# Echocardiographic Findings in Patients with Chronic Obstructive Pulmonary Disease and Their Correlation with Disease Severity

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## Abstract

**Background :** Chronic obstructive pulmonary disease (COPD) is a common disease and has remarkable effects on cardiac functions, including those of the right ventricle, left ventricle, and pulmonary blood vessels. Most of the increased mortality associated with COPD is due to cardiac involvement. Echocardiography(Echo) provides a rapid, noninvasive, portable, and accurate method to evaluate the cardiac changes.

**Aim of study:** To assess cardiac changes secondary to COPD by echocardiography and to find if there is a correlation between echocardiographic findings and severity of COPD.

**Materials and Methods:** A total 50 of patients with COPD were diagnosed and staged by pulmonary function test (PFT) according to GOLD criteria into 4 stages. For all patients, detailed history, carful clinical examination, electrocardiography(ECG), chest x ray(CXR), and routine blood tests were done. All patients evaluated by echocardiography.

**Results:** On echocardiographic evaluation of COPD,40% of cases had normal echocardiographic parameters. Measurable tricuspid regurgitation (TR) was observed in 25/50 (50.0%) of cases . Pulmonary hypertension (PHT), which is defined as systolic pulmonary arterial pressure (sPAP)> 30 mmHg was observed in 14/25 (56.0%) of patients with TR (28.0% of total patients) , in which prevalence of mild, moderate, and severe PHT were 7/14 (50.0%), 4/14 (28.6%), and 3/14 (21.4%), respectively. The frequencies of PHT in mild, moderate, severe, and very severe COPD were 7.1%, 14.3 %, 35.7%, and 42.9%, respectively. Cor pulmonale was observed in 6/14 (42.9%) of cases (12.0% of total patients) ; The frequencies of cor pulmonale in patients with mild, moderate, and sever PHT were 0 , 75.0% ,100.0 % ,respectively ; 2.0% cases had left ventricle systolic dysfunction(LVSD) and 10.0% cases had evidence of left ventricle diastolic dysfunction(LVDD). Left ventricle hypertrophy (LVH) was found in 4.0% of cases**.**

**Conclusion:** Prevalence of cardiovascular complications (especially PHT and cor pulmonale) is high among COPD patients and has a linear relationship with increasing severity of COPD. Echocardiography helps in early detection of cardiac complications in COPD cases giving time for early interventions.

**Keywords:** Chronic obstructive pulmonary disease (COPD), Echocardiography(Echo), electrocardiography (ECG).

## Introduction

Chronic obstructive pulmonary disease (COPD) is a common preventable and treatable disease ,characterized mainly by persistent airflow limitation that is usually progressive and associated with enhanced chronic inflammatory response in the airways and the lungs to noxious particles and gases. [1]

COPD has a considerable effects on cardiac functions, including effects on the right ventricle ,left ventricle, and pulmonary blood vessels[2].It is well established now that cardiovascular disease contributes significantly to both morbidity and mortality in COPD [3].

The cardiovascular sequelae of COPD have been recognized for decades. The spectrum of cardiovascular disease includes right ventricular (RV) dysfunction, pulmonary hypertension (PHT), coronary artery disease (CAD), and arrhythmias. Pulmonary vascular disease associated with COPD increases morbidity and worsens survival. Patients with COPD also carry an increased risk of mortality due to arrhythmia, myocardial infarction, or congestive heart failure compared with those who do not[4].

The important notion that COPD itself is an independent risk for CVD has potentially important implications. As a systemic inflammatory disease, COPD may accelerate the development of cardiovascular disease above and beyond that due to smoking alone[5].

A number of population studies have shown that airflow limitation as measured by $FEV_1$ or $FEV_1/FVC$ ratio is a predictor of cardiovascular risk. The $FEV_1$ is also an independent predictor of cardiovascular mortality in COPD [3]. There is also a relationship between the rate of decline in $FEV_1$ and cardiovascular disease.

Echocardiography provides a rapid, noninvasive, portable and accurate method to evaluate the cardiac functions including:: 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(RHC) ($r > 0.7$)[2]. The need for further invasive diagnostics is often triggered by the Doppler echocardiographic(DE) assessment of the peak sPAP. But the reported accuracy of sPAP determination by DE is controversial. While initial comparisons between DE and RHC revealed an acceptable correlation, more recent studies questioned the diagnostic value of DE in PHT [6].

The Doppler echographic examination is a central part of the initial diagnosis and assessment of patients with pulmonary vascular disease and other forms of pulmonary hypertension. Often, the results of the initial DE examination are pivotal in the decision making process for which patients are referred for further hemodynamic assessment of their PHT [7].

Although the exact prevalence of PHT in COPD is not known, an elevation in pulmonary arterial pressure is found to occur in 20%–90% of patients when measured by right heart catheterization with some evidence that pulmonary hemodynamics worsen with worsening of airflow obstruction[8,9] .Several studies have shown an abnormal rise in the mean pulmonary arterial pressure (mPAP) in COPD of 0.4–0.6 mmHg per year. These studies reported that PH in COPD progresses slowly and could occurs in mild as well as severe forms of disease[10,11].

## Aims of Study

1. To assess echocardiographic findings in COPD patients.
2. To assess correlation between echocardiographic findings and severity of COPD.

## Patients and Methods

A cross sectional study carried out in Respiratory Consultation clinic of Baghdad Teaching Hospital for the period from 1st of February to the end of June, 2015. A convenient

sample of fifty patients presented with signs and symptoms of COPD were the sample of the study. The data were collected by direct interview and fulfilling a prepared questionnaire. Diagnosis of COPD was made on basis of detailed history, carful clinical examination supported by spirometry, electrocardiographic, and radiological data. The diagnosis of COPD was confirmed by a specialist in Respiratory Medicine in Baghdad Teaching Hospital. The questionnaire included the followings:

1. Sociodemographic characteristics: Age, gender and occupation.
2. Smoking: None, ex or current smoker.
3. Family history.
4. Clinical presentation.
5. ECG findings.
6. Echocardiographic findings.

**Statistical analysis** All patients' data entered using computerized statistical software; Statistical Package for Social Sciences (SPSS) version 20 was used. Descriptive statistics presented as (mean ± standard deviation) and frequencies as percentages. **Kolmogorov Smirnov analysis verified the normality of the data set.** Multiple contingency tables conducted and appropriate statistical tests performed, Chi-square used for categorical variables and Fishers exact test was used when expected variables were less than 20%. In all statistical analysis, level of significance (p value) set at $\leq 0.05$ and the result presented as tables and/or graphs.

## Results

A total of 50 COPD patients were included in present study with mean age 58±9 years, 52% of them were aging 50-59 years. Males were more than females with male to female ratio as 7.3:1

ECG findings were abnormal among 18 COPD patients and Echo findings were abnormal among 20 patients. Abnormal Echo findings were shown in table 1.

**Table 1: ECG & Echo findings of COPD patients.**

| Variable | No. | % |
|---|---|---|
| **ECG findings** | | |
| Normal | 32 | 64.0% |
| Abnormal | 18 | 36.0 |
| Total | 50 | 100.0 |
| **Echocardiography findings** | | |
| Normal | 20 | 40.0 |
| LVDD | 5 | 10.0 |
| LVSD | 1 | 2.0 |
| PHT | 14 | 28.0 |
| Cor-pulmonale | 6 | 12.0 |
| RHF | 1 | 2.0 |
| LVH | 2 | 4.0 |
| RVSD | 1 | 2.0 |
| Total | 50 | 100.0 |

There was a significant association between abnormal ECG findings of COPD patients and very severe COPD ($p<0.001$). A significant association was observed between COPD patients diagnosed as PHT and cor pulmonale with severe and very severe disease ($p=0.000$). Significant association was observed between PHT severity and COPD severity ($p=0.014$). All these findings were shown in table 2..Also cases of COPD diagnosed as cor pulmonale were significantly associated with severe and very severe disease ($p<0.05$), table 3.

**Table 2: Distribution of ECG, Echo and PHT according to severity.**

| Variable | Mild | | Moderate | | Severe | | Very severe | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | | |
| **ECG findings** | | | | | | | | | 28.2* | **<0.001** |
| Normal | 19 | 59.4 | 11 | 34.4 | 2 | 6.3 | 0 | - | | |
| Abnormal | 2 | 11.1 | 2 | 11.1 | 6 | 33.3 | 8 | 44.4 | | |
| **Echo findings** | | | | | | | | | 79.9* | **0.000** |
| Normal | 19 | 95.0 | 1 | 5.0 | 0 | - | 0 | - | | |
| LVDD | 0 | - | 1 | 20.0 | 1 | 20.0 | 3 | 60.0 | | |
| PHT | 1 | 7.1 | 2 | 14.3 | 5 | 35.7 | 6 | 42.9 | | |
| Cor-pulmonale | 0 | - | 0 | - | 3 | 50.0 | 3 | 50.0 | | |
| RHF | 0 | - | 0 | - | 1 | 100.0 | 0 | - | | |
| LVH | 0 | - | 0 | - | 1 | 50.0 | 1 | 50.0 | | |
| LVSD | 0 | - | 0 | - | 0 | - | 1 | 100.0 | | |
| RVSD | 0 | - | 0 | - | 0 | - | 1 | 100.0 | | |
| **PHT severity** | | | | | | | | | 15.8* | **0.014** |
| Mild | 1 | 14.3 | 2 | 28.6 | 4 | 57.1 | 0 | - | | |
| Moderate | 0 | - | 0 | - | 1 | 25.0 | 3 | 57.0 | | |
| Severe | 0 | - | 0 | - | 0 | - | 3 | 100.0 | | |

**Fishers exact test.*

**Table 3: Distribution of cor pulmonale according to COPD severity.**

| Variable | Mild | | Moderate | | Severe | | Very severe | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | | |
| **Cor-pulmonale** | | | | | | | | | 9.2* | **0.02** |
| Yes | 0 | - | 0 | - | 3 | 50.0 | 3 | 50.0 | | |
| No | 21 | 47.7 | 13 | 29.5 | 5 | 11.4 | 5 | 11.4 | | |

**Fishers exact test.*

The frequencies of cor pulmonale in patients with mild, moderate, and sever PH were 0 , 75.0% ,100.0 % ,respectively ; so we can see good correlation between severity of PH and the development of cor pulmonale, table 4.

**Table 4 : Frequency of cor pulmonale with severity of PH.**

| Severity of PH | Frequency of cor pulmonale |
|---|---|
| Mild (7) | 0(0) |
| Moderate (4) | 75% (3) |
| Severe (3) | 100.0 % (3) |

There was a significant decrease in FEV1 means associated with Echo findings especially with PHT and cor-pulmonale ($p<0.001$), table 5.

**Table 5: ANOVA analysis of FEV1 according to Echo findings.**

| Echo findings | FEV1 |
|---|---|
| | Mean±SD |
| Normal | 77.2±11.2 |
| LVDD | 71.1±19.8 |
| LVH | 70.2±0.9 |
| PHT | 48±18.6 |
| Cor-pulmonale | 36.2±11.3 |
| RHF | 44±0.1 |
| ***ANOVA (P value )*** | **<0.001** |

## Discussion

In present study, abnormal electrocardiography ECG findings were present among 36% of studied COPD patients.

We also found that 60% of COPD patients had abnormal echo results. This finding is close to results of Gupta NK, *et al* study in India (2011), which reported that 50% of COPD patients had abnormal echo findings[2].The main echo finding among COPD patients was pulmonary hypertension which is found to be 28% of various COPD severity ,while in Gupta NK, et al it was 42.5%[2].

PHT severity among COPD patients in our study was distributed as followings; 50.0% mild, 28.6% moderate and 21.4% severe. This finding is similar to results of Chaouat A, et al study in USA (2005)[12].

The frequencies of PHT in mild, moderate, severe, and very severe COPD were 7.1% , 14.3% , 35.7% , and 42.9% , respectively. In one study it was found to be 25%, 43%, and 68% in mild, moderate, and severe COPD, respectively[13]. In our study also revealed that severe PHT is present only in very severe COPD and we found a significant association between each of cor pulmonale and PHT cases with severe and very severe COPD ($p<0.05$). This finding is similar to results of Shujaat A, et al study in USA (2007)[14].

So we conclude that the incidence of PHT is directly proportional to the severity of disease. This finding is similar to results of Sultan KM, *et al* study in Iraq (2009)[15] which found high prevalence of pulmonary arterial hypertension with increasing severity of COPD.

Cor pulmonale is present in 12 % of patients in our study. Approximately 25% patients with COPD eventually develop cor pulmonale [16]. Cor pulmonale was found in 40% of patients with COPD in one autopsy study [17,18]. It is estimated that 10% to 30% of all

hospital admissions for heart failure in the United States every year are due to cor pulmonale[19] and approximately 85% of patients with cor pulmonale have COPD.[16]

Among COPD patients, there was a significant association between low FEV1 and cor pulmonale ($p<0.001$)[14].

Several studies indicate that left ventricular (LV) function remains normal in individuals with COPD, whereas others illustrate that LV dysfunction may be present [20,21]. Abnormal LV performance in individuals with COPD may be attributed to a number of factors,like hypoxemia and acidosis; coexisting coronary artery disease; ventricular interdependence (because of the right ventricle (RV) and left ventricle(LV) shared a common septum, RV dilatation may lead to bulging of the septum into the LV, which leads to increase LV end-diastolic pressure, decrease venous return, and diminish LV stroke volume and cardiac output and large swings in intrathoracic pressure [22] In our study, left ventricular systolic dysfunction (LVSD) is present in 2.0% patients, in previous studies it was present in 4%–32% patients of COPD[34].Left ventricular diastolic dysfunction(LVDD) was reported in COPD patients with normal pulmonary arterial pressure and it increased with RV after load[23]. In our study LVDD is present in 10.0% of patients, various mechanisms may explain the presence of LVDD in COPD patients. This might be due to chronic hypoxemia which lead to abnormalities of myocardial relaxation, lung hyperinflation, and distension leading to increased stiffness of the parietal pleura and thus of the wall of cardiac fossa leading to added load on ventricle, and also due to ventricular interdependence.Left ventricular hypertrophy (LVH) was reported in 4% of patients in our study, in one previous study LVH was present in 25%–60% patients dying of COPD particularly in patient who also had right ventricular hypertrophy[24].

## Conclusions

- Prevalence of abnormal echocardiography among COPD patients was high.
- Pulmonary hypertension and cor pulmonale were more prevalent among severe and very severe COPD patients.
- COPD severity was more likely to be associated with increasing age, intensity of smoking and positive family history of COPD.

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## الخلاصة

**الخلفية:** مرض الانسداد الرئوي المزمن هو مرض شائع وله تأثيرات كبيرة على وظائف القلب، بما في ذلك من البطين الأيمن، البطين الايسر، والأوعية الدموية الرئوية وان معظم الزيادة في الوفيات المرتبطة بمرض الانسداد الرئوي المزمن ناتجة عن مضاعفات الاصابة القلبية. يوفر تخطيط صدى القلب طريقة سريعة، سهلة التنقل,غير باضعة، ودقيقة لتقييم التغيرات الحاصلة في القلب.

**هدف الدراسة:** تقييم التغيرات القلبية الناتجة عن مرض الانسداد الرئوي المزمن عن طريق تخطيط صدى القلب ومعرفة ما إذا كان هناك ارتباط بين نتائج تخطيط صدى القلب وشدة مرض الانسداد الرئوي المزمن<

**طريقة البحث:** تم اختيار مجموعة مؤلفة من 50 مريض تم تشخيص اصابتهم بمرض الانسداد الرئوي المزمن و تقسيمهم الى أربعة مراحل وفقا لمعايير المبادرة العالمية لمرض الانسداد الرئوي المزمن. لجميع المرضى تم اخذ التاريخ الطبي المفصل وإجراء فحص سريري دقيق مع عمل تخطيط القلب الكهربائي ,تصوير الصدر بالاشعة السينية ,واختبارات الدم الروتينية.كافة المرضى تم تقييمهم بواسطة تخطيط صدى القلب

**النتائج:** أظهر تقييم المرضى بواسطة تخطيط صدى القلب ان 40٪ من الحالات التي تمت دراستها كانت تحمل معطيات طبيعية .وقد لوحظ قلس الصمام ثلاثي الشرف القابل للقياس في 50/25 (50.0٪) من الحالات. ارتفاع ضغط الدم الرئوي والذي يعرف بانه ارتفاع ضغط دم الشريان الرئوي الانقباضي أكثر من 30ملم زئبق لوحظ في 14\25 (56,0%) من المرضى الذين وجد عندهم قلس الصمام ثلاثي الشرف (28% من عدد المرضى الكلي في الدراسة) وقد توزعت شدة المرض(ارتفاع ضغط الدم الرئوي) كالاتي :7\14(50,0%) خفيف ,4\14(28,6%) معتدل ,3\14(21,4%) شديد.كما أظهرت الدراسة أن وتيرة ارتفاع ضغط الدم الرئوي بالنسبة لكل من مراحل مرض الانسداد الرئوي المزمن الخفيف ,المعتدل ,الشديد ,و الشديد جدا كان كالاتي:7,1% ,14,3% ,35,7% ,42,9% على التعاقب. أظهرت الدراسة وجود مرض القلب الرئوي في 6\14(42,9%) من الحالات (12% من العدد الكلي للمرضى في الدراسة) كما لوحظ ان وتيرة مرض القلب الرئوي بالنسبة لحالات ارتفاع ضغط الدم الرئوي الخفيف ,المعتدل ,والشديد , كان :صفر ,75% ,100% ,على التوالي.كما لوحظ اعتلال البطين الايسر الانقباضي في 2% من الحالات ,اعتلال البطين الايسر الانبساطي في 10% ,وتضخم البطين الايسر في 4% من الحالات.كما وجد ان هنالك انخفاض كبير في معدل حجم الزفير القسري في ثانية واحدة بالتزامن مع التغييرات المكتشفة بواسطة تخطيط صدى القلب (بالاخص ارتفاع ضغط الدم الرئوي ومرض القلب الرئوي).

**الاستنتاج:** ان معدل انتشار مضاعفات القلب والاوعية الدموية (وخاصة ارتفاع ضغط الدم الرئوي ومرض القلب الرئوي) عند المصابين بمرض الانسداد الرئوي المزمن عال وله علاقة خطية مع زيادة شدة المرض. تخطيط صدى القلب يساعد في الكشف المبكر عن المضاعفات القلبية عند مرضى الانسداد الرئوي المزمن معطيا بذلك الوقت للتدخل المبكر