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CORRELATION OF CT PARAMETERS WITH PULMONARY FUNCTION TESTS IN EVALUATING THE COPD PATIENTS.

Radio-Diagnosis

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ABSTRACT

COPD is an irreversible, disabling respiratory disease that is characterised by great diagnostic complexity. COPD can be diagnosed early and accurately, but the current diagnosis tests, including PFT, have limited ability to determine structural changes in the lungs. HRCT has become a central imaging modality in visualizing the lung parenchyma: emphysema, broncho wall thickening, and air trapping. This study analysed the correlation between Scores of CT-derived lung attenuation and PFT Values of FEV1, FVC and FEV1/FVC in varying state of COPD. This study aimed to modify diagnostic model which included structural and functional evaluations. A total 70 patients of COPD ever treated at a tertiary care hospital were selected. In addition, lung quantification was done on HRCT to determine mean lung attenuation, airway wall thickness, and emphysema map. At the same time, PFT was performed to assess FEV1, FVC, and the FEV1/FVC ratio in the cohort. Correlation among the values obtained with HRCT and PFT tests. These findings revealed a positive and powerful relationship between the HRCT measures and PFT indices particularly lung attenuation scores. Compared to patients with lesser degrees of airflow obstruction and normal or near normal FEV1 and FEV1/FVC, patients with greater extent of emphysema and lower luft LU attenuation values on HRCT scan, showed reduction in peripheral lung sparing. There was integration of HRCT with PFT may offer a logical evaluation approach to the severity of COPD, how it affects the structure and function of the lungs. Study concluded the clinical usefulness of the HRCT parameters and PFT in the diagnosis and staging of COPD.

KEYWORDS

COPD, High-Resolution Computed Tomography, HRCT, Pulmonary Function Test, PFT, FEV1, FVC, Emphysema, Lung Attenuation.

INTRODUCTION

COPD diagnosis based on spirometry provides an opportunity to perform trials before the limitation of airflow and application of methods aimed at preserving the function of lungs. Research has indicated that, early diagnosed and managed patient undergo a slower decline in the level of lung functions than those diagnosed at a later stage (Kumar et al., 2018).[1]

Compared to routine CT scan, HRT scan has high resolution that is especially intended for lung parenchyma and airway imaging. HRCT employs specific protocols to enhance image quality, usually focusing on two main phases of respiration: inspiration and expiration. In the inspiratory phase of the deep breath and HRCT reconstructions of lung parenchyma demonstrate the alveoli, the interstitium and small calibre airways would be depicted. It will enable a diagnosis of disease like emphysema, which includes destruction of alveolar walls, and enlargement of the airspace, thus lowering lung density. The expiratory phase is as important because it shows regions of trapped air, which is sorputaneous in small airways diseases, common with COPD. (Vimala et al., 2019).[2]

Pulmonary Function Tests (PFTs) are among the basic diagnostic tests that play a central role in confirming diagnosis. The most popular PFT that are widely employed in assessment of lung function include Forced Expiratory Volume in one second and Forced Vital Capacity and the FEV1/FVC ratio. FEV1 is the volume of air that can be forcibly exhaled in one second following the maximal inhalation from as deep a breath as possible. In patients of COPD, the flow rate during this first second is abysmally low because of the inability of the individual to exhale the air rapidly through a restricted or occluded airway (Bhaskar et al., 2018).[3]

Thus, the present study is undertaken to correlate the CT parameters with pulmonary function tests in evaluation of COPD patients at a tertiary care hospital.

Methodology

70 patients presented to hospital's pulmonology and respiratory outpatient departments (OPD) and inpatients departments; presented with symptoms of COPD were screened after taking informed consent.

Inclusion Criteria

1. Patients aged 40 years or older.
2. Patients diagnosed with COPD.
3. Patients referred for HRCT and PFT.
4. Patients willing to participate.

Exclusion Criteria

1. Other pulmonary diseases.
2. Acute respiratory infections.
3. Previous thoracic surgery.
4. Inability to perform PFT.
5. Pregnant patients.
6. Severe comorbidities.
7. Inadequate HRCT or PFT data.

The demographic data, clinical history, HRCT data, PFT data and other relevant medical information was collected with standardized proforma and the collected data was analysed by using SPSS (Statistical Package for the Social Sciences). Descriptive statistics was done and correlation was determined. Regression analysis was done. ANOVA was used to compare HRCT parameters and PFT results across different COPD severity stages as defined by the GOLD criteria (mild, moderate, severe, and very severe). ROC curve analysis was done. This helped in determining the sensitivity and specificity of certain CT findings (e.g., extent of emphysema) for identifying severe COPD cases. A p-value less than 0.05 was indicated that the observed relationship between HRCT parameters and PFT results were statistically significant.

OBSERVATION AND RESULT

The present study observed that COPD predominantly affected the older adults. Smoking, occupational and environmental exposures to pollutants such as dust, fumes, and chemicals were the most common risk factor and COPD patients often experienced the weight loss due to muscle wasting, while others may have obesity-related comorbidities that complicate disease management. The observed common comorbidities were CAD, hypertension, DM and heart failure.

Table 1 Mean Lung Attenuation by COPD Severity (HU)

COPD Severity (GOLD Stage)	Inspiratory Lung Attenuation (HU)	Expiratory Lung Attenuation (HU)
GOLD I (Mild)	-820	-740
GOLD II (Moderate)	-860	-760
GOLD III (Severe)	-900	-780
GOLD IV (Very Severe)	-910	-800

As shown in table 1, the CT finding revealed that during the inspiratory

phase the average lung attenuation across all patients was -850 Hounsfield Units (HU). COPD patients in severe condition demonstrated significantly lower lung attenuation values, averaging -910 HU, indicating extensive emphysematous changes. During expiratory phase mean lung attenuation was -770 HU across all patients. This phase helps identify areas of air trapping, which is a common finding in COPD due to small airway disease.

Table 2 Average Airway Wall Thickness By COPD Severity (mm)

COPD Severity (GOLD Stage)	Average Airway Wall Thickness (mm)
GOLD I (Mild)	2.1 mm
GOLD II (Moderate)	2.4 mm
GOLD III (Severe)	2.8 mm
GOLD IV (Very Severe)	3.0 mm

The average airway wall thickness in the study population was 2.5 mm in larger airways (measured in bronchi with diameters between 2-3 mm). Patients in the GOLD III and IV stages had significantly thicker airway walls, with measurements averaging 3.0 mm as shown in table 2.

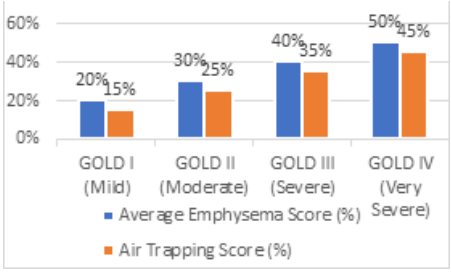

Figure 1. Emphysema and Air trapping scores by COPD Severity (%)

The average emphysema score was 20% in GOLD I and increased to 50% in GOLD IV. The average air trapping score (percentage of lung volume affected) was 15% in mild phase and increased to 45% in severe (very) as depicted in figure 1. The HRCT parameters—lung attenuation, airway wall thickness, emphysema scores, and air trapping—demonstrated variations.

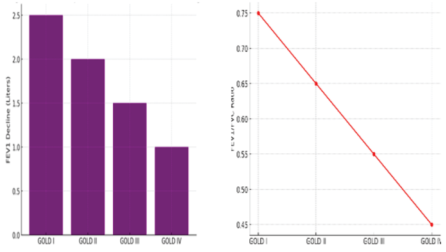

Figure 2. Relationship between FEV1 Decline and GOLD Stages

The FEV1/FVC ratio demonstrates a marked decline as COPD severity increases in figure 2, with ratios below 0.70 indicating airflow limitation typical of obstructive lung disease. Patients having ratios as low as 0.45, indicating significant airflow obstruction.

DISCUSSION

Several insights about the structural and functional relationship of the lungs in COPD were derived from the analysis of correlations between HRCT parameters and PFT indices in patients with COPD. The HRCT derived lung attenuation was found to have a significant, inverse relationship with FEV1, one of the usual PFT indices of airflow obstruction. The correlation of emphysematous destruction with airflow obstruction was established through decline in lung attenuation values manifesting less FEV1% ass the condition eased (Gartman & Csikesz, 2014) [5].

Moreover, airway wall thickness, an aspect of airway remodeling detected on HRCT also had an inverse relationship with the FEV1/FVC ration a second specific PFT parameter. Airway wall thickness increases the caliber of the airway; thus, the resistance and the total of the airways will be reduced and, in its proportion, FEV1 and FEV1/FVC (Chae et al., 2011; Hogg, 2000) [6-7].

The study also determined the relationship between the magnitude of emphysema assessed using HRCT and decline of lung function measured in the patients with COPD all out of which majority were at their mature stages. Emphysema is characterized by the loss of alveolar walls and increased size of airspaces reducing lung elastic coat and therefore impaired gas exchange. The emphysema percentage quantified on HRCT represents a valuable index for estimating the severity of COPD and for predicting a worse functional status (D'Anna et al., 2011) [8].

Assessment of another parameter of HRCT, that is air trapping, showed its link to the degree of airway obstruction, primarily in SAD. Retained air is that air which does not leave the lungs during expiration because of some form of airway obstruction which results in hyperinflation. There were learning curve differences in PFT performance; FEV1 levels and FEV/FVC ratios were significantly reduced. There was air trapping which is a critical functional outcome of anatomical airway disease and its demonstration on HRCT could be useful in estimating the severity of airflow reduction in COPD patients (Ghanei et al., 2012) [9].

Lastly, the stratification analysis by GOLD stages (0,1, 2, 3 and 4-very severe COPD) reinforced the connection between the indices derived from the analysis of the HRCT parameters and the PFT. With the disease severity escalating from Mild to Very Severe COPD, FEV1 and FEV1/FVC were markedly lower and HRCT examination showed lower lung attenuation, greater thickening of airway walls, higher percentages of emphysema and air trapping percentages. Such data indicate the importance of linking HRCT scans with PFT to stage the disease and assess the COPD evolution (Gupta 2011; Shaw et al., 2002) [10-11].

Thus, the main correlations identified between the examined HRCT parameters and PFT indices in the present paper confirm the significant association between structural alterations and functional decline. The use of HRCT in conjunction with PFTs should be encouraged more in the diagnosis, staging and management of COPD as depicted in the findings

The changes observed on HRCT are consistent with the pathophysiologic processes of COPD they include emphysema, airway remodelling and air trapping that all adhere to the declining lung function seen (Rao et al., 2018) [12].

Emphysema decreases lung density, which is expressed on HRCT as patchy areas of low density known as LAA, which is an indication of the percentage of low attenuation area. It also leads to the stated physiological destruction of lung parenchyma that diminished the otherwise required elastic recoiled of the lungs so as to expel air. Thus, the hallmark features of COPD such as airflow limitation and hyperinflation are present in patients with extensive emphysematous changes. These physiological changes affect the Pulmonary Function Test (PFT) which includes FEV1, which determines the amount of force with which a patient expires in one second. The differences in the lung attenuation values measured on the HRCT scans are a reflection of COPD's loss of elastic tissue's recoil, expiratory airflow obstruction, and characteristic airflow patterns. Another concerned observation on HRCT is the airway wall thickening which is much important in patients with COPD of chronic bronchitis phenotype. This thickening happens due to inflammation and remodeling of the bronchial wall according to the period and whereby the lumen becomes narrow and the resistance to airway increases. The physiological implication of this structural change is a decline in airflow and especially during expiry as resistance to air expires increases following constriction of airways. On HRCT, this thickening is seen as smooth rings or ovals of varying thickness in the large airways, and is related with increased secretion and submucosal gland hyperplasia. The degree of airway wall thickening also partitions with the level of airway obstruction as suggested by FEV1 as well as FEV1/FVC ratio in PFT. Such association highlights physical effects of airway narrowning resulting from chronic inflammation and remodeling making it difficult for the lungs to sustain regular breathing (Vimala et al., 2019).[2]

HRCT also shows air trapping The limitation to expiratory airflow that is witnessed at physiological basis in this disease can be directly related to the visualization of air trapping by the HRCT scan giving it important information for grading its severity (Bhaskar et al., 2018).[3]

In severe emphysema, bullae can be detected on little HRCT. Bullae visible in the HRCT scans are used as confirmation of the worst types of emphysema, decreased lung vitality, and an indication for intense

treatment measures (Gupta et al., 2008).[4]

The findings of this study concerning the relationship between High-Resolution Computed Tomography (HRCT) and Pulmonary Function Tests (PFT) in COPD constitute a powerful model for decision-making in the treatment of the diseased state. By using both HRCT and PFT we are provided with detailed structural changes in the lungs and the consequent functional impairments.

Also, correlating the extent of emphysema determined by HRCT with PFT results to help to improve the accuracy of COPD diagnosis is a major advantage. Although PFTs and the FEV1 and FEV1/FVC ratios are crucial for diagnosing and staging COPD. HRCT, in contrast, may show expiratory CT images with emphysematous changes, airway wall remodelling, and air trapping that are not detectable in PFT in some cases because of the early-stage disease or mild airflow limitation. For instance, a patient with centrally abnormal FEV1 values but normal peripheral FEV1 values but highly severe emphysema on HRCT might, therefore, be managed differently from a patient with the same PFT results and little or no structural damage. Overall, the combined use of these modalities means that clinicians can diagnose COPD phenotypes, more accurately, and much earlier (Kumar et al., 2018).[1]

In regards to phenotyping COPD, the association between HRCT scans and PFT values is beyond helpful. On the contrary, patients with little emphysema but significant airway disease may be better served by more aggressive bronchodilator or anti-inflammatory therapy targeted at reducing airway resistance (Gupta et al., 2008).[4]

HRCT helps in tracing complications such as bulla formation which predisposes a patient to develop spontaneous pneumothorax; thus, helping in making decisions and leading to the patients' demise (Vimala et al., 2019).[2]

Moreover, through evaluation of lung parenchymal density, HRCT predicts if emphysema distribution is heterogeneous (focal) or homeogenous (extended or diffuse) which determines surgical candidacy. Where the PFT result could otherwise imply severe airflow limitation, HRCT allows for a detailed view of the structural damage to guide more specific surgical decisions about lobectomy or segmentectomy (Bhaskar et al., 2018).[3]

CONCLUSION

The present study concluded that the integrating HRCT into routine practice for COPD patients offers numerous benefits, from early detection and accurate staging to personalized treatment and ongoing monitoring of disease progression. By combining HRCT with PFT, clinicians can provide more precise and individualized care, improved outcomes.

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