

Early Detection of Right Ventricular Dysfunction in Chronic Obstructive Pulmonary Disease by Echocardiography

GD Ramchandani*, Girish Mathur**, KK Pareek***, Sanjiv Maheshwari****

Nearly 200 years ago, Laennec described the relationship between chronic pulmonary disease and right ventricular (RV) dysfunction:

*"All diseases which give rise to severe and long-continued dyspnoea produced, almost necessarily, hypertrophy or dilatation of the heart, through the constant efforts the organ is called on to perform, in order to propel the blood into the lungs against the resistance opposed to it by the cause of the dyspnoea"*¹.

Our understanding of cardio-pulmonary pathophysiology has increased exponentially since then, though Laennec's basic observation concisely described the essence of RV dysfunction in chronic lung disease. Structural changes of the lung parenchyma and functional abnormalities in gas exchange lead to pulmonary hypertension (PH), with subsequent RV remodelling and hypertrophy. The term "cor pulmonale" had previously been used to describe this relationship, though the importance of PH was not emphasised. The condition is often characterised by mild PH, and RV dysfunction is characterised by hypertrophy with preserved cardiac function. However, RV failure can occur during disease exacerbations or when multiple comorbidities are present, and the development of PH increases mortality in many chronic pulmonary conditions¹.

Pulmonary hypertension is a common complication of chronic obstructive pulmonary disease (COPD). The increase in pulmonary artery pressures is often mild-to-moderate. However, 5 - 10% of patients with advanced COPD may suffer from severe pulmonary hypertension and present with a progressively downhill clinical course because of right heart failure added to ventilatory handicap².

COPD is associated with structural and mechanical changes in the pulmonary vascular bed that increase RV afterload. Pulmonary vascular remodelling occurs not only in patients with advanced COPD but also in patients with mild disease and even in smokers with normal lung function. This narrowing and stiffening process occurs in both the proximal and distal pulmonary arteries and results in increased pulmonary vascular resistance (PVR) and reduced pulmonary artery (PA) compliance³.

RV diastolic dysfunction may independently contribute to exercise intolerance in COPD⁴. The development of right heart failure in patients with COPD is also linked to worse outcomes with an increased risk of hospital readmissions and mortality. Thus, noninvasive imaging modalities that provide an accurate measurement of right ventricular (RV) function are crucial in a clinical setting. Although invasive haemodynamic measurements of RV function still remain the gold standard, echocardiography is the standard clinical method to assess RV function³.

A study in 1993⁵, was designed to detect the RV systolic and diastolic dysfunction in patients with COPD by 2D echocardiography and to correlate these characteristics with PAP and to compare it with control subjects. A total of 25 patients of stable compensated COPD and 11 control subjects were included.

The baseline characteristics were as follows:

- Maximum number of patients were in the age group of 51 to 60 years.
- Out of the 25 patients studied, 18 (72%) were male and 7 (28%) were female.
- p-pulmonale was the commonest ECG manifestation of COPD.
- In 80% of COPD patients studied, adequate measurements of the RV parameters were obtained using subxiphoid technique.

Results

- 2-D echo was found to be a sensitive non-invasive method for early detection of PAP, RV systolic and diastolic dysfunction in patients of COPD.
- RV systolic function (RVEF and RWVT) were significantly abnormal in patients of stable compensated COPD and they significantly correlated with PAP.
- RV diastolic function, i.e., E/A ratio and PFR were altered in 60% of patients of COPD studied against control subjects and significantly correlated with PAP.

*Professor, Department of Medicine, Daswani Dental College, Ranpur, Kota - 324 009, Rajasthan.

Senior Consultant, *Senior Consultant and Incharge, Department of Medicine, SN Pareek Memorial Hospital and Research Centre, Kota - 324 009, Rajasthan.

Corresponding Author: Dr GD Ramchandani, Professor, Department of Medicine, Daswani Dental College, Ranpur, Kota - 324 009, Rajasthan. Tel: 9829326815, E-mail: drgdrkota@yahoo.com.

- PFR was altered in all patients of COPD studied against control subjects and significantly correlated with PAP.

*Dissertation submitted to the University of Rajasthan, 1993, Dr GD Ramchandani

Echocardiography benefits in COPD

Echocardiography provides a rapid, noninvasive portable and accurate method to evaluate the right ventricle function, right ventricular filling pressure, tricuspid regurgitation, left ventricular function, and valvular function. Many studies have confirmed that echocardiographically derived estimates of pulmonary arterial pressure correlate closely with pressures measured by right heart catheter ($r > 0.7$)⁵.

Another recent study assessed the cardiac changes secondary to COPD by echocardiography and also aimed to find out the correlation between echocardiographic findings and severity of COPD, if any.

A total 40 of patients of COPD were selected and staged by pulmonary function test (PFT) and evaluated by echocardiography.

- On echocardiographic evaluation of COPD, 50% cases had normal echocardiographic parameters.
- Measurable tricuspid regurgitation (TR) was observed in 27/40 cases (67.5%).
- Pulmonary hypertension (PH), defined as systolic pulmonary arterial pressure (sPAP) > 30 mmHg was observed in 17/27 (63%) cases in which prevalence of mild, moderate, and severe PH were 10/17 (58.82%), 4/17 (23.53%), and 3/17 (17.65%), respectively.
- The frequencies of PH in mild, moderate, severe, and very severe COPD were 16.67%, 54.55%, 60.00%, and 83.33%, respectively. Right atrial pressure was 10 mmHg in 82.5% cases and 15 mmHg in 17.5% cases.
- Cor pulmonale was observed in 7/17 (41.17%) cases; 7.50% cases had left ventricle (LV) systolic dysfunction and 47.5% cases had evidence of LV diastolic dysfunction defined as $A \geq E$ (peak mitral flow velocity of the early rapid filling wave (E), peak velocity of the late filling wave caused by atrial contraction (A) on mitral valve tracing), left ventricle hypertrophy was found in 22.5% cases.

The authors of the study concluded that the prevalence of PH has a linear relationship with severity of COPD and severe PH is almost always associated with cor pulmonale. Echocardiography helps in early detection of cardiac complications in COPD cases giving time for early

interventions.

Cardiac manifestation of COPD

The cardiac manifestations of COPD are numerous. Impairment of right ventricular dysfunction and pulmonary blood vessels are well known to complicate the clinical course of COPD and correlate inversely with survival. Significant structural changes occur in the pulmonary circulation in patients with COPD. The presence of hypoxaemia and chronic ventilatory insufficiency is associated with early evidence of intimal thickening and medial hypertrophy in the smaller branches of the pulmonary arteries. Coupled with these pathological changes are pulmonary vasoconstriction arising from the presence of alveolar hypoxaemia, destruction of pulmonary vascular bed, changes in intrinsic pulmonary vasodilator substances (such as decrease in PGI₂ (prostacyclin synthase), decrease in eNOS (endothelial nitric oxide synthase), and increase in ET1 (endothelin1) leading to remodeling, increase in blood viscosity, and alteration in respiratory mechanics. All these lead to a significant increase in pulmonary vascular resistance, the consequence of which is pulmonary hypertension. Severe PH increases right ventricular afterload with a corresponding increase in right ventricular work, which results in uniform hypertrophy of the right ventricle. In patients with COPD, hypoxic vasoconstriction is associated with not only right ventricular hypertrophy but also right ventricular dilation which eventually leads to clinical syndrome of right heart failure with systemic congestion and inability to adapt right ventricular output to the peripheral demand on exercise.

Echocardiography provides a rapid, noninvasive, portable, and accurate method to evaluate the cardiac changes.

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