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Original Article

When left ventricular failure complicates chronic obstructive pulmonary disease: Hypoxia plays the major role

Paudel B[1], Dhungel S[2], Paudel K[1], Pandru K[1], Paudel R[1]
[1]Department of Medicine, Manipal Teaching Hospital, Pokhara, Nepal, [2]Professor and Head; Department of Medicine, Nepal Medical College, Attarkhel, Kathmandu

Abstract
Introduction: As the chronic obstructive pulmonary disease (COPD) progress, is usually accompanied by involvement of the both left ventricle (LV) and right ventricle (RV), and their systolic and diastolic function. Signs and symptoms of LV failure can be difficult to distinguish from those of COPD.
Objective: The study was carried out to determine the prevalence of LV systolic dysfunction in the COPD patients and to assess the possible risk factor behind such development.
Material and Methods: It is a prospective study of 60 cases of COPD patients with or without cor-pulmonale attending Manipal Teaching Hospital.
Results: The prevalence of LV systolic dysfunction was found to be 26.7%, and the findings directly correlate with the severity of COPD i.e., the more the severity of the lung disease more the probability for the incidence of LV systolic dysfunction. These data are in support of the hypothesis that hypoxia and the excess accumulation of toxic metabolic products like lactic acid, significant right-to-left shunting through the bronchial circulation explains the diminished LV ejection fraction in severe COPD patients.
Conclusion: Routine echocardiography investigation of the severe COPD patients is required for assessing the status of LV function and to rule out the possible association of LV systolic dysfunction.

Key words: Chronic obstructive pulmonary disease, Cor-pulmonale, Hypoxia, LV systolic dysfunction

Chronic obstructive pulmonary disease (COPD) is a disease state characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema which is progressive and is partially reversible. Right ventricular (RV) hypertrophy and dilatation secondary to pulmonary hypertension caused by COPD (i.e., cor pulmonale) is unrelated to the left side of the heart. With RV pressure overload, the septum tends to be displaced toward the left ventricle (LV) during systole, which causes a distortion of the LV [1]. Since the myocardial fibres of the RV free walls are connected with those of the septum and LV free wall, a pressure increase in the RV is accompanied by changes in the LV systolic function [2]. This might be a partial explanation for the LV involvement in the course of COPD, causing an increased morbidity and mortality of ischemic heart disease and LV dysfunction[3]. Understanding the relationship between RV hypertrophy and LV systolic function in patients with COPD will be helpful for the better patient management.

Objective

The main objective of this study is to determine the prevalence of LV systolic dysfunction in the COPD patients and to assess the possible risk factor behind such development.

Materials and methods

It is a prospective study of 60 cases of COPD patients with or without cor-pulmonale attending Manipal Teaching Hospital (MTH), Pokhara during 01st March, 2006 to 28th February, 2007. The diagnosis of COPD was based on clinical history, physical findings, chest radiography, pulmonary function tests (PFT). Forced expiratory volume in one second (FEV_1) and vital capacity (VC) were measured and patients were subdivided by severity according to GOLD classification of COPD[4]. Patients with systemic hypertension, history of congenital, rheumatic, or ischemic heart disease, chronic atrial fibrillation, complete right or left bundle branch block were excluded. All patients underwent an Echo-Doppler examination to evaluate the LV ejection fraction (EF) and pulse oximetry was used to measure O_2 Saturation (SaO_2). LV systolic dysfunction was defined as the LVEF $\leq$ 45%.

Correspondence
Dr. Badri Paudel,
Lecturer, Department of Medicine,
Manipal Teaching Hospital, Pokhara, Nepal
Email: badribmu@gmail.com

Results

60 cases (25 male and 35 female) of COPD attending MTH from 01st March, 2006 to 28th February, 2007, were enrolled in this study. PFT was performed in all the studied subjects to evaluate the severity of COPD. We also observed the LV systolic function in this population to detect the presence of any systolic dysfunction (LVEF ≤ 45%). 16 cases had LV systolic dysfunction. 16 cases (26.7%) had LV systolic dysfunction. The age and sex distribution of COPD with/without LV systolic dysfunction is depicted in Table 1. Prevalence of COPD was common after the onset of middle age, the peak was found to be at the age group of 60-69 years.

Two cases (3.3%) of mild COPD and 4 cases (6.7%) of moderate COPD and 10 cases (16.7%) of severe COPD had systolic dysfunction. and the prevalence of LV systolic dysfunction was found to be 26.7% (Table 2). We observed the relation between the severities of COPD with LV systolic dysfunction and found that those with more severe COPD are more susceptible for the higher prevalence of LV systolic dysfunction. 13 cases (21.7%) had severe COPD, while 28 cases (46.7%) had moderate COPD. 10 cases out of 13 severe COPD cases (77.0%) and 4 cases out of 28 moderate COPD cases (14.2%) had LV systolic dysfunction (Table 2).

We observed the SaO_2 (O_2 saturation) through pulse oximetry and all the severe cases of COPD patients had respiratory failure (SpO_2<90%) while mild and moderate COPD were still maintaining the arterial saturation of >90% (although 6 cases of mild and moderate COPD had LV systolic dysfunction).

Table 1: Age and sex distribution of COPD patients with / without DCM

Age group	Group 1 (With LV systolic dysfunction; n = 16)		Group 2 (Without LV systolic dysfunction ;n = 44)	
	Male	Female	Male	Female
40-49	1	2	1	2
50-59	2	2	6	9
60-69	2	2	3	10
70-79	3	1	2	5
80-89	1	0	4	2
Total	9	7	16	28

Table 2: Classification of COPD by severity

	Severity of COPD (60 cases)		
	Mild (19 cases)	Moderate (28 cases)	Severe (13 cases)
With LV systolic dysfunction	2 (3.3%)	4(6.7%)	10(16.7%)
Without LV systolic dysfunction	17(28.3%)	24(40%)	3(5.0%)

Discussion

The hallmark of COPD is expiratory airflow obstruction which is progressive and associated with an abnormal inflammatory response that is not fully reversible. Many people suffer from this disease for years and die prematurely from it or its complications. COPD is often associated with changes of the structure and the function of the heart. Approximately 20% of hospital admissions for heart failure are caused by RV failure associated with COPD and cor pulmonale. Signs and symptoms of LV failure can be difficult to distinguish from those of COPD. When LV failure complicates COPD, it is not uncommon for some of the diagnostic physical and physiologic findings of each disease to be obscured. For example, hyperinflation of the lung can overshadow such physical findings as a gallop rhythm or murmur. The same complexities apply to

management, because some interventions may be appropriate for both COPD and heart failure, whereas others may be contraindicated by one or the other condition. The challenges of diagnosing and managing LV failure in the setting of COPD and cor pulmonale are unique. The aim of this study was to investigate the effects of COPD on LV systolic function and to assess the possible risk factor behind such development.

Physiologically, RV and LV are two distinct chambers that are anatomically and functionally bound in some ways: both share the interventricular septum and both are enclosed in the pericardium. As a consequence, alterations in RV size and function will influence LV performance. Ventricular interaction is a marked phenomenon in patients with COPD, but LV systolic functional disorders are still rare. Very few studies were performed to evaluate the LV systolic function in such population. Our objective, therefore, was to study the relation between COPD and LV ejection fraction in this group of COPD subjects and to assess the possible risk factor behind such development.

In North America and Europe symptomatic DCM incidence is 20 in every 100,000 and the prevalence of 38 per 100,000. In a recent study, Dario-Vizza and colleagues assessed the frequency of systolic dysfunction to be less than 5%[5]. In this study we tried to exclude the entire factors which contribute in the development of the systolic dysfunction e.g. hypertension, ischemic heart disease, diabetes. But there is still significant higher prevalence (26.7%) of LV systolic dysfunction in such COPD population.

Several factors might influence the LV ejection fraction. First, large intrathoracic pressure changes, occurring in COPD, can influence the LV performance[6]. RV pressure overload not only induces RV hypertrophy/dilation, but the interventricular septum is shifted toward the LV during systole and LV systolic function is altered[7-9]. Besides, almost half of all patients who die with cor pulmonale due to COPD also have LV hypertrophy on postmortem examination[10]. Animal studies have shown that the magnitude of LV hypertrophy is well correlated with the duration of RV pressure overload[11]. Second, decreased arterial oxygen tension contributes to a decrease in myocardial contractility. As we know the bronchial arteries ramify into a capillary network drained by bronchial veins, some of which empty into the pulmonary veins, constituting a physiological "right-to-left" shunt. However, in some forms of pulmonary disease with pulmonary hypertension blood flow through the bronchial circulation can increase significantly, account for nearly 30% of LV output (normally is about 1%) and produce a significant right-to-left shunt resulting significant desaturation of left atrial blood which also contributes the progressive development of hypoxia[12,13]. Third, enzymes located on the endothelial surface control the level of circulating compound such as bradykinin, serotin, angiotension and adenine nucleotides. During hypoxia there is endothelial dysfunction and may lead to atherosclerosis and ischemia of cardiac muscles[14].

Finally, the dysfunction of the LV found in of COPD patients may be not only the result of a primary abnormality affecting the RV and lungs, but also due to a very complex interaction between hemodynamic and neurohumoral abnormalities. The impairment of the mechanical contraction of the affected myocardium is produced not only by the diminished delivery of the oxygen and metabolic substrates, but also by the accumulation of potentially deleterious substances (e.g. K^+, lactic acid, H^+) in the cardiac tissues and the displacement of the interventricular septum toward the LV during systole[15].

In this study to evaluate the risk factor for the development of LV systolic dysfunction in COPD patients we evaluate the COPD by severity. 13 cases (21.7%) had severe COPD, while 28 cases (46.7%) had moderate COPD. Among the severe COPD 10 cases (77.0%) had developed LV systolic dysfunction while mild to moderate COPD are less likely to develop LV systolic dysfunction. All the severe COPD patients had respiratory failure (SaO_2<90%). We strongly believe that hypoxia has the major role for the development of LV systolic dysfunction. But in this study we neglected the other factors like the metabolic / respiratory acidosis and deleterious metabolic substrates. So we recommend routine echocardiography investigation of the severe COPD patients for assessing the status of LV function and to rule out the possible association of LV systolic dysfunction.

Conclusion

Prevalence of LV systolic dysfunction in the COPD patients is significantly higher than the other population, was found to be 26.7% and the findings directly correlate with the severity of COPD i.e., the more the severity of the lung disease more the probability for the incidence of LV systolic dysfunction. Although the exact mechanism behind the development of LV systolic dysfunction in such population is still not so clear, but we believe that hypoxia play the major role and the excess accumulation of toxic metabolic products like lactic

acid, and significant right-to-left shunting through the bronchial circulation also contribute. So, we recommend for the routine echocardiography for all the COPD patients especially the more severe ones.

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