrolled in the research during the 18 months of research time after the ethical clearance by Institutional Ethical Committee (IEC).The enrollment screening included a measurement of height, weight and BMI. Each participant's FEV1 was measured using spirometry. Dyspnea, six-minute-walk distance (6MWD) and BODE index was measured. 2D Echocardiography was performed on the a fore-mentioned patients.

Results: With decrease in FEV1, 6MWD also decreases with significant correlation ($p<0.01$). Mean FEV1 in mMRC Class II was 49.50±11.996, in Class III was 35.47±12.279 & in Class IV was 26.67±5.686. Mean FEV1 decreases with increase in dyspnea/mMRC as well as RVSP with statistically significant ($p<0.01$). RVSP of >40mmHg was found more in class III & IV mMRC as well as only in BODE stage III & IV subjects. Severe PAH was found in BODE stage 3 & 4 only.

Conclusion: The results of our research showed that the BODE index can be used to predict RV function, & that rising BODE index parameters are associated with a worsening RVD. Our research shows a strong association between severity of COPD and Right Ventricular dysfunction. Due to the additional therapeutic implications of such problems, echocardiographic screening of COPD patients is both essential & helpful.

Keywords: COPD, Dyspnea, Echocardiography, BODE Stage

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Introduction: First defined as "a disease condition characterized by persistent airflow limitation due to chronic bronchitis & emphysema," chronic obstructive pulmonary disease (COPD) has since been expanded to include other lung diseases.[1] According to the medical community, chronic bronchitis is diagnosed when a person has a productive cough for at least three months per year for two years. Population-based research in India show widely varying estimates of the disease's prevalence. Research conducted in the North of India reveal prevalence rates in male individuals between 2.12% & 9.4%, which is significantly greater than the 1.4% to 4.08% recorded in studies conducted in the South of India. Results showed an increase in prevalence with age, particularly among males, heavy smokers (those with 20+ pack-years of experience), & those with lower socioeconomic status. Research has shown a wide range in the male to female participant ratio (1.32:1 to 2.6:1) with a median of 1.6:1.[2-9]

In low & middle income countries, chronic obstructive pulmonary disease (COPD) is now among top three killers. Therefore, it is crucial to determine factors leading to worse outcomes for people with this condition. Studies have shown that the forced expiratory volume in first second (FEV1) does not fully capture the full scope of the disease on a systemic level. For instance, there is only a weak relationship between the FEV1 & the severity of dyspnea, & the rate of decline in patients' health is not reflected by the rate at which their FEV1 is changing.[10] An innovative multidimensional grading system called the BODE Index [body mass index (BMI), airflow obstruction, dyspnea, & exercise capacity] was developed to assess the likelihood of death in COPD patients.[10,11]

Heart disease & other circulatory system problems are the second leading cause of death in COPD patients, after lung cancer itself. Previous research has linked RV dysfunction to higher cardiovascular events & the ability to predict mortality in COPD patients. Therefore, it is crucial to evaluate RV functioning in this patient population. The connection between the BODE index & RV dysfunctions is unknown. We sought, using 2D-echo in COPD patients, to determine the probable connection between them. The aim and objectives of the study are as follows:

Aim: To evaluate right ventricular dysfunction and its association with multi-dimensional scoring system (BODE Index) in Chronic Obstructive Pulmonary disease (COPD) at tertiary care center.

Objectives:
1. To classify the diagnosed COPD patients on the basis of BODE INDEX (stage 1 to stage 4).
2.To tabulate Echocardiographic findings with respect to right ventricular dysfunction.
3.To assess and compare the results of Echocardiographic findings with stages of COPD severity.

Material and methodology: It was a prospective observational hospital based research, conducted in TMMC & RC, TMU, Moradabad,U.P.It was a time bound research & all the cases (n=76)confirming inclusion criteria were enrolled in the research during the 18 months of research time after the ethical clearance by Institutional Ethical Committee (IEC).

Inclusion Criteria:
1. Diagnosed cases of COPD on the basis of spirometry.
2. Patients willing to participate in the research & giving informed & written consent.

Exclusion Criteria:
1. Acute exacerbation of COPD patients.
2. Left-sided heart failure
3. Rheumatic heart disease
4. Congenital heart disease
5. Ischemic heart disease
6. Patients taking ATT for Pulmonary Tuberculosis

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Methodology: Every participant's smoking habits, as well as their own & their family's medical histories, were meticulously documented. The enrollment screening included a measurement of height, weight and BMI. Each participant's FEV1 was measured using spirometry 20 minutes after receiving the salbutamol nebulization & again at enrollment using equipment that fulfilled the performance requirements established by the American Thoracic Society.

Dyspnea was recorded according to Modified Medical Research Council Dyspnea Scale, Level D (Dyspnea). Six-minute walk distance (6MWD) was assessed on a 25-meter walk track twice on the same day, at least 30 minutes apart from each other. BODE index was graded as below:

- Stage 1 BODE = BODE index 0-2; Stage 2 BODE = BODE index 3-4; Stage 3 BODE = BODE index 5-6; Stage 4 BODE = BODE index 7-10.

If FEV1 was greater than or equal to 65%, it was labeled as 0, if it was between 50% & 64% it was labeled as 1 , between 36 % & 49% it was labeled as 2, & if it was less than or equal to 35% it was labeled as 3.

There were three possible results for the 6-minute walk distance: 0 (more than 350 meters), 1 (250-349 meters), 2 (150-249 meters), & 3 (less than 150 meters).

Four points were assigned to each of the mMRC dyspnea classes, with class 0 & I receiving 0, class II receiving 1, class III receiving 2, & class IV receiving 3

For Pulmonary hypertension (PAH) - mild - **0,** moderate – **1**, severe - **2**

For Right Ventricular Systolic Pressure (RVSP)- < 20 mmHg – **0**, 21 -30 mmHg – **1**,

31- 40 mmHg – **2,** 41- 50 mmHg – **3**, >50- **4**

RA/RV Not Dilated – **0,** Dilated - **1**

Tricuspid Regurgitation - Trace – **0**, Trivial – **1**, MILD – **2,** Moderate – **3**, Severe - **4**

Following this, 2D Echocardiography was performed on the aforementioned patients. All subjects were imaged with an M5S transducer & a PHILIPS Echo machine while lying on their left sides (frequency 50 Hz). Pulsed & continuous wave Doppler methods, as recommended by the American Society of Echocardiography, were used to measure blood flow rates (ASE).

The subsequent parameters were captured on 2D Echocardiography:

1. Intensification of the RA duct
2. Expanding the RV
3. Velocity of tricuspid regurgitation
4. RV enlargement
5. Internal jugular vein (IVC) diameter
6. Systolic displacement of the tricuspid annular plane (TAPSE)

Regular parameters

- Wall thickness of the right ventricle - 5 mm (normal)

"Normal" is defined as a TRV of less than or equal to 2.8 meters per second (Abnormal)

Standard values for the internal diameter of the right ventricle range from 9 to 26 millimeters, & a moderate case of pulmonary hypertension is defined as anything outside of that range (30 -39 mmHg)

Not too strong, not too weak (40- 50 mmHg)

- very high (above 50 mm Hg)

The normal range for right atrial pressure is 10 to 20 mmHg.

23.3 3.6 mm TAPSE

The acquired data was analyzed statistically with SPSS version 24.

Results: Out of the total 76 research subjects, 59 (77.6%) were males & rest were females (n=17, 22.4%).Maximum patients were from age group 61-70 years (n=27, 35.53%), followed by 23 subjects (30.26%) belong to age group 51-60 years.Maximum subjects had BMI <21 (n=52, 68.4%) & 24 subjects

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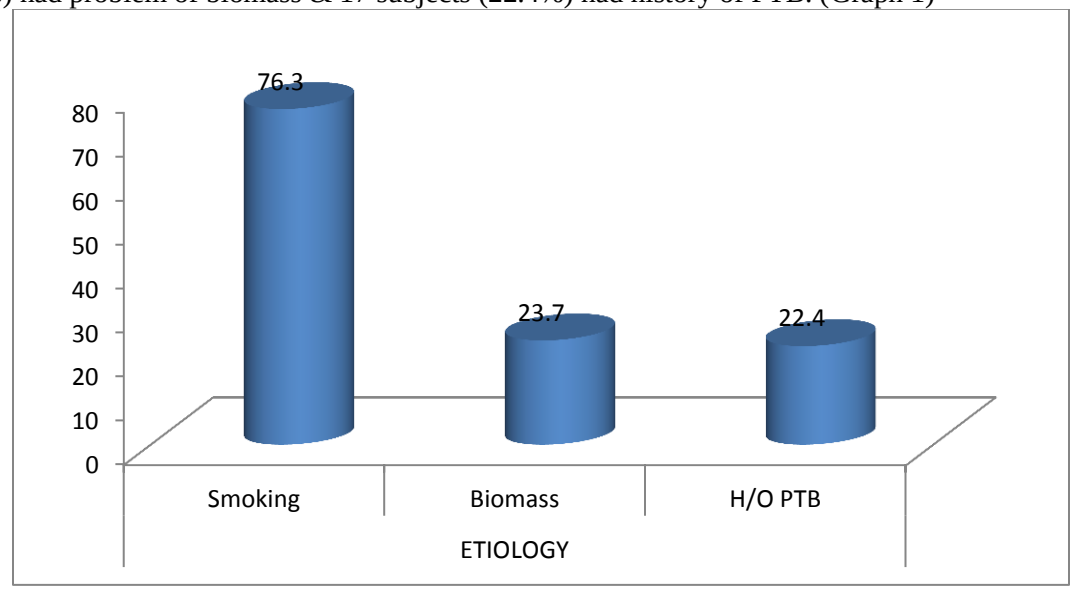
(31.6%) had BMI >21. Maximum research subjects had habit of smoking (n=58, 76.3%), 18 subjects (23.7%) had problem of biomass & 17 subjects (22.4%) had history of PTB. (Graph 1)



GRAPH 1: Etiology among the research subjects

Mean FEV1/FVC was 56.21±9.621 (range 32-82), mean FEV1 was 42.87±14.168 (range 12-79), mean FVC was 54.83±13.305 (range 27-95) & mean MEF was 17.83±8.321 (range 5-46). (Table 1)

Table 1: Descriptive analysis of PFT profile

Parameters	Minimum	Maximum	Mean	SD
FEV1/FVC	32	82	56.21	9.621
FEV1	12	79	42.87	14.168
FVC	27	95	54.83	13.305
MEF (25-75)	5	46	17.83	8.321

In present research, maximum subjects had mild PAH (n=39, 51.3%), followed by moderate PAH (n=25, 32.9%) & only 12 subjects (15.8%) had severe PAH. Maximum subjects had RVSP within range 31-40 mmHg (n=29, 38.2%), followed by 24 subjects (31.6%) in range 21-30 mmHg, 10 subjects (13.2%) had <20 mmHg, 8 subjects (10.5%) had RVSP in range 41-50 mmHg & 5 subjects (6.6%) had >50 mmHg. Maximum subjects had RA/RV not Dilated (n=63, 82.9%) & 13 subjects (17.1%) had Dilated. Majority of subjects had mild TR (n=28, 36.8%), in 21 subjects Trace was present (27.6%), 16 subjects had Trivial (21.1%), 9 subjects had Moderate (11.8%) & only 2 subjects had severe TR (2.6%). (Table 2)

Table 2: 2 D ECHO findings among the research subjects

2 D ECHO	N	%
PAH		
Mild	39	51.3
Moderate	25	32.9
Severe	12	15.8
RVSP		
<20 mmHg	10	13.2
21-30 mmHg	24	31.6
31-40 mmHg	29	38.2
41-50 mmHg	8	10.5
>50 mmHg	5	6.6

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RA/RV		
Not Dilated	63	82.9
Dilated	13	17.1
TR		
Trace	21	27.6
Trivial	16	21.1
Mild	28	36.8
Moderate	9	11.8
Severe	2	2.6

Majority of subjects had Class II dyspnea (n=40, 52.6%), followed by 32 subjects (42.1%) reported Class III Dyspnea. Maximum subjects had BODE Stage 3 (n=29, 38.2%), followed by 27 subjects had BODE Stage 4 (35.5%), 17 subjects had BODE Stage 2 (22.4%) & 3 subjects had BODE Stage 1 (3.9%). (Table 3)

Table 3: Airway status, dyspnea, 6MWD and BODE staging among the research subjects

Airway	**N**	**%**
≥65%	5	6.6
50-64%	21	27.6
36-49%	24	31.6
≤35%	26	34.2
Dyspnea (mMRC)		
Class 0 & I	0	0
Class II	40	52.6
Class III	32	42.1
Class IV	4	5.2
6MWD		
>350 m	0	0
250-349 m	37	48.7
150-249 m	33	43.4
<150 m	6	7.9
BODE Stage		
Stage 1	3	3.9
Stage 2	17	22.4
Stage 3	29	38.2
Stage 4	27	35.5

FEVI decreases with increase in RVSP with statistically significant difference (p=0.026).Mean 6MWD in 250-349 m range was 50.47±10.943, in 150-249 m range was 36.97±13.028 & in <150 m was 26.33±5.610. Hence with decrease in FEV1, 6MWD also decreases with significant correlation (p<0.01).Mean FEV1 decreases with increase in dyspnea/mMRC class with statistically significant difference (p<0.01) as shown in table 4.

Table 4: Comparison of FEV1 according to RVSP, 6MWD and mMRC

RVSP	**Mean FEV1**	**SD**	**Anova Test**	**p value**
<20 mmHg	44.70	11.186	2.96	0.026*
21-30 mmHg	44.25	14.308		
31-40 mmHg	45.83	14.595		
41-50 mmHg	36.50	12.012		

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>50 mmHg	25.60	4.930		
6MWD				
250-349 m	50.47	10.943	17.91	<0.01*
150-249 m	36.97	13.028		
<150 m	26.33	5.610		
mMRC				
Class II	49.50	11.996	14.93	<0.01*
Class III	35.47	12.279		
Class IV	26.67	5.686		

*: statistically significant

Subjects with RVSP of >40mmHg was found more in class III & IV mMRC. There was a statistically significant correlation between RVSP & Dyspnea, 6MWD, BODE stage (p= 0.001) as shown in table 5.

Table 5: Comparison of RVSP according to Dyspnea mMRC, 6MWD and BODE stage

		Dyspnea (mMRC)		
		Class II	**Class III**	**Class IV**
RVSP	**<20 mmHg**	5	4	0
	21-30 mmHg	15	9	0
	31-40 mmHg	18	11	0
	41-50 mmHg	2	5	1
	>50 mmHg	0	3	2
Chi Square		26.19		
p value		0.001*		
		6MWD		
		250-349 m	**150-249 m**	**<150 m**
RVSP	**<20 mmHg**	5	4	0
	21-30 mmHg	16	7	1
	31-40 mmHg	13	14	2
	41-50 mmHg	2	5	1
	>50 mmHg	0	3	2
Chi Square		15.23		
p value		0.005*		
		BODE STAGE		
		Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
RVSP	**<20 mmHg**	0	3	4	2
	21-30 mmHg	2	7	9	6
	31-40 mmHg	0	7	14	8
	41-50 mmHg	0	0	2	6
	>50 mmHg	0	0	0	5
Chi Square		22.14			
p value		0.036*			

*: statistically significant

Severe PAH was found in BODE stage 3 & 4 only. The difference in PAH according to BODE stage was statistically significant (p=0.002) as shown in table 6.

Table 6: Comparison of PAH according to BODE stage.

		BODE STAGE			
		Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
PAH	Mild	3	11	16	9

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	Moderate	0	6	12	7
	Severe	0	0	1	11
Chi Square		21.26			
p value		0.002*			

*: statistically significant

Discussion: Patients with COPD were included in a prospective observational hospital-based research at TMMC & RC, TMU, Moradabad,U.P. This research aimed to assess right ventricular dysfunction in tertiary care COPD patients & its relationship to a multi-dimensional scoring system (BODE Index).

There were a total of 76 participants in the research; 59 (77.6%) were males & 17 (22.4%) were girls. There was hence a preponderance of male researchers. Other studies found a wide range of male-to-female ratios, from 80% (J.C.Banergae[12]) & 81.25 percent to 92% (Benjamin Burrows[13]) & 94.6 percent (V. K. Singh[14]).

For men, smoking is the primary cause of COPD.

The majority of participants in this research were aged 61–70 (n=27, 35.53%), with a further 23 subjects (30.26%) falling in the age range of 51–60. The majority of admitted patients are between the ages of 50 & 70, mostly due to the longer history of tobacco use & the increased likelihood of respiratory tract infections that would have negatively affected their quality of life.

This research's discussion of age distribution is consistent with those of other research i.e. Gupta & Khastgir[15] found that the average age was 50.2-12. Keller & Shepard[16] found it to be 59.7 and Putnik& Povazan[17] found it to be 66.6 in their studies. Similar results were found by Gautam SK et al[18], who found that the majority of COPD patients (35/51) were between the ages of 50 & 69.

Nearly three-quarters (n=58, 76.3%) of smokers, 23.7% of those with biomass issues, & 22.4% of those with a personal or family history of PTB participated in this research.Most of the patients (30/50) had a history of smoking, as reported by Gautam SK et al[18].Most patients with COPD had smoked for at least 20 packs of cigarettes in their lifetime, as stated by BTS guidelines[19].Similar results were reported in a research done by Gupta & Khastgir[15], with an average of 26.4 (16.1) pack years of smoking past being recorded.

Right ventricular dilatation, right ventricular hypertrophy, right atrial dilatation &interventricular wall motion abnormalities are more common in patients with advanced COPD (GOLD stages 3 & 4), according to a research by Abhishek Ket al[20]. These abnormalities are associated with worsening health over time.

It has been found that people with COPD had an aberrant upsurge in MPAP (Ppa) of 0.4-0.6 mmHg every year, according to two investigations by Kessler R et al[21]&Oswald-MamosserM et al[22]. These studies show that PH can affect people with both mild & severe COPD. Higham MA et al[23]. found that individuals with mild PH (20-30 mmHg) had a 50% 5-year survival rate, patients with moderate & severe PH (30-50 mmHg) had a 30% 5-year survival rate, & a small group of patients with severe PH (>50 mmHg) had a 0% 5-year survival rate.

The severity of the condition, as determined by pulmonary function testing & clinical classification, was found to correlate strongly with Echocardiographic measures of RV function, as reported by Syed Aijaz Nasiret al[24] in their research. TAPSE, FAC, & TDI TASV had a strong positive association with FEV1% & FEV1/FVC, while RIMP, RV basal strain, RVSP, & RV FWT had a large negative correlation. TAPSE, FAC, & TDI TASV (S') correlated negatively with GOLD stage & BODE index, while RIMP, RV basal strain, RVSP, & RV FWT were positively correlated.

Increased BODE index parameters were related with increasing degradation of RV systolic functions in COPD patients, as determined by 2D-STE-derived RVFW strain, as reported by Tayyar Gökdeniz et al[25] in their research. The research by Gautam SK et al.[18] exhibited a similar pattern, demonstrating that the prevalence of all echocardiographic abnormalities increased with illness severity, with the highest prevalence being observed in the most harshly affected subjects.

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In his research, Danchin[26] investigated echocardiographic data in COPD subjects with & without a past of right heart failure, & he got that individuals without account of right heart failure had lesser right ventricular regions than patients with one or more incidents of right heart failure.

Right heart disaster, or more severe disease, is associated with a higher risk of right ventricular hypertrophy, as suggested by the present research.Patients with chronic obstructive pulmonary disease (COPD) typically develop heart failure due to a cascade of events beginning with hypoxia, progressing through pulmonary hypertension, right ventricular hypertrophy, RV dilatation, & finally RV failure. In response to systolic overload from the RV's increased size, the RA dilates[18].

Right ventricular dilatation, right ventricular hypertrophy, right atrial dilatation & inter-ventricular wall motion abnormalities are more common in patients with advanced COPD (GOLD stages 3 & 4), according to a research by Abhishek Ket al[20]. These abnormalities are associated with worsening health over time.

A potential limitation of the research is that 1) it was conducted in a hospital & hence the results may not be generalizable to the general public.Second, because there have been no systematic studies of the regional symptoms of COPD, caution is warranted when applying the data to populations outside of India.This analysis can only tell us so much about whether or not a boost to the BODE index has an opposite effect on the other variables taken into account because it is a cross-sectional research.

Conclusion: The BODE index is a quick & simple multidimensional grading system used to assess patients with COPD in pulmonary clinics. It assesses the overall clinical symptoms of the disease in addition to the pulmonary ones, such as airflow limitation. The results of our research showed that the BODE index can be used to predict RV dysfunction, & that rising BODE index parameters are associated with a worsening RVD.

Our research shows a strong association between disease severity & the frequency of cardiovascular problems in COPD patients. Due to the additional therapeutic implications of such problems, echocardiographic screening of COPD patients is both essential & helpful.

The relationship between COPD prognosis & RV function on echocardiography has not been substantially examined in the past, thus even though this research was small, the findings are noteworthy. Prognosis in these patients can be greatly improved with the aid of echocardiography, which is both inexpensive & noninvasive. More comprehensive investigations in the future are needed in this area.

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