

# Emerging Functional Imaging Techniques in Lung Disease Assessment

Orozco Murphy\*

Department of Experimental Medicine, Università degli Studi di Roma Tor Vergata, Via Montpellier 1, 00133 Rome, Italy

## Introduction

Emerging functional imaging techniques have revolutionized the landscape of pulmonary diagnostics by enabling visualization and quantification of physiological processes such as ventilation, perfusion, inflammation and metabolic activity. These advancements are instrumental in early disease detection, monitoring disease progression, evaluating treatment efficacy and guiding interventions. This article delves into the spectrum of emerging functional imaging techniques in lung disease assessment, highlighting their principles, clinical applications and future prospects [1]. Lung diseases are a major cause of morbidity and mortality globally, encompassing a wide range of acute and chronic conditions such as Chronic Obstructive Pulmonary Disease (COPD), asthma, pulmonary fibrosis, lung cancer and pulmonary embolism. Traditional imaging modalities such as chest X-ray and High-Resolution Computed Tomography (HRCT) have been the cornerstone of pulmonary diagnostics, providing critical structural information. However, these techniques often fall short in capturing the functional status of the lungs, particularly in the early stages of disease when structural changes are minimal [2].

## Description

Functional imaging differs from anatomical imaging by focusing on physiological processes rather than structural characteristics. In the context of lung diseases, functional imaging enables assessment of ventilation (airflow), perfusion (blood flow), gas exchange, inflammation and cellular metabolism. The integration of these techniques into clinical practice is transforming the diagnostic paradigm, especially for diseases where traditional imaging offers limited insight. PET imaging utilizes radiotracers to visualize metabolic activity and inflammatory processes within the lung. The most commonly used tracer is fluorodeoxyglucose (FDG), which is taken up by metabolically active cells, such as inflammatory and neoplastic cells. PET-FDG imaging is valuable in assessing inflammatory conditions like sarcoidosis, tuberculosis and interstitial lung diseases (ILDs). PET is integral to cancer staging, detecting metastasis and evaluating treatment response. Distinguishing infection from malignancy or post-therapy changes [3].

SPECT is similar to PET but uses gamma-emitting radioisotopes to assess regional lung function, particularly ventilation and perfusion. SPECT-V/Q imaging has emerged as a superior method to traditional planar V/Q scans. Helps evaluate the functional impact of COPD and emphysema. SPECT is more widely available and less expensive than PET, though it offers lower resolution and requires specialized software for accurate interpretation.

**\*Address for Correspondence:** Orozco Murphy, Department of Experimental Medicine, Università degli Studi di Roma Tor Vergata, Via Montpellier 1, 00133 Rome, Italy, E-mail: [murphyorozco@ozc.it](mailto:murphyorozco@ozc.it)

**Copyright:** © 2025 Murphy O. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Received:** 02 April, 2025, Manuscript No. jprm-25-167388; **Editor assigned:** 04 April, 2025, PreQC No. P-167388; **Reviewed:** 18 April, 2025, QC No. Q-167388; **Revised:** 23 April, 2025, Manuscript No. R-167388; **Published:** 30 April, 2025, DOI: 10.37421/2161-105X.2025.15.733

One of the most promising advancements in lung imaging is MRI using hyperpolarized noble gases. These gases enhance MRI signal, allowing high-resolution imaging of ventilation and gas exchange. Visualizes ventilation defects, aiding in phenotyping and treatment planning. Detects early functional changes before structural abnormalities appear. Monitors graft function and early rejection. Hyperpolarized gas MRI is non-ionizing and offers exquisite functional detail. However, it requires specialized equipment, gas polarization systems and regulatory approval for clinical use. EIT is a bedside, radiation-free imaging technique that uses surface electrodes to measure changes in electrical impedance within the thorax, reflecting ventilation distribution. Guides ventilation settings in ICU patients. Assesses regional lung function dynamically. Evaluates lung re-expansion after surgery. EIT is portable, repeatable and safe for continuous monitoring. Limitations include lower spatial resolution and dependence on patient cooperation. Xe-CT combines inhaled xenon gas with conventional CT imaging to assess regional ventilation and perfusion. Maps functional defects in diseases like COPD. Assists in determining functional lung volumes pre-operatively [4].

DECT uses two different X-ray energy levels to differentiate tissue composition and blood perfusion, enabling functional insights alongside anatomical imaging. Visualizes perfusion defects. Assesses tumor vascularity and response to therapy. DECT is increasingly available and integrates easily into existing CT protocols. However, it involves higher radiation doses compared to standard CT. FRI is a computational method that uses HRCT data to create 3D models of the lungs, simulating airflow, resistance and deposition patterns. Drug Delivery Optimization: Predicts aerosol deposition. Quantifies functional changes in asthma and COPD. FRI provides detailed and individualized insights but relies on complex software and high-quality CT imaging. Comparative Assessment and Integration of Modalities Each imaging modality offers unique strengths and limitations. An integrated, multimodal approach can provide a comprehensive picture of lung function and structure: PET and SPECT excel in metabolic and perfusion imaging. MRI and EIT are ideal for non-ionizing, functional assessments. DECT and Xe-CT bridge anatomical and functional insights. FRI enhances interpretability of static images through dynamic simulation. The implementation of functional imaging has already demonstrated tangible clinical benefits [5].

## Conclusion

Emerging functional imaging techniques represent a paradigm shift in the assessment and management of lung diseases. By transcending the limitations of anatomical imaging, these modalities provide critical insights into the physiological and metabolic status of pulmonary tissues. As technology advances and accessibility improves, functional imaging will become increasingly integral to personalized respiratory care. The fusion of functional and structural imaging, supported by computational analytics and AI, holds the promise of revolutionizing diagnostics, enhancing therapeutic precision and ultimately improving patient outcomes in the realm of pulmonary medicine.

## Acknowledgement

None.

## Conflict of Interest

None.

## References

1. Mergen, Victor, Stéphane Rusek, Filippo Civaia and Philippe Rossi. "Virtual calcium removal in calcified coronary arteries with photon-counting detector CT-first in-vivo experience." *Front Cardio Med* 11 (2024): 1367463.
2. Hagen, Florian, Martin Soschynski, Meike Weis and Muhammad Taha Hagar, et al. "Photon-counting computed tomography-clinical application in oncological, cardiovascular and pediatric radiology." *Georg Thieme Verlag* 196 (2024): 25-35.

3. Armstrong, Gregory T., Kevin C. Oeffinger, Yan Chen and Toana Kawashima, et al. "Modifiable risk factors and major cardiac events among adult survivors of childhood cancer." *J Clin Oncol* 31 (2013): 3673-3680.
4. Adenaw, Nebiyu and Michael Salerno. "PET/MRI: Current state of the art and future potential for cardiovascular applications." *J Nuclear Cardiol* 20 (2013): 976-989.
5. Herrmann, Joerg, Amir Lerman, Nicole P. Sandhu and Hector R. Villarraga, et al. "Evaluation and management of patients with heart disease and cancer: Cardio-oncology." *Mayo Clinic Proceedings* 89 (2014): 1287-1306.

**How to cite this article:** Murphy, Orozco. "Emerging Functional Imaging Techniques in Lung Disease Assessment." *J Pulm Respir Med* 15 (2025): 733.