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# Integrated Diagnostic Approach in Pulmonology: Imaging, Volumetric Quantification, and Pulmonary Function Tests

## *El trípode diagnóstico en neumonología: Radiología, cuantificación volumétrica y función pulmonar*

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### Three complementary views of the same lung

In the evaluation of parenchymal lung disease, we have traditionally worked with two approaches: the expert eye of the radiologist, who identifies morphological patterns, and the objective measurements of the physiologist, who quantifies function. Both are indispensable, but they often remain isolated: the radiologist describes an "accentuation of the interstitium," the spirometer shows an FVC (forced vital capacity) of 67%, and we ask ourselves: do these two findings actually explain each other?

For years, we attributed this gap to the inherent complexity of correlating imaging and function. The issue is less complexity than **dimensionality**: radiologists have a two-dimensional, qualitative perspective that favor pattern recognition, while computational analysis provides a three-dimensional, quantitative perspective that enables volumetric measurement. These approaches are not mutually exclusive, but complementary: **radiologists see what the algorithm cannot recognize, and the algorithm measures what the human eye cannot quantify.**

### Integrated diagnostic approach in action

This integrated approach is not merely theoretical: we have been using it systematically in our department, and results have altered therapeutic decisions in complex cases. The key concept is to recognize that:

- **Radiologists SEE but cannot measure:** they identify morphological patterns (honeycombing, ground-glass opacities, emphysema), recognize spatial distributions, and define phenotypes. However, they cannot quantify volumes or percentages with millimeter precision.
- **The algorithm MEASURES but cannot see:** based on voxel-by-voxel Hounsfield values, it identifies normal parenchyma, infiltrates, vascular structures, emphysema, and collapse, and calculates the volume of each compartment by lobe, segment, or region with digital precision. It quantifies total and compartmental volumes, calculates objective regional distributions, and enables reproducible numerical follow-up over time. However, it does not diagnose etiologies or recognize subtle morphological patterns: it cannot distinguish whether an infiltrate rep-

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resents fibrosis, pneumonitis, sarcoidosis, or edema.
– **Physiologists INTEGRATE:** they correlate structure (what is seen and what is measured) with the actual functional impact, guide therapeutic timing, and assess treatment response.

No perspective is superior to another: they are complementary, and all three are necessary when confronting complex phenotypes.

### Index case: when no single perspective is enough

66-year-old male patient, 183 cm tall, 120 kg (BMI 35.8), former smoker with a 136 pack-year history presented with progressive dyspnea. Spirometry showed an FVC of 67% of the predicted value, FEV1 (forced expiratory volume in the first second) of 81%, and an FEV1/FVC ratio of 119%: a moderate restrictive pattern without obstruction.

### First Perspective – Radiology (two-dimensional/qualitative)

The radiologist identified two relevant patterns: -Thickening of the subpleural interlobular interstitium is noted within the posterior segments of both upper and lower lobes. Additionally, there are scattered centrilobularand paraseptal low-attenuation areas in the upper lobes, consistent with centrilobular emphysema.

This description is precise and clinically relevant: radiologists **SEE the mixed pattern** (emphysema plus basal/posterior interstitial thickening). However, they cannot answer the following questions: how much of each component is present? Is it sufficient to explain an FVC of 67%?

### Second Perspective – Quantification (three-dimensional/quantitative)

– We processed the same CT scan using volumetric segmentation (Lung CT Segmenter, 3D Slicer):
– Total lung volume: 4,118 ml
– Functional parenchyma: 3,254 ml (79.0%)
– Infiltration: 791 ml (19.2%)
– Emphysema: 521 ml (12.6%)
– Atelectasis/collapse: 643 ml (15.6%)
– Regional distribution: Ventral 13.1% vs. dorsal 24.2% infiltration

The algorithm **MEASURES** the volume of each compartment with precision. However, it cannot distinguish whether that "infiltration" represents fibrosis, pneumonitis, sarcoidosis, or edema: the algorithm measures, but it does not diagnose.

### Third Perspective – Pulmonary Function

– FVC: 67% of the predicted value
– FEV1/FVC: 119% (without obstruction)
– Pure restrictive pattern

### Integrating the Three Perspectives

No single perspective was sufficient on its own:
– **Radiology alone:** identifies the mixed pattern but does not quantify its functional impact.
– **Quantification alone:** measures volumes but does not define etiology or morphological pattern.
– **Pulmonary function alone:** documents restriction but does not explain the underlying structural mechanism.

**Complete integrated diagnosis:**

1. **Morphological pattern (radiology):** centrilobular emphysema plus basal/posterior interstitial thickening → the radiologist identifies **CPFE** (Combined Pulmonary Fibrosis and Emphysema)
2. **Quantitative correlation (volumetry):** Infiltration 19.2% + collapse 15.6% + emphysema 12.6% = 47.4% total involvement → **the numbers mathematically explain the FVC of 67%.**
3. **Functional phenotype (spirometry):** pure restriction without obstruction → consistent with a predominant restrictive mechanism.
4. **Clinical synthesis:** Defined CPFE with restrictive predominance. The ventral/dorsal gradient (13% vs. 24%) suggests a gravitational component of interstitial lung disease (ILD), rather than solely mechanical atelectasis related to obesity.

**Integrated conclusion:** The patient requires referral to a specialized ILD center for evaluation of antifibrotic therapy. This is not simply "obesity plus a subtle nonspecific pattern."

The integrated diagnostic approach worked because each pillar contributed unique and irreplaceable information: - The radiologist saw the pattern that defines the phenotype (CPFE). - Quantification measured the structural burden that correlates with function. -Spirometry objectively established the degree of functional impairment that guides therapeutic timing.

### No single perspective replaces the others: they mutually enhance each other.

#### Why we need the third pillar (quantification) now

Descriptive terms ("accentuation," "multiple," "patchy") are valid for communicating patterns, but they do not allow for:

– **Quantitative structure–function correlation:** How many milliliters of infiltration are needed to reduce FVC by 10%?
– **Objective phenotyping in borderline cases:** Is 12% emphysema CPFE, or emphysema-dominant disease with minimal fibrosis?
– **Precise evolutionary follow-up:** Did the infiltration increase from 450 mL to 800 mL over 12 months, or is it simply interobserver variability?
– **Decisions based on therapeutic thresholds:** Have we crossed the cutoff point that justifies antifibrotic therapy according to clinical trials?

It's not that radiologists *must* measure: when we need the numbers to correlate with function or enable quantitative longitudinal follow-up, qualitative assessment (however precise) falls short.

Computational analysis does not replace the radiologist; rather, it complements their assessment with a dimensionality that morphological description alone cannot achieve.

## Barriers to implementing the complete triad in Argentina

Volumetric lung quantification is not an experimental technology. The software is open source (3D Slicer), the segmentation techniques are internationally validated, and the regional analysis algorithms have been published. Nevertheless, its clinical adoption is minimal in our country.

### Identified barriers:

1. **Absence of standardized Argentine protocols:** What slice thickness should be used? Which reconstruction kernel? Maximum inspiration or tidal breathing?
2. **Lack of consensus metrics:** Should we report absolute volume (mL), percentage (%), or mass (grams)? Should compartments be defined by HU density thresholds or by texture analysis?
3. **No population-based reference values:** There are no Argentine nomograms of normal lung volumes by CT according to age, sex, and height, adjusted for the ethnic characteristics of our population.
4. **Absence of explicit QA/QC (quality assurance/quality control) procedures:** How do we ensure the segmentation has no "leakage" into the mediastinum or chest wall?
5. **Limited professional training:** Diagnostic Imaging Departments don't have specific training in volumetric quantification.
6. **Inadequate acquisition for 3D reconstruction:** Many centers provide only a single plane (typically axial) or images in JPG/PNG format. **Volumetric analysis requires multiplanar acquisition (axial, sagittal, coronal) and delivery of the original DICOM files** that preserve the complete three-dimensional information. Without this minimum standard, volumetric quantification is impossible.

These barriers are not technical, but organizational and protocol-related. **We can address them through concerted, interdisciplinary effort. I invite readers to collaborate in establishing a formalized working group with the support and collaboration of the Argentinian Association of Respiratory Medicine (AAMR), which has been informed of this project this publication.**

## Final notes

This editorial arises from direct clinical experience in using the diagnostic triad in complex cases. The objective is not to promote a specific technology, but to encourage a conceptual shift: moving from isolated disciplinary approaches toward systematic quantitative integration.

The interdisciplinary call is genuine: the success of this initiative depends on pulmonologists, radiologists, and physiologists working **as equals** in the construction of standards, rather than one discipline imposing its vision on the others.

## Conflict of interest

The author has no conflict of interest to declare in relation to the content of this article. The software mentioned (3D Slicer) is open source and freely accessible, with no commercial affiliation.