Tomographic diagnosis of pulmonary emphysema

Diagnóstico tomográfico de enfisema pulmonar

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The synergy between pulmonology and radiology is unique, and it is common knowledge that these two medical specialties are interdependent in the diagnosis and monitoring of various lung diseases. Pulmonary emphysema is one of the examples of lung disease in which imaging data, clinical data and laboratory data should be analyzed in conjunction.

For many years, conventional chest X-ray was used for the investigation of patients with emphysema. However, the only direct sign of emphysema on a chest X-ray is the presence of air-filled bubbles.[1] Indirect signs include rectification and lowering of the diaphragm, focal reduction of pulmonary vasculature and increased retrosternal clear space. In the general population, the sensitivity of chest X-rays for detecting emphysema is only 40%.[2] In severe emphysema, however, the combined sensitivity of the two chest X-ray images (frontal and lateral) can be as high as 90%, as one group of researchers has suggested.[3] In the presence of severe emphysema, however, the importance of a chest X-ray is limited to the identification of complications such as consolidation, atelectasis or pneumothorax. In the advanced stages of the disease, the very phenotype of the patient is highly suggestive of the diagnosis, as demonstrated by Netter.[4]

Pulmonary function tests are undoubtedly fundamental to the diagnosis and monitoring of COPD. These tests have various advantages over diagnostic imaging, among which we highlight the absence of ionizing radiation, the low cost, the well-established correlation with the clinical profile, the reproducibility of the results and the ability to predict prognosis.[5] The change in the shape of the inspiratory flow-volume curve is one of the earliest, most important findings in COPD patients. Pulmonary function tests can also indicate the presence of pulmonary fibrosis associated with emphysema when the discrepancy between spirometry results and DLCO results is analyzed.[6] Other studies, however, have suggested that pulmonary function tests have limitations in patients with less severe emphysema.[1]

Chest HRCT revolutionized the scope of imaging tests in many aspects of pulmonology. The use of CT scans for the investigation of lung cancer, interstitial diseases and emphysema has become part of the pulmonology routine. In emphysema, however, the potential of CT has not been realized. Although it has enormous diagnostic potential, the use of CT has been restricted to centers of excellence or research centers. The routine use of CT scans is still limited to confirming the diagnosis of emphysema in the presence of inconclusive clinical data and to the subjective analysis of the extent and type of emphysematous lesions.

Emphysema is traditionally investigated using HRCT and edge-preserving smoothing filters for structures of different density, which facilitates visualization by the unaided eye. According to current concepts,[7] the distinction between centrilobular, panacinar and paraseptal emphysema is based on the subjective analysis of HRCT images (unpublished data). There is a strong correlation between HRCT image analysis and histopathological analysis ($r = 0.91$).[1]

Spiral CT, with or without multislice detectors, is currently available in the vast majority of diagnostic imaging centers. Such devices have made it possible to perform chest CT scans with the acquisition of all images during a single breath-hold. Such technical capacity has been a breakthrough in the investigation of lung diseases. Objective measurement of total lung volume and of lung volume affected by pulmonary emphysema can be performed with approximately 99% precision (1% maximum variation between subsequent tests).[8] In a previous study, it was demonstrated that the rate of emphysema in healthy patients with no history of lung disease or smoking is, at most, 0.35% (including emphysema of the trachea and main bronchi).[8] It has also been demonstrated that CT densitometry and volumetric assessment of emphysema is more accurate than is the subjective assessment obtained through histopathological analysis.[9] Densitometry and volumetric assessment of emphysema through CT employs a threshold value below which lung density is considered almost as low as that of air. Due to lung tissue destruction by emphysema, there is not enough volume of dense soft parts to elevate air density values to emphysema-free lung density values. According to the various studies published to date, the threshold value to set normal lung apart from emphysematous lung varies, and the selection of values depends greatly on the parameters of acquisition and reconstruction of CT slices. For isolated HRCT scans (not spiral CT scans) using edge-preserving smoothing filters, Müller identified the −910 HU threshold value as being that which best correlates with histopathology. The correlation between the −910 HU threshold value and macroscopic and microscopic quantification through histopathology was demonstrated in 1995. More recently, a group of authors noted that, in multislice spiral CT scanners, the −960 HU and −970 HU threshold values showed the best correlation with histopathological examination results.[1]

Densitometry and volumetric assessment of emphysema through CT can be performed on tests performed specifically to confirm clinical suspicion and analyze the type of emphysema, its distribution in the lungs and the extension of the lesions. However, this is currently recommended only for specific cases, and the use of the method for screening the population at risk of emphysema is not recommended. Among the most common indications are cases of patients with recurrent spontaneous pneumothorax, patients with severe emphysema, candidates for invasive procedures (such as lung volume reduction surgery) or minimally invasive procedures (such as the placement of intrabronchial valves or stents) for emphysema treatment, patients with alpha-1 antitrypsin deficiency and candidates for lung transplantation.[10]

However, CT densitometry and volumetric assessment can also be performed on chest X-rays requested for different reasons, such as to evaluate lung cancer or cystic lung diseases. Provided that a certain degree of variability (due to the various slice thicknesses or to the use of intravenous contrast, among others) is accepted, CT densitometry and volumetric assessment can be useful in such patients.[1,8,11]

One of the limitations to a more widespread use of CT densitometry and volumetric assessment is the high cost of the software and workstation that are required in order to perform such assessment. The volumetric reconstruction and density analysis software is not generally included when a CT scanner is purchased. In this issue of the Brazilian Journal of Pulmonology, Felix et al.[12] present a locally developed system and compare it with a freeware system. The authors have developed and tested a computer program that can quantify emphysema on individual CT scans. Despite the various limitations of the software, among which we highlight of its inability to quantify the total volume of emphysema in the lungs, it is an alternative when the purchase of programs that are more sophisticated is not economically viable. However, it should be noted that the authors do not specify whether the software has been approved by the Brazilian National Ministry of Health for clinical application.

Despite our enthusiasm for the use of CT densitometry and volumetric assessment, our experience shows that there are a number of variables that can affect the results. The cooperation of the patient, the patience and meticulousness of the operator, the appropriate maintenance and calibration of the equipment and even the manufacturer and model of the CT scanner can all influence the quality of the image. The procedure should be performed by a properly trained professional and, above all else, the results should always be evaluated in view of the clinical and functional data.

Chest CT scans and the techniques for quantitative analysis of emphysema have contributed to an impressive advance in the understanding of pulmonary emphysema. A more widespread use of CT densitometry and volumetric assessment will definitely bring about changes in many of the current concepts regarding pulmonary emphysema, benefitting emphysema patients with a poor prognosis due to having been diagnosed in a late phase of this irreversible disease, with no treatment options other than those aimed at symptom relief.

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