Echocardiographic Evaluation of Patients with Chronic Obstructive Pulmonary Disease

Shishirakumar A. Goudar¹ and Virendra Chandrashekhar Patil¹*

¹Department of Medicine, Krishna Institute of Medical Sciences, Karad - 415110 (Maharashtra), India.

Authors' contributions

This work was carried out in collaboration between both authors. Authors SAG and VCP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SAG managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i1631296
Editor(s): (1) Dr. Paola Angelini, University of Perugia, Italy.
Reviewers: (1) Bright Thilagar, Wayne State University, USA.
(2) Imran Rashid Rangraze, RAK Medical & Health Sciences University, United Arab Emirates.
Complete Peer review History: http://www.sdiarticle4.com/review-history/66285

Received 10 January 2021
Accepted 15 March 2021
Published 25 March 2021

ABSTRACT

There is an overlap of risk factors between heart disease and COPD like cigarette smoking, sedentary lifestyle and old age. The economic burden of COPD is also very high. It is now proven that the only strategy which can reduce COPD incidence is cessation of smoking. The Aim of the present research is to study the Two-dimensional transthoracic Echocardiography (TTE) findings in patients with chronic obstructive pulmonary disease (COPD). The method is that all the enrolled patients were subjected to chest radiography, pulmonary function test, Two-dimensional transthoracic echocardiogram and Doppler study, according to the standard protocol. The findings in our study are consistent with previous studies about the COPD. Total 111(60.7%) of the patients had echocardiographic evidence of pulmonary hypertension and 83(45.4%) of the patients in this study had evidence of cor pulmonale. We found significant difference between the duration of smoking and severity of the disease based on FEV1 values (p= 0.005). A significant moderate inverse correlation existed between pack years of smoking and FEV1 scores. (r= - 0.379, P < 0.001).

Keywords: Echocardiographic; chronic obstructive pulmonary disease (COPD); chest radiography; doppler; two-dimensional transthoracic echocardiography.
1. INTRODUCTION

There is an overlap of risk factors between heart disease and COPD like cigarette smoking, sedentary lifestyle and old age. The Lung Health Trial which followed 6000 patients of COPD for 14 years found that FEV1 was an independent factor for predicting the probability of mortality from myocardial infarction [1-2]. Studies have shown high prevalence of heart disease, diabetes and hypertension in patients with low FEV1 values [3-6]. ECHO is a rapid investigation and gives data about pulmonary hypertension (PH) and structural abnormalities. It has been proven that the estimates of pulmonary arterial pressure by echocardiography are closely correlated with pressures obtained by right heart catheter [7-10]. Viegi G et al, 2000 reported prevalence of 18.3% among adults of age >25 years in rural areas of north Italy [11]. Daniëlsson et al, 2012 reported a prevalence of 16.2% in Upsala in adults age >40 years [12]. Saleem et al, 2017, conducted a community based cross-sectional study in Madurai district, on 480 participants. Prevalence of COPD was 22.1%. The prevalence in males was 39.2% and females was 12.2%. Prevalence was higher among increasing age, males, illiterate, smokers, poor ventilation and those using biomass fuels [13]. Though COPD is common among older age group, the prevalence in younger age is also of public health importance as they would be continuously exposed to the risk factors. The prevalence of COPD is higher in males than females. COPD prevalence is also high in low BMI cases [13-18].

The economic burden of COPD is also very high. It is now proven that the only strategy which can reduce COPD incidence is cessation of smoking [19]. The estimated cost of healthcare associated with COPD is $18 billion direct cost and $14 billion indirect cost [20]. Hospitalizations during an acute episode contribute to 40% of the direct costs and prescription drugs contribute 20% [21]. It is disease which progresses slowly and lung function continues to decline. Persistent cough, dyspnea, wheezing, and chest tightness can be presenting symptoms. Symptoms do not usually occur until FEV1 is approximately 50% of the predicted normal value. Chest radiographs assist in the classification of the type of COPD. Obvious bullae, paucity of parenchymal markings, or hyperlucency on chest X-ray suggests the presence of emphysema. Chest radiographs show no abnormality in at least 21% to 50% of patients with chronic bronchitis. The features that are usually described are those of emphysema, that is, signs of overinflation [22,23].

1.1 Aim

To study the Two-dimensional transthoracic Echocardiography (TTE) findings in patients with chronic obstructive pulmonary disease (COPD).

1.2 Objectives

1. To assess the cardiac findings secondary to chronic obstructive pulmonary disease by echocardiography.
2. To find out the correlation between echocardiography findings and the severity of chronic obstructive pulmonary disease.

2. MATERIALS AND METHODS

2.1 Sample Size Calculation

In the present study the Sample Size is Determined with the help of following method. According to Saleem et al, the prevalence of COPD is 22.1% [13]. Hence, we chose p=22.1%, q=1-p i.e. 78%. Using the formula for cross-sectional studies, with an absolute precision of 6 percentage points (d) at 95% confidence interval, and p=22.1%, the sample size comes up to 183 patients.

Formula: N=4pq/d2

2.1.1 Investigations

All the enrolled patients were subjected to chest radiography, pulmonary function test, Two-dimensional transthoracic echocardiogram and Doppler study, according to the standard protocol.

1. Chest radiograph:

A Chest X-ray PA view was taken in all the patients and the following points were noted.

2. Features of emphysema

- Low lying flat diaphragms
- Hyper translucent lung fields
- Narrow vertically placed heart shadow
- Horizontally placed ribs with widened intercostal spaces
- Broncho-vascular markings attenuated and not reaching periphery

3. Features of chronic bronchitis

- Prominent broncho vascular markings
4. Features of cardiomegaly
   - Cardiothoracic ratio > 50%

5. Features of pulmonary hypertension
   - Enlarged right descending pulmonary artery

2.2 Two Dimensional Transthoracic Echocardiography (TTE)

All patients selected were subjected to resting two-dimensional transthoracic echocardiography and Doppler study. The machine used was vivid E95(GE) with multifrequency probe 3.5 to 7 MHz. Two dimensional Doppler, 'M' mode, pulse wave Doppler, continuous wave Doppler and colour flow map and tissue Doppler imaging studies were done according to the standard protocol.

Right ventricular dysfunction assessed by 'M'-mode and tissue velocity doppler. TAPSE<1.7cm with tissue velocity <10 m/s considered as right ventricular dysfunction. Pulse wave Doppler on pulmonary valve used to assess Acceleration time (ACT). IVC assessed by subcostal view, pulmonary hypertension classified as mild, moderate and severe grades according to IVC collapsibility and diameter [24].

2.3 Spirometry Examination

- Participants were explained the purpose of the test and demonstrated the procedure
- Participants made to sit comfortably and to empty the bladder before the procedure
- Participants were given following advice during procedure
  - Breath in until the maximum capacity
  - Hold the breath and seal the lips tightly around a clean mouthpiece
  - Blow out the air forcibly and as fast as possible and continue blowing until the maximum capacity.

3. RESULTS

This study was a cross sectional, observational study conducted in Krishna Hospital and Medical Research Centre, Karad. The study was carried out over a period of 18 months. A total 183 patients diagnosed with chronic obstructive pulmonary disease (COPD) were included in this study to evaluate for echocardiographic changes.

The mean age in present study was 61.86 ± 10.42 years. Mean age in males was 62.56± 10.06, mean age in females was 59.71±11.27. In the present study male: female ratio was 3.4: 1.

In the present study majority of patients had history of smoking 127(69.4%) and mean duration of smoking was 15.54 ± 13.64 pack years. Majority of patients 75(41%) had history of smoking for 1-20 pack years. The mean duration of symptoms were 4.75 ± 4.43 years with majority of the patients 136(74.3%) had symptoms from 1-5 years. The symptoms were long standing, some persisting for years. Dyspnea was seen in all 183 patients, mean duration of dyspnea was 3.71 ± 4.09 years.

Chest radiograph features: Sixty five percentage of the patients had features of emphysema, 140(76.5%) of the patients had increased broncho-vascular markings suggestive of chronic bronchitis, 66(36.1%) showed cardiomegaly and 36(19.7 %) of the patients had prominent pulmonary conus. The mean FEV1 was 43.37 ± 23.52 % of predicted value. The mean FVC value was 63.68 ± 34.38 %. Mean FEV1 /FVC ratio was 1.42 ± 6.59.

Table 1. American association of cardiology guidelines for echocardiography

<table>
<thead>
<tr>
<th>Echocardiographic parameters</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF%</td>
<td>(60%-80%)- Normal, &lt;60%- abnormal</td>
</tr>
<tr>
<td>IS (cm)</td>
<td>≤4cm- Normal, &gt;4cm– dilated</td>
</tr>
<tr>
<td>TS (cm)</td>
<td>≤4cm- Normal, &gt;4cm– dilated</td>
</tr>
<tr>
<td>RV</td>
<td>≤4.5cm- Normal, &gt; 4.5cm– dilated</td>
</tr>
<tr>
<td>Right ventricular thickness (Lateral)</td>
<td>3-4 mm= Normal &gt;4 mm= Right ventricular hypertrophy</td>
</tr>
<tr>
<td>TAPSE ('M'-mode)</td>
<td>≥1.7cm-Normal, &lt;1.7 cm- Right ventricular dysfunction</td>
</tr>
<tr>
<td>Tissue doppler velocity</td>
<td>≥0.10m/second- Normal &lt;0.10m/second- Right ventricular dysfunction</td>
</tr>
<tr>
<td>TR gradient</td>
<td>&lt;35= Normal, 35-45= mild PH, 45-59= moderate PH, ≥60= severe PH</td>
</tr>
<tr>
<td>RSVP</td>
<td>TR jet gradient + IVC</td>
</tr>
<tr>
<td>ACT (Acceleration time)</td>
<td>≥100m/s-Normal, &lt;99m/s= Pulmonary hypertension</td>
</tr>
</tbody>
</table>
Majority of the patients belonged to very severe stage of COPD 99(54.1%), followed by severe 55(30.1%), moderate 16(8.7%) and mild 13(7.1%). The ejection fraction was normal in all 183 patients and the mean was 61.59±3.36.. The right atrial diameter (IS and TS) was dilated in 52(28.42%) and mean for IS (vertical section) was 3.48±0.87, the mean for TS (transverse section) was 3.49±0.80 and the right atrial dilatation was seen in 52(28.4%) of the patients. The right ventricular diameter was dilated in 72(39.34%) patients, the mean was 3.56±0.69 and the right ventricular dilatation was seen in 72(39.3%) of the patients. The right ventricular wall thickness was suggestive of hypertrophy (4 mm) in 54(29.5 %), the mean was 0.37±0.27 and right ventricular hypertrophy was seen in 54 (29.5%) patients. The TAPSE ‘M’ mode indicative of RV systolic function was abnormal (<1.7cm) in 60(32.8 %) patients and the mean was 17.32±2.27 and right ventricular systolic dysfunction was seen in 17(9.3%) of the patients.

The tissue Doppler velocity was abnormal (<0.10 m/s) in 67(36.6 %) patients suggesting right ventricular dysfunction and the mean was 0.10±0.02. The TR gradient was normal in 79(43.2%) patients, showed mild pulmonary hypertension in 29(15.8%) patients, moderate pulmonary hypertension in 33(18%) patients and severe pulmonary hypertension in 42(23%) patients and the mean was 40.67±18.53. Total 111(60.7%) of the patients had echocardiographic evidence of pulmonary hypertension and 83(45.4%) of the patients in this study had evidence of cor pulmonale. The IVC diameter was dilated (>2.1 cm) in 64.5% patients and the mean was 1.85±0.26. The RVSP was abnormal in 141(77%) patients and the mean was 48.66±23.61. Acceleration time (ACT) was abnormal in 132(72.1 %) patients and the mean was 84.09±22.34. It was found that all of these echocardiographic parameters, right atrial size (IS), right ventricular diameter, TR gradient, IVC diameter, RVSP and ACT were significantly altered with increasing severity of disease. (all ‘p’<0.05). In present study and 31(16.9 %) had evidence of interventricular septal motion abnormalities. A significant moderate inverse correlation exists between pack years of smoking and FEV1 values. (r= -0.379, ‘p’ < 0.001)

A significant moderate inverse correlation exists between duration of cough and FEV1 values (r = - 0.244, ‘p’ = 0.001), duration of dyspnea and FEV1 values. (r = - 0.305P < 0.001) and duration of edema and FEV1 values. (r= - 0.25, ‘p’ = 0.001). There was significant difference between chest radiograph findings and severity of the disease. They had increased broncho vascular markings, cardiomegaly and pulmonary conus which were present in significantly greater proportion with more severe disease (‘p’<0.05). The findings like emphysema showed no significant difference with severity of the disease. There was significant difference between echocardiographic parameters like right atrial size [IS (cm)], right ventricular dilatation, TR gradient, IVC diameter, RVSP and ACT and severity of the disease. They were significantly altered with more severe disease. (‘p’<0.05).

There was significant difference between severity of the disease and all echocardiographic findings and (‘p’<0.05), which were seen significantly altered with increase in severity of disease. There was significant difference between all echocardiographic findings (except ejection fraction and right ventricular wall thickness) and presence of pulmonary hypertension (all ‘p’<0.05), which were significantly altered with presence of pulmonary hypertension.

4. DISCUSSION

In our study, majority of the patients belonged to very severe stage of COPD (54.1%), followed by severe (30.1%), moderate (8.7%) and mild (7.1%). Similar distribution was observed in many studies. The distribution of participants in study by Chaudhary and Shrimali was also similar with severe COPD (62%), moderate COPD (34%) and mild COPD (4%) [25]. In the study by Suma et al, 60% of the patients had severe airflow obstruction, 36% had moderate and 4% had mild disease [26]. The distribution in Kaur et al was , severe (58%), moderate (28%), very severe (10%), mild (4%) [6,9]. However, in Gupta et al the distribution was different mild (45%), moderate (27.5%), severe (12.5%), and very severe COPD (15%) [4].

The findings in our study are consistent with previous studies about the COPD.

We found significant difference between the duration of smoking and severity of the disease based on FEV1 values (p= 0.005). A significant moderate inverse correlation existed between pack years of smoking and FEV1 scores. (r= - 0.379, P < 0.001)

The findings in our study are consistent with previous studies regarding association between
4.1 Chest Radiograph

On chest radiograph 65% of the patients had features suggestive of emphysema and 76.5% of the patients had increased bronchovascular markings suggestive of chronic bronchitis.

Suma et al and Ghadiya et al also reported similar findings with 80% of the patients having features suggestive of emphysema and 64-66% with increased bronchovascular markings [26,27].

Contrary to our study, Chaudhary and Shrimali reported majority (80%) chest radiograph suggestive of features of emphysema and 68% chronic bronchitis [25]. Other features on chest radiograph in our study were cardiomegaly (36.1%) and pulmonary hypertension (prominent pulmonary conus / prominent right descending pulmonary artery>16mm) in 19.7% of the patients. Suma et al and Chaudhary and Shrimali reported chest radiograph evidence of pulmonary hypertension in 30% patients each and cardiomegaly in 20% and 24% respectively [26,25].

We found that increased bronchovascular markings, cardiomegaly and pulmonary conus were present in significantly greater proportion with more severe disease (all \( p<0.05 \)). Our study findings are consistent with above mentioned studies.

4.2 Echocardiographic Findings

The following were the echocardiography findings of our study. The ejection fraction was found to be normal in almost all the patients. The right atrial size (IS and TS) was dilated in 52(28.42%) and right ventricular size was dilated in 72(39.34%) patients. The right ventricular wall thickness was suggestive of hypertrophy (>4 mm) in 54(29.5%). The TAPSE M-mode indicative of right ventricular function was abnormal (<1.7cm) in 60(32.8%) patients. The tissue doppler velocity was abnormal (<0.10 m/s) in 67(36.6%) patients suggesting right heart dysfunction. The TR gradient was normal in 79(43.2%) patients, showed mild pulmonary hypertension in 29(15.8%) patients, moderate pulmonary hypertension in 33(18%) patients and severe pulmonary hypertension in 42(23%) patients. The IVC diameter was dilated (>2.1 cm) in 118(64.5%) patients. The RVSP was abnormal in 141(77%) patients. Acceleration time (ACT) was abnormal in 132(72.1%) patients. It was found that of all these factors right atrial diameter [IS (cm)], right ventricular dilatation, TR gradient, IVC diameter, RSVP and ACT were significantly altered with more severe disease. (all \( p<0.05 \)).

Therefore, on echocardiography we found right atrial dilatation in 52(28.42%) and right ventricular dilatation in 72(39.34%) patients. Right ventricular hypertrophy was found in 54(29.5%). Right ventricular failure was seen in 17(9.3%) and interventricular septal motion abnormalities in 31(16.9 %). Evidence of cor pulmonale was seen in 83(45.4%) of the patients and pulmonary hypertension in 111(60.7%). It was found that, all echocardiographic findings were seen significantly in greater proportion with more severe disease (all \( p<0.05 \)).

Khatri D et al, in their review of hospital data on ECHO findings in 86 COPD patients reported that, 43% had right atrial dilation, 41% had right ventricular dilation, 24% had left atrial dilation and 22% had left ventricular dilation. Normal PAP was present in 48% cases and 52 % cases had pulmonary hypertension. Tricuspid regurgitation was seen in 50%. Left ventricular abnormalities found were dilation (22%), LVDD (37%), concentric left ventricular hypertrophy (7%), LVSd (30%). Significant association was seen between the pulmonary hypertension with right atrial dilatation, right ventricular dilatation, left atrial dilatation , LVDD, TR (\( p<0.05 \)) [28].

5. CONCLUSION

The cardiac changes due to chronic obstructive pulmonary disease (COPD) and their association with severity of COPD was evaluated in present study. Echocardiographic parameters like right atrial size (vertical section), right ventricular diameter, IVC diameter, RSVP and acceleration time (ACT) were significantly altered with more severe disease. A significant moderate inverse correlation exists between pack years of smoking, duration of symptoms and FEV1 values. Increased broncho vascular markings, cardiomegaly and pulmonary conus were present in significantly greater proportion with more severe disease. There was significant difference between all echocardiographic findings and severity of COPD. There was also significant difference between echocardiographic findings (except ejection fraction, right ventricular wall thickness) and pulmonary hypertension, which
were significantly altered with the presence of pulmonary hypertension. We can conclude that, significant echocardiographic changes can be seen in patients of COPD which increases with increasing severity. Echocardiography may help in early detection of cardiac changes due to COPD for early intervention.

CONSENT
As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL
As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS
Authors have declared that no competing interests exist.

REFERENCES
17. Waked M, Khayat G, Salameh P. Chronic obstructive pulmonary disease prevalence


23. Dr Yuranga Weerakkody and Dr Mai-Lan Ho; Chronic obstructive pulmonary disease. Radiology Reference Article.


© 2021 Goudar and Patil; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here: http://www.sdiarticle4.com/review-history/66285