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3D CT volumetric analysis of the lung in COPD patients: Comparison with pulmonary function tests

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***Abstract*---**Background: Retro and prospective comparative analytical study will be done over a 2-year period on patients with a multidisciplinary diagnosis of chronic obstructive pulmonary disease at the radiology department of Ain Shams University Hospitals. The aim of the study: To assess the role of the new CT lung analysis in quantitative assessment of chronic obstructive lung disease. The procedures: Patients will be subjected to CT chest without contrast then 3D models will be reconstructed using a software that allows automatic segmentation of each lung lobes and volume calculation, and giving each lung zone a Goddard score to determine the severity. The instruments: Patients will be assessed by the pulmonary function tests and body plethysmography. The results: The results will be collected and compared together. Data analysis will be performed using IBM statistical program for social science, version 22.0 (SPSS, 2013; IBM Corp., USA). Quantitative and qualitative data will be

expressed as mean±SD, frequencies, and percentages. In addition, the relationship between total lung capacity (TLC), CT lung volume, and percentage LAA will be assessed and considered significant when the P-value is less than 0.05. Conclusion: This study is expected to evaluate the accuracy of measurements of lung volumes reconstructed using three-dimensional CT imaging from thin-section multi-detector CT (MDCT) images compared to standard pulmonary function testing. This will add a value to the respiratory physicians to plan the management of COPD patients.

***Keywords*---**3D CT, lung volume, COPD, pulmonary function tests.

Introduction

Chronic obstructive pulmonary disease is very common and has many implications on both morbidity and mortality *(Plantier et al., 2018).* The current method used for assessment of its severity is the spirometry, the forced expiratory volume in the first second in liters (FEV 1) *(Karimi-Shah & Chowdhury, 2015)*, in addition to the use of computed tomographic (CT) to determine the extent of parenchymal distortion and degree of emphysematous changes *(Hansell et al., 2015).* Few previous studies have evaluated lung volumes on CT in the context of chronic obstructive pulmonary disease, using both automated software *(Iwano et al., 2009), (O'Donnell et al., 2010)* and manual measurements *(Hightower et al., 2016).*

Methodology

Patients will be subjected to:

- CT chest without contrast imaging, then all thin-section CT data for each patient will be transferred to the synapse software; from which three-dimensional models will be reconstructed using the 3D software program (FujifiLN, synapse 3D, V4.4EU). This software allows automatic segmentation of each lung lobes and volume calculation, which is expressed in milliliters.
- Threshold limits of -400 to -1024 Hounsfield units (HU) will be applied to exclude soft tissue surrounding the lung and large vessels within the lung.
- First, the volume of voxels on these three-dimensional images will be calculated as total lung capacity (TLC-CTV).
- Second, the volume of voxels with attenuation values < -950 HU will be measured as emphysematous lung capacity (ELC-CTV). The value -950 HU is the threshold previously reported to separate emphysematous lung from normal lung *(Ohno et al., 2007) (Sverzellati et al., 2005) (Wu et al., 2002) (Fourdrain et al., 2017).*
- CT densitometry: it is an automated identification of the low-attenuation area (LAA), which is defined as an area with Hounsfield unit (HU) density less than 950, and is also defined as a cluster.
- Normal lung capacity (NLC-CTV) will be calculated by subtracting ELC-CTV from TLC-CTV.

- Goddard score calculation: it is the calculation of the percentage of low attenuation area (LAA) per surface area, and a specific scoring will be obtained to detect the severity degree. Each lung will be divided into three zones: the upper zone, extending from the apices to the level of the aortic arch; the mid zone, extending to the level of tracheal bifurcation; and the lower zone, extending to the level of the diaphragm.

Pulmonary Function Testing

- Lung function
  FEV_1, FEV_1/FVC ratio, and maximum mid-expiratory flow (MMEF) will be measured using the spirometry system (Masterscreen 2001, version 4.5; Erich Jaeger GmbH, Germany). Readings will be performed in triplicate, with the highest values recorded and expressed as percentages of the predicted value. The examination will be carried out according to the guidelines of the American Thoracic Society *(Miller et al., 2005). Airways obstruction is defined as post bronchodilator*FEV_1/FVC is 0.70 or less and FEV_1 less than 80% predicted. The patients are classified according to the severity using GOLD 2019 into four categories *(Singh et al., 2019).*
- Body plethysmography
  Measurement will be performed using a Master Lab–Body Plethysmography Unit (Body Box MasterScreen 2001, version 4.5; Erich Jaeger GmbH, Germany) according to the main principles of the American Thoracic Society/European Respiratory Society Task Force Guidelines (Miller et al., 2005).

Study end point

When enough data of all the pre -determined sample size is obtained and analyzed.

Statistical Analysis

The results will be collected and compared together. Data analysis will be performed using IBM statistical program for social science, version 22.0 (SPSS, 2013; IBM Corp., USA). Quantitative and qualitative data will be expressed as mean±SD, frequencies, and percentages. In addition, the relationship between total lung capacity (TLC), CT lung volume, and percentage LAA will be assessed and considered significant when the *P*-value is less than 0.05.

Statistical Package

The collected data will be revised, coded, tabulated and introduced to a PC using a reliable software program. Data will be presented and suitable analysis will be done according to the type of data obtained for each parameter.

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