

Correlation of Sterno-Aortic Distance with FEV1/FVC and FEV1 in Patients with COPD*

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ABSTRACT

BACKGROUND: Chronic obstructive pulmonary disease (COPD) is defined by the Global Initiative for Chronic Obstructive Lung Disease as "a disease state characterized by airflow limitation that is not fully reversible". Several qualitative and quantitative CT parameters have been studied in diagnosing patients with COPD. The clinical application of CT scan in quantitative assessment of the morphologic features of airways in patients with COPD has been subjects of numerous investigations. However, studies on sterno-aortic distance as a parameter in assessing morphologic feature of COPD in CT scan has been rare. Hence, this study aims to find a correlation of sterno-aortic distance with pulmonary function test in patients with COPD.

Methods: Eighty-one patients diagnosed with COPD who underwent chest CT scan and PFT within the period of one year were included. Sterno-aortic distance were measured and correlated with PFT results and severity of COPD.

Results: Most patients enrolled were males with average age of 64 ± 11 years old. Most of these patients are categorized as mild COPD with 38 % and severe COPD with 38% of the total population. Patients classified as moderate COPD comprise 24 % of the total population. There is significant weak inverse correlation between sterno-aortic distance and PFT results, FEV1 ($r = -0.419$, $p < 0.001$) and FEV1/FVC ($r = -0.322$, p value of 0.003). There is a significant correlation derived between sterno aortic distance and severity of COPD ($\rho = 0.88$, p -value of <0.001).

Conclusions: Sterno-aortic distance is a valuable parameter in patients with COPD as well as its severity.

Keywords: chronic obstructive pulmonary disease, COPD, sterno-aortic distance, chest CT scan

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is defined by the Global Initiative for Chronic Obstructive Lung Disease as "a disease state characterized by airflow limitation that is not fully reversible". The airflow limitation is caused by a combination of small airway remodeling and emphysema with varying distribution and severity (1). COPD is characterized by decreased maximal expiratory airflow, hyperinflation, and gas trapping. The physiologic abnormalities are caused by a combination of loss of elastic recoil and narrowing of small airways (2).

COPD consist of heterogenous group of disorders i.e. chronic bronchitis, emphysema and peripheral airway disease. The diagnosis of COPD is conventionally based upon spirometry (3). Spirometry (meaning the measuring of breath) is the most common of the pulmonary function tests (PFTs), measuring lung function, specifically the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled. Spirometry is an important tool used for generating pneumatographs, which are helpful in assessing conditions such as asthma, pulmonary fibrosis, cystic fibrosis, and COPD (4). Total lung capacity is the amount of air that remains in the lungs at the end of maximal inspiration. In patients with COPD, the greatest increase in total lung capacity is seen in patients with severe emphysema.

Several qualitative and quantitative CT parameters have been studied in diagnosing patients with COPD. In a study done by Arakawa et al., parameters such as tracheal index, thoracic cage ratio, thoracic cross sectional area and sterno-aortic distance were used in patient with COPD. Their study showed that these parameters are significantly correlated with FEV1/FVC ratio.

The clinical application of CT scan in in quantitative assessment of the morphologic features of airways in persons with COPD has been subjects of numerous investigations. Some imaging indices used are wall area, percentage, luminal area, and bronchial wall attenuation (5). It has been said that patients with COPD develop an increase in their thoracic cage diameter as the disease progresses. Parameters such as thoracic cage ratio and tracheal index have been studied in the past. However, studies on sterno-aortic distance as a parameter in assessing morphologic feature of COPD in CT scan has been rare. Hence, this study aims to find a correlation of

sterno-aortic distance with pulmonary function test in patients with COPD.

RESEARCH QUESTION

What is the diagnostic value of sterno-aortic distance in the diagnosis of COPD?

OBJECTIVES

General Objective:

1. To determine the correlation between sterno-aortic distance with FEV1/FVC and FEV1 in patients with COPD.

Specific Objectives:

1. To determine the sterno-aortic distance of patients with COPD.
2. To determine the FEV1/FVC and FEV1 among patients with COPD.
3. To determine the correlation between sterno-aortic distance with FEV1/FVC and FEV1 among patients with COPD.

HYPOTHESIS

Null:

There is no correlation between sterno-aortic distance and with FEV1/FVC and FEV1 in patients with COPD.

Alternative:

There is a correlation between sterno-aortic distance FEV1/FVC and FEV1 in patients with COPD.

METHODOLOGY

1. Study Design

This study is a cross-sectional study of cases of patents diagnosed with COPD and underwent CT scan and pulmonary function test.

2. Time Frame/Setting

This study was conducted at the Philippine Heart Center, enrolled subjects are those who have chest CT scan and PFT from January 2007 to December 2014.

3. Study Population

a. Inclusion Criteria

1. 40 years old and above
2. Patients who are diagnosed with COPD who underwent both CT scan and PFT with a maximum interval of one year

b. Exclusion Criteria

1. Patients whose CT scan was done outside the PHC
2. Clinically unstable patient
3. Patients with other chest CT scan findings i.e bullae, mass, pleural effusion
4. Patients with CT scan findings involving both upper lungs
5. patients with coexisting bronchiectasis, asthma, PTB, and bronchogenic cancer

c. Sample Size

Using NCSS-PASS 13 software, the minimum sample size requirement was estimated to be at least 61 patients base on the following parameter: Alpha = 5%, Power = 80%. Correlation coefficient between sterno-aortic distance and pulmonary function test in patients with COPD is -0.351 based on the paper of Arakawa et al (6).

4. Study Maneuver

Patients who fulfilled the inclusion criteria were included in this study. Patient's age, gender, height, and weight were recorded. The sterno-aortic distance was obtained thru their CT scan. The sterno-aortic distance was measured from the posterior surface of the sternum to the anterior margin of the aorta at the level of the carina (Appendix A). Two radiologists reviewed the CT scan images independently. These radiologists were blinded to the results of the pulmonary function tests (FEV1/FVC and FEV1). Measurements obtained by these radiologists were analyzed using t-test to check for interobserver variability. These measurements were correlated with the FEV1/FVC and FEV1 of patients who underwent pulmonary function tests results using Pearson correlation. These measurements were correlated with the severity of COPD according to the GOLD criteria.

Description of Data Collection

The results of chest Computed Tomography scan and pulmonary function test of patients diagnosed with COPD were reviewed. Eighty-one patients from January 2007 to December 2014 who qualify the inclusion criteria were included.

Inter-observer Variability

Two trained radiologists reviewed the Computed Tomography images. They were blinded to the pulmonary function test results. The data was then analyzed using t-test to check for interobserver variability.

Measurement of sterno-aortic distance

Coronal and sagittal images of chest CT scan were used. The steno-aortic distance was measured from the posterior surface of the sternum to the aorta at the level of the carina (Appendix A).

Pulmonary function test

The pulmonary function test results of patients who qualify in this study were reviewed. The presence of COPD was confirmed using FEV1/FVC ratio while the severity of COPD was measured using FEV1. These values were correlated and used to stratify the patients according to the GOLD criteria of COPD.

Description of Outcomes

The outcome of this study is to determine the correlation of sterno-aortic distance with severity of COPD.

5. Data Analysis

Data analysis will be done using Strata SE version 13. Quantitative variables were summarized and presented as mean and SD while qualitative variables were tabulated and presented as frequency and percent distribution. Correlation between sterno-aortic distance and pulmonary function test (FEV1 and FEV1/FVC) in patients with COPD were determined and tested using Pearson's product moment correlation and was graphically presented in a scatter plot. A p-value Of 0.05 was considered statistically significant.

WAIVER OF CONSENT

This study was conducted in compliance with the ethical principles of Declaration of Helsinki. Prior to the study invitation, the protocol was reviewed and approved by the Philippine Heart Center Ethics Review Board (PHC IERB). The investigator requested for the waiver of consent for the following reasons: difficulty of obtaining individual authorization since the last contact with research subjects.

The risk to the subject's privacy is minimal and no sensitive information was obtained. The investigator ensured that the subject's anonymity is maintained. The data were obtained by review of PFT records from the Pulmonary Department and CT scan images from the Radiology Department. There was no patient data that revealed.

DEFINITION OF TERMS

- 1. COPD** - chronic obstructive pulmonary disease
- 2. Sterno-aortic distance** - distance from the posterior surface of the sternum to the anterior margin of the aorta at the level of the carina.
- 3. FEV1** - volume of air exhaled in one second after full inspiration
- 4. FEV1/FVC**- the percentage of the vital capacity which is expired in the first second of maximal expiration

REVIEW OF RELATED LITERATURE

Chronic obstructive pulmonary disease (COPD) is one of the leading most common cause of morbidity and mortality worldwide. The increasing incidence of exposure to its risk factors has placed a burden on our society and economy.

COPD is defined by the American Thoracic Society as an abnormal permanent enlargement of the air spaces distal to the terminal bronchioles with destruction of their walls. COPD is a heterogeneous group of disorders including emphysema, peripheral airways disease and chronic bronchitis. In the past, diagnosis of COPD has been greatly dependent on spirometry. However, In the recent years, with the advent of computed tomography (CT), there has been increasing interest in diagnosing patients with COPD using computed tomography parameters.

Several qualitative and quantitative CT parameters have been studied in diagnosing patients with COPD. In a study done by Arakawa et al., parameters such as tracheal index, thoracic cage ratio, thoracic cross sectional area and sterno-aortic distance are used in patients with COPD. Their study showed that these parameters are significantly correlated with FEV1/FVC ratio.

This study aims to determine if there is a significant correlation between sterno-aortic distance and COPD. Sterno-aortic distance is the distance between the posterior surface of the sternum to the anterior margin of the aorta at the level of the carina. Even though sterno-aortic distance has been used in some study, studies on this parameters has yet to show any finite correlation. In a study by Gupta et al., which included 40 patients with COPD, various quantitative parameters were used. These include tracheal index, sterno-aortic distance, thoracic cage ration and thoracic cross sectional area, which are said to be suggestive of hyperinflation in COPD. Their study showed that sterno-aortic distance greater than 4 cm were found in 5 patients with COPD. The same study also showed that these parameters had significant correlation with age, duration of illness, pack years of smoking and dyspnea scale, as well as with FEV1 and FEV1/FVC ratio.

The use of CT scan recently has been the pivot point in assessment of airway morphologic features in patients with COPD. A study by Yamashiro et al., showed that bronchial peak wall attenuation in CT correlates with significantly with expiratory air-flow obstruction in patients with COPD. The change in airway characteristic is believed to be due to chronic remodeling. This is one parameter in which the use of CT scan was used in determining the presence of COPD, by using bronchial wall attenuation.

In diagnosing patients with COPD, CT scan is an important and indispensable tool for its evaluation. COPD patients with emphysema on CT scan have a higher BODE index (body mass index, airflow obstruction, dyspnea and exercise performance) while they have lower inspiratory capacity to total lung capacity than those without emphysema. Hence the addition of CT scan in to pulmonary function tests serves as a valuable tool in obtaining the diagnosis.

Another study done by Mostafa and Mostafa, 50 male patients with average age of 40 to 60 years old were examined for COPD using HRCT. Male subjects were included in accordance to a study done by Wang et al., which showed that the prevalence of emphysema is higher in man than in woman. Their study showed that 33 out of 50 patients (66%) were found to have a sterno-aortic distance of 4 cm or more.

Heagan and Kolbenstvedt also reported that sterno-aortic distance was measured in CT sections at the carinal level if 4 cm or more is characteristic for emphysema.

Amidst all the data collected from different studies, reports on correlations between the sterno-aortic distance to COPD have been rare. Since COPD patients usually presents with emphysematous changes such as increase in AP diameter of the thorax, degree of hyperearation, or changes in lung attenuation, the increase in sterno-aortic distance is said to be present in patients with COPD.

RESULTS

TABLE 1. Demographics of patients with COPD included in this study.

Characteristics n=81	Mean ± SD or n(%)
Age	64.42 ± 11.19
Gender	M= 62 (77) F= 19 (23)
Height (cm)	163.19 ± 7.71
Weight (kg)	62.83 ±15.07
COPD	
Mild	31 (38)
Moderate	19 (24)
Severe	31 (38)

The demographic characteristics of patients with COPD included in this study is shown in Table 1. In this study, 81 records of patients who are diagnosed with COPD and underwent chest CT scan within one year interval were included and reviewed. There were 62 (77 %) male subjects and 19 (23 %) females. Most patients have an average age of 64 years old. The subjects have a mean height of 163.19 cm and mean weight of 62.83 kg. Most of these patients are categorized as mild COPD with 38 % and severe COPD with 38% of the total population. Patients classified as moderate

COPD comprise 24 % of the total population. Two radiologists reviewed the records of these 81 patients.

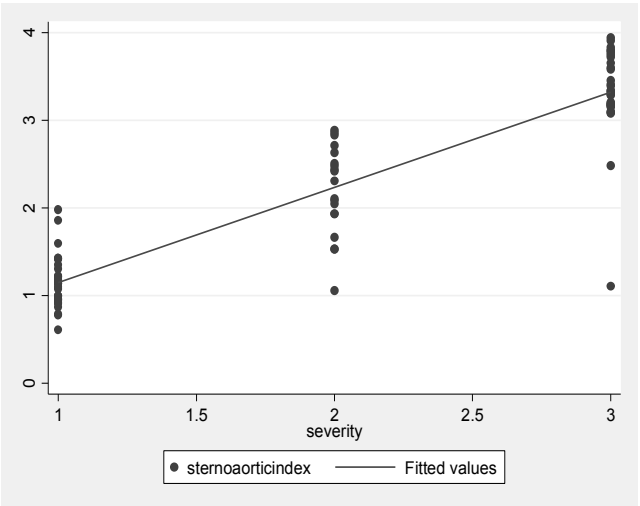


Figure 1 shows that sterno-aortic distance have a significant correlation with the severity grading of COPD by GOLD criteria (*r* of 0.3 - 0.4). The greater is the sterno-aortic distance, the more severe is the obstructive process.

TABLE 2. Correlation coefficient of sterno-aortic distance in CT scan with PFT

PFT Parameters	Sterno-aortic Distance	
	r	p
FEV1/FVC	-0.322	0.003
FEV1	-0.419	< 0.001

P = < 0.05 will be considered significant
r = Pearson's correlation

Table 2 shows that there is significant weak inverse correlation between sterno-aortic distance and FEV1 (*r* = -0.419, *p* value of <0.001). There is likewise a significant weak inverse correlation between sterno-aortic distance and FEV1/FVC (*r* = -0.322, *p* value of 0.003).

TABLE 3. Correlation of sterno-aortic distance by CT scan with severity of COPD

COPD	rho	p
Severity	0.88	<0.001

p = <0.05 will be considered significant
r = Spearmann's rho correlation

Table 3 shows that there is a strong direct significant correlation between sterno-aortic distance and severity of COPD ($\rho = 0.88$, p -value of <0.001).

Table 4. Interobserver variability of the sterno-aortic distance measured by the two radiologists.

	Radio 1 Mean $\pm$ SD	Radio 2 Mean $\pm$ SD	p - value
Sterno-aortic distance	2.24 $\pm$ 1.06	2.23 $\pm$ 1.05	0.316

In assessing for interobserver variability between the two radiologists who reviewed the chest CT scan of the subjects, a t-test was done (Table 3). A value of 0.316 was obtained indicating that there is no significant variability between the measurements of the two observers.

DISCUSSION

This study showed that measurement of the sterno-aortic distance could be potentially used as a quantitative CT index in patients with COPD. It showed significant weak inverse correlation with FEV1 ($r = -0.419$, $p < 0.001$) and FEV1/FVC ($r = -0.322$, $p < 0.003$), which are parameters of obstructive pulmonary disease in pulmonary function test. These findings showed that as we observe an increase in the sterno-aortic distance, there is likewise a corresponding decrease in the FEV1 and FEV1/FVC values, which are measures of an obstructive process. This is in congruent with the study of Gupta et al., that various CT parameters such as tracheal index, sterno-aortic distance, thoracic cage ratio and thoracic cross sectional area are said to be suggestive of hyperinflation in COPD. (3) These findings are also in agreement with the paper done by Arakawa et al., which showed that parameters such as tracheal index, thoracic cage ratio, thoracic cross sectional area and sterno-aortic distance are used in patient with COPD. However, their study showed that these parameters are significantly correlated with FEV1/FVC ratio. (6)

This study also showed a strong direct significant correlation between sterno-aortic distance and severity of COPD ($\rho = 0.88$, p -value of <0.001). The study Mostafa and Mostafa showed a correlation between HRCT and spirometry in patients for early diagnosis of emphysema, however, their study revealed moderate correlation. (7) Nakano, et al., made an attempt to correlate HRCT of emphysema and spirometry that with moderate and showed significant correlation. (7)

These findings can be explained by the fact that changes in the thoracic diameter were observed in patients with chronic obstructive disease of the airways. This can be attributed to the fact that as an increase in the severity of the obstructive disease, an increase in the degree of hyperinflation of the thorax is likewise noted. (3)

Emphysema causes abnormal enlargement of the airspaces distal to the terminal bronchiole, hence, airway wall obstruction is evident. This causes air trapping and subsequent hyperinflation of the lungs. (7)

In addition, this study was able to establish the range of sterno-aortic distance of patients with COPD. As shown in Figure 1, the higher the severity of COPD, the wider is range of sterno-aortic distance. This can be attributed to a relatively difference in the degree of compensation of the thorax to the degree of air trapping in hyperinflation.

The subjects in this study were those patients who underwent chest CT scan and pulmonary function test within one year period from 2007 to 2014. One of the limitations in this study would be the fact that the CT images from this period would be compressed and reconstructed, hence, this would limit the radiologist from obtaining optimal sterno-aortic distance measurement. Also the distribution of patients should be more equal and groups the severity should be well-represented since in this study most patients included were patients with mild and severe COPD, both occupying 38% of the entire population of subjects. A follow up should have been also done in these patients so the progression of the disease can be evaluated. This can give a stronger and more predictive diagnostic value.

In order to obtain a more specific CT parameter that can give predictive value to COPD, a comparison with sterno-aortic distance and other CT parameters such as tracheal index, thoracic cage ratio and bronchial wall attenuation can be an area for further research.

CONCLUSION

This study shows that sterno-aortic distance is a valuable index in evaluating patients with COPD. The sterno-aortic distance measured in chest CT scan showed significant weak inverse correlation when correlated with FEV1 and FEV1/FVC, and that there is a strong direct significant relationship between sterno-aortic distance and severity of COPD.

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APPENDIX

APPENDIX A. MEASUREMENT OF THE STERNO-AORTIC DISTANCE AT THE LEVEL BEFORE THE FIRST BRANCH OF THE AORTIC ARCH.

