BRIEF COMMUNICATION

Utility of Chest Computed Tomography for Chronic Obstructive Pulmonary Disease Patients

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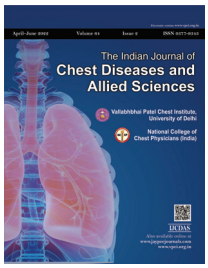

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Abstract

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases and influenced by host factors including abnormal lung development.[1] Currently, the diagnosis of COPD is based on the clinical history of the patient along with a post-bronchodilator forced expiratory volume in one second/forced vital capacity (FEV_1/FVC) ratio lower than 0.70 on spirometry. Even though spirometry is considered the most valuable tool in diagnosing COPD, it lacks in certain aspects such as covering the morphological analysis of the disease and correlating between the lesions and lung function. Also, spirometry usually becomes abnormal pretty late in the disease evolution, and hence, is unable to identify early and pre-COPD patients leading to delayed diagnosis. Chest computed tomography (CT) scan provides *in vivo* assessment of organ structure and can prove itself to be a useful tool to provide additional information about parenchymal remodeling, airway dilation, and vascular calcification. This, in turn, can be useful to not only detect and stratify the severity of the disease but can also to predict its clinical course. We must consider the utility of CT scan to offer impactful therapy for what is found in those images. However, does this additional information really makes a difference in the management of COPD patients? Can this information be obtained using inexpensive and easy methods (such as spirometry and questionnaires)? Does this additional information really justify the expense of radiation exposure? This article highlights the utility, limitations, and future prospects of adding a chest CT scan as a routine investigation in patients with COPD.

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Abbreviations used in this Article

CT = Computed tomography; COPD = Chronic obstructive pulmonary disease; FEV_1 = Forced expiratory volume in one second; FVC = Forced vital capacity; LVRS = Lung volume reduction surgery; PAH = Pulmonary artery hypertension

Utility of Chest CT for COPD Patients

There have been several improvements in CT imaging over the last 25 years that might help us to provide a better detail of the structure of lung parenchyma, phenotypes, and even lung function. CT scan provides an excellent *in vivo* assessment of the lung anatomy from which we can easily extract information on parenchymal remodeling, airway dilation, and vascular calcification. Chronic obstructive pulmonary disease is considered a multi-compartment disease affecting the lung parenchyma, airways, and pulmonary vasculature.[1,2] Airflow limitation in COPD can be attributed to parenchymal destruction due to emphysema. Emphysema is characterized by alveolar wall destruction and can be assessed visually using chest CT.[3–7] With the use of a chest CT scan, emphysema can be quantitatively evaluated using low attenuation area percent (LAA%) which is derived from the voxel frequency distribution histogram. A threshold of –950 Hounsfield units (HU) is most commonly employed.[8–10] CT scans also indicate the emphysema phenotype (centrilobular, panlobular, paraseptal, or pericicatricial). This parameter is considered useful as it has been found to be a predictor of mortality as large emphysema in upper areas is associated with increased survival in COPD patients compared to basal localization.[11]

Bronchiectasis is defined by abnormal and permanent dilatation of the bronchi and is associated with an increased risk of colonization with pathologic respiratory bacteria leading to increased severity of acute respiratory events and death in COPD patients. Obtaining knowledge of this condition has clear implications for the treatment of recurrent exacerbations associated with chronic respiratory diseases. These patients are extremely vulnerable to colonization with potentially pathogenic organisms, such as *Pseudomonas aeruginosa* and *Enterobacteriaceae*, thus, requiring appropriate empiric antimicrobial therapy in the absence of isolation of respiratory pathogen on culture. As there is no clear association between the severity of COPD and the presence of bronchiectasis, and it cannot be predicted by spirometry, therefore, a chest CT scan should be used to predict the presence of this condition.

Chest CT scan provides us with better imaging of the larger and smaller airways by constructing a 3D model of the airways. This helps to visualize the internal and external diameters of the

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bronchi along with airway wall thickness. Measurement of the airway parameters has been shown to correlate with the severity of airflow obstruction and exacerbations. Small airway obstruction (less than 2 mm) can be assessed on chest CT scans by the presence of mosaic attenuation at inspiratory and air trapping at expiratory scans. Chest CT scan may also help to diagnose the disorders of the large bronchi or trachea, like malacia, stenosis, tumors, and diverticula.

Chronic obstructive pulmonary disease is often complicated by pulmonary artery hypertension (PAH) which often starts insidiously, the most common symptom being dyspnea. Pulmonary artery hypertension in COPD patients is associated with an increased exacerbation rate, worsen exercise capacity, and a poor prognosis.[12–14] Pulmonary artery hypertension is most reliably diagnosed by the right heart catheterization, which is an invasive technique. CT scan can be used as an important tool to diagnose PAH. The CT approach to the diagnosis of PAH begins with identifying an enlarged pulmonary artery diameter greater than 29 mm, which is usually larger than that of the ascending aorta at the same level.[15,16] This diameter must be measured in the axial plane at the bifurcation, orthogonal to the long axis of the pulmonary artery. Additional findings such as increased segmental artery-to-bronchus ratio >1:1 in 3 or more lobes further increase the specificity for PAH diagnosis.[16] Chest CT scan also provides measures of skeletal muscle mass that can be prognostic for future events.

Computed tomography scans can also inform therapy that may be disease-modifying or even curative. These can be extremely useful in the functional assessment of pulmonary reserve before any surgical intervention, like lung transplantation and lung volume reduction surgery (LVRS). Lung volume reduction surgery focuses on resecting the most emphysematous part of the lung with the idea to reduce the size of the hyperinflated lung so that it could better fit the chest wall. The National Emphysema Treatment Trial (NETT) clearly demonstrated that patients with severe upper zone-predominant emphysema clearly benefit from LVRS, leading to improved lung function and better prognosis.[17] CT scan is mandatory for the appropriate selection of the candidate, along with the assessment of lung function and exercise capacity before LVRS is carried out. Lung volume reduction surgery is now being replaced by less invasive non-resectional techniques, such as bronchoscopic lung volume reduction (BLVRS) which utilizes coils and valves, in order to achieve deflation. While the safety of these procedures is still under investigation, these bronchoscopic interventions still require anatomical detail of the lung parenchyma for the appropriate selection of patients who are likely to benefit from LVRS, providing them with an opportunity for life-changing therapy.

Chronic obstructive pulmonary disease is associated with an increased risk for the development of lung cancer. CT scans are often used for lung cancer screening, thus, detecting lung cancer at an early and potentially curable stage. Several studies have mentioned the valuable role of CT in the screening of lung cancer in smokers, with the largest study demonstrating that serial CT scanning was associated with a 20% relative reduction in cancer-related deaths when compared with patients who underwent annual chest radiography.[18] Apart from the above-mentioned benefits, chest CT scans can be extremely valuable in diagnosing additional extra-pulmonary conditions, such as calcification of the coronary arteries or thoracic aorta and bone demineralization. CT scan can aid in the early diagnosis of osteoporosis and osteopenia which are often underdiagnosed in patients of COPD. Chest CT scans should be a part of routine clinical practice as these facilitate the identification of clinically relevant and actionable diseases in patients with COPD.

Limitations

Chest CT scans are rapidly becoming a part of routine among smokers who are at an increased risk for lung cancer for the evaluation of pulmonary nodules incidentally detected on chest radiographs and to plan for lung transplantation and LVRS in advanced COPD cases. Even though CT scans provide us with extremely valuable additional findings such as quantification of emphysema by densitometry, measurement of bronchial wall thickness and lumen diameter along with non-emphysematous air trapping thought to be related to small-airway abnormality. Despite its widespread use, a chest CT scan is still not considered as a part of routine clinical practice. The majority of these assessments are limited to the research setting and hence, do not have a clear role in routine clinical practice. Furthermore, such algorithms require a highly complex software along with a human interface with specific training as machine error is frequent. It has also been shown that chest CT scans underestimate the extent of emphysema when the lesions are less than 0.5 cm. In a study conducted by Miller et al.,[19] it was observed that the extent of centriacinar and panacinar emphysema was consistently underestimated because CT scans missed lesions that were less than 0.5 cm. While there is no doubt that these additional findings can prove to be useful in the near future in COPD management, its value must justify the resource expenditure required to obtain such measurements. Though data from studies, such as COPDGene and SPIROMICS have found associations between quantified CT metrics and respiratory symptoms, exacerbations, and disease progression, it is really hard to justify the expense or radiation exposure. Apart from a definitive role of chest CT scans in the evaluation of a pulmonary nodule and in LVRS, it is still unclear if these additional findings really add to our ability to treat patients on a daily basis. Furthermore, for a developing country, like India, the widespread availability of CT machines and the cost preclude its incorporation in our routine clinical practice. This is not to say that CT should not be routinely performed. It just needs to provide a more immediate value to patients and providers in order to be broadly accepted today.

Future Prospects of Chest CT for COPD Patients

Currently, we are in dire need of disease-modifying therapy in COPD. We must identify and phenotype individuals who are at risk at an early disease stage in order to test new treatments. Recent data have clearly indicated the importance of identifying patients with an early disease. The main reason why the majority of disease modification studies have failed is due to the fact that these have merely focused on late-stage disease instead of early-stage disease. Airflow obstruction in COPD develops by two main mechanisms. Firstly, it could occur due to accelerated lung function decline, and secondly, due to failure to attain peak function in early adulthood, with an age-appropriate decline in lung function. CT imaging acts as a key factor in distinguishing these two groups, which in turn, can be extremely useful as disease-modifying therapies, most likely to be successful in COPD patients with accelerated lung function decline. Similarly, CT imaging can be more useful when inspiratory and expiratory scans are obtained at an early disease stage, as small airway abnormalities have been demonstrated to predict FEV_1 decline, even in patients without airflow obstruction.[20]

In conclusion, CT imaging can be used to identify patients who could be targeted for early intervention studies. Personalized imaging could be developed to counsel patients about the risks if they continued smoking, a model similar to the concept of lung age. For this to achieve, the major burden still lies with the researchers who need to continue generating data regarding the association between CT metrics and COPD-specific clinical outcomes.

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