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Comparing Definitions of Small Airway Dysfunction: the HRCT-based study

Small airway dysfunction (SAD) represents an early pathological change in respiratory diseases and plays a critical role in conditions such as asthma and chronic obstructive pulmonary disease (COPD). Detecting SAD early is crucial for disease management. Yet, its identification remains a challenge due to the lack of symptoms in the early stages and limitations in the tools used to evaluate it. Spirometry, the most widely used test, measures the volume and speed of air that can be inhaled and exhaled, but its repeatability and lack of a gold standard hinder its widespread use in large studies. Another method, parametric response mapping (PRM), uses high-resolution computed tomography (HRCT) to assess gas trapping in the lungs, offering a spatial visualisation of small airway abnormalities. However, differences in how spirometry and PRM define SAD, as well as their clinical implications, are still not well understood. A recent study published in Insights Imaging explores the discordant definitions of SAD between spirometry and PRM, examining their relationships with lung morphology through HRCT and highlighting factors predictive of SAD.

Spirometry vs. PRM in SAD Detection

Spirometry and PRM provide contrasting approaches to SAD detection, with each method yielding different insights into lung pathology. In spirometry-defined SAD, structural airway changes such as thickened walls, narrowed lumens, and reduced branch counts are prominent, indicating a close association with airway morphology. In contrast, by identifying gas trapping, PRM demonstrates heightened sensitivity in detecting early functional impairment in the lungs. However, it can be influenced by the density of pulmonary vessels and other lung structures. A prospective study involving 388 participants used both tests alongside HRCT imaging to understand how each method characterises SAD. It found that SAD was present in 122 individuals according to spirometry and 158 individuals according to PRM, underscoring a significant discordance between the two diagnostic tools. This discrepancy suggests that spirometry may capture more advanced or morphologically distinct changes in small airways, while PRM detects early functional deficits, potentially offering complementary roles in SAD assessment.

Morphological Differences in SAD Detected by HRCT

High-resolution computed tomography (HRCT) was used to analyse SAD's structural differences as defined by both spirometry and PRM. Visual and quantitative assessments of HRCT revealed that individuals with spirometry-defined SAD exhibited more notable structural changes, such as emphysema, bronchial wall thickening, and tree-in-bud patterns, which are visual markers of mucus plugging and airway obstruction. These patients had thicker airway walls, smaller lumens, and fewer bronchial branches than those with non-SAD lungs. On the other hand, PRM-defined SAD was characterised by the presence of slender pulmonary blood vessels, reflecting a different pattern of lung dysfunction. Unlike spirometry-defined SAD, PRM-detected cases showed minimal changes in airway structure at the whole-lung level but indicated changes in medium-sized airways. These findings imply that spirometry better detects morphological changes, while PRM is adept at identifying early-stage functional abnormalities before significant structural alterations occur.

Predictive Factors and Implications for Future Diagnostic Tools

The study further explored factors predictive of SAD in each method using a combination of clinical data and HRCT assessments. For spirometry-defined SAD, significant predictors included age, male gender, emphysema extent, tree-in-bud visual signs, bronchial wall thickening, and the count of bronchial branches. PRM-defined SAD, however, was influenced by age, male gender, body mass index (BMI), tree-in-bud signs, emphysema, and the proportion of small blood vessels within the lung. The predictive models constructed using these variables exhibited strong performance, with area under the curve (AUC) values of 0.855 for spirometry and 0.808 for PRM. These findings underscore the potential of combining HRCT imaging with clinical factors to enhance SAD prediction, enabling tailored approaches to patient diagnosis. Furthermore, they highlight the need for developing new radiological tools that incorporate the strengths of both spirometry and PRM, thereby providing a comprehensive view of airway structure and function and offering more accurate SAD detection in clinical practice.

Spirometry and PRM offer distinct yet complementary perspectives on small airway dysfunction. While spirometry is closely related to airway morphology, PRM's sensitivity to early functional impairment makes it valuable for detecting SAD in its initial stages. However, PRM's reliance on gas trapping assessment is influenced by pulmonary vessel density and other lung structures, which may affect its accuracy in reflecting airway

morphology. Integrating patient clinical data and HRCT features into predictive models provides an effective means to identify SAD, aiding in the early detection and management of respiratory conditions. Moving forward, the development of combined diagnostic tools that leverage the detailed morphological insight of spirometry with the functional sensitivity of PRM may offer improved screening and monitoring of small airway diseases, leading to better patient outcomes.

Source: **Insights Imaging**

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