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Advancing Diagnostic Precision of Emphysema in Chronic Obstructive Pulmonary Disease:

Machine-learning Classification Integrating Non-invasive Biomarkers, Clinical Characteristics, and Pulmonary Function

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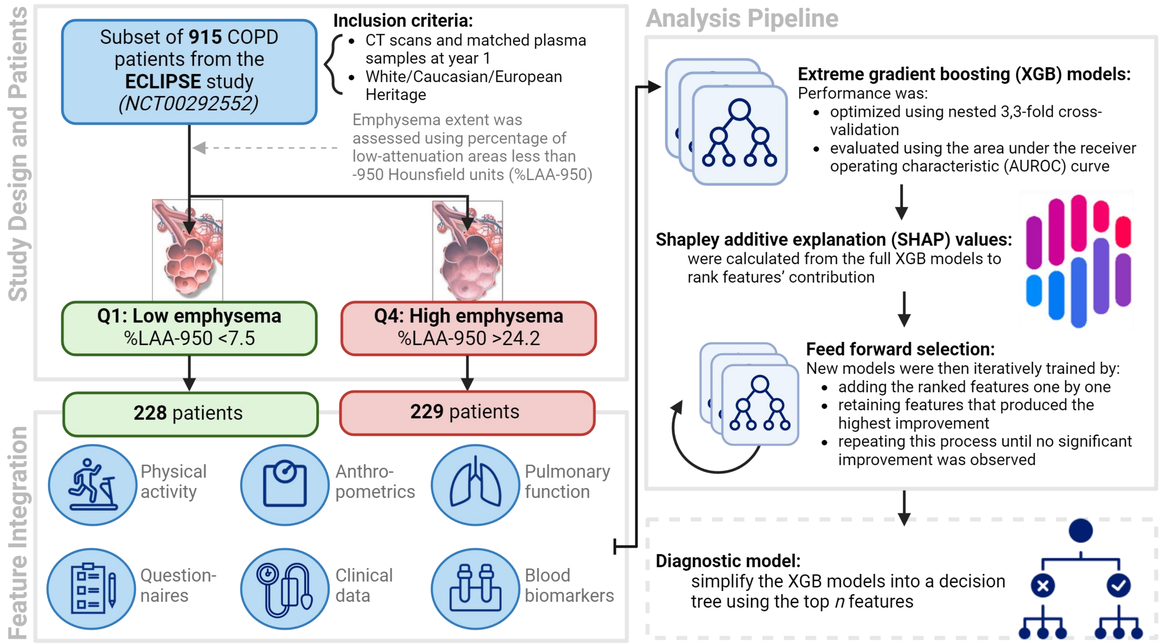
Introduction

Computed tomography (CT) is used for evaluating phenotypic abnormalities in chronic obstructive pulmonary disease (COPD), yet its cost and time-intensive nature limit routine use. Developing an easily implementable technique for classifying emphysema extent is thus essential.

This study aimed to develop a diagnostic model to classify emphysema extent in COPD patients relying solely on easily obtained measures such as clinical characteristics and non-invasive biomarkers.

Methods



Year 1 characteristics

	Low emphysema *(n=228)*	High emphysema *(n=229)*	P-value
Age, years	60.8 ± 7.9	63.2 ± 6.7	<0.001
Male, n (%)	134 (58.8)	151 (65.9)	0.138
BMI, kg/m^2	27.8 ± 5.7	24.5 ± 4.8	<0.001
Tissue fat, %	32.8 ± 8.5	31.5 ± 8.6	0.104
FEV_1, % predicted	59.8 ± 14.3	39.0 ± 13.4	<0.001
6MWT, m	413 ± 114	367 ± 123	<0.001
mMRC score	1.4 ± 1.1	1.9 ± 1.1	<0.001
SGRQ-C, activity score	49.3 ± 28.1	71.6 ± 22.6	<0.001
AECOPD*	0.7 ± 1.1	0.9 ± 1.1	0.03

*BMI: body mass index; FFMI: fat-free mass index; FEV_1: forced expiratory volume in 1 second; 6MWT: 6-minute walking test; mMRC: Modified Medical Research Council; SGRQ-C: St. George's Respiratory Questionnaire (COPD); AECOPD: acute exacerbation of COPD *Average number of moderate exacerbations recorded in the 12 months prior.*

Summary statistics are expressed as mean ± standard deviation, except for "Male", which is presented as total numbers and frequency distributions.

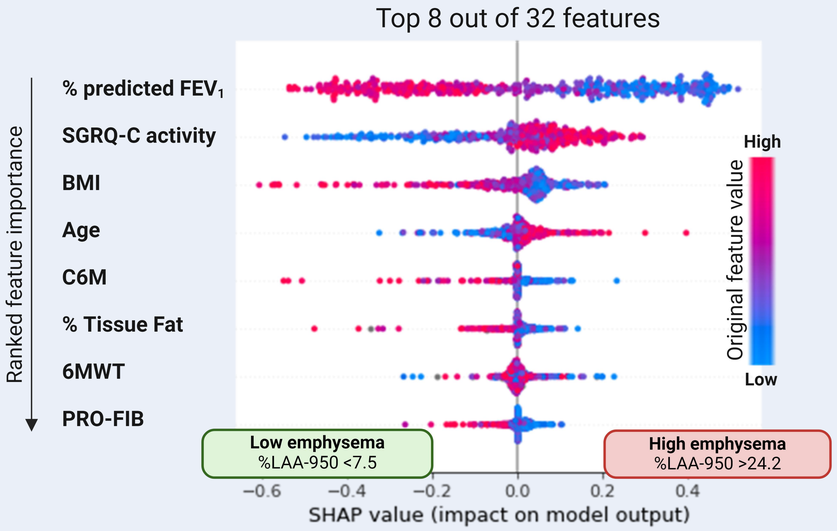
Results

XGB models integrating 32 features achieved an AUROC of **0.82** (95%CI **0.80**-**0.84**)

Feed forward selection retained **top 5 ranked features**, which demonstrated an AUROC of **0.86** (95%CI **0.84**-**0.87**)

Top 5 features of high emphysema:

- Low % predicted FEV_1
- High SGRQ-C activity score
- Low BMI
- High age
- Low levels of C6M

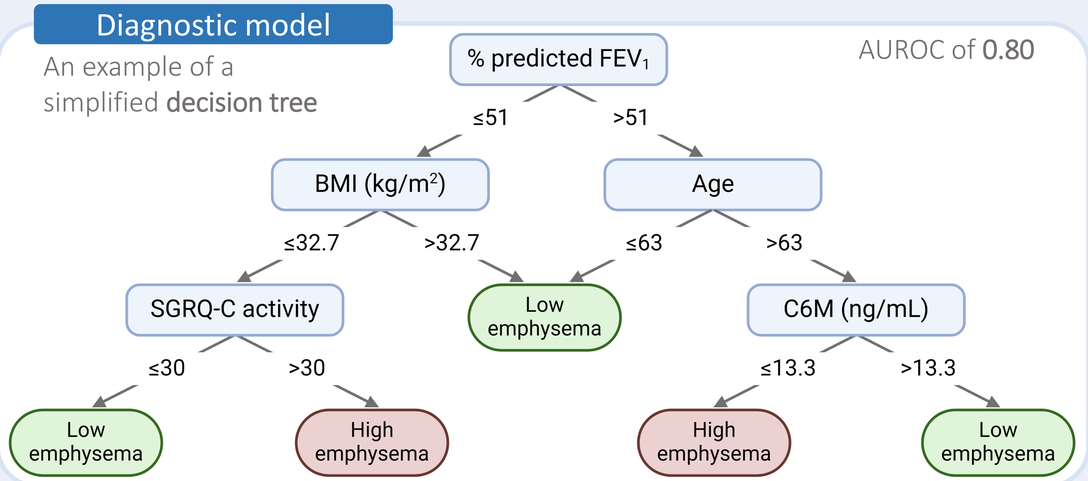


SHAP figure explained: *Y-axis* indicates the feature names in order of importance from top to bottom. *X-axis* represents the SHAP value, which indicates the degree of change in log odds. The *color of each point* on the graph represents the value of the corresponding feature, with red indicating high values and blue indicating low values. *Each point* represents a row of data/patient from the original dataset. *C6M: Blood biomarker for type VI collagen degradation; PRO-FIB: Blood biomarker for degradation of fibrinogen.*

Diagnostic model

An example of a simplified **decision tree**

AUROC of **0.80**



Conclusion

Diagnostic models incorporating easily obtainable measures effectively distinguished COPD patients with high emphysema extent from those with low extent. Such models for classifying emphysema patterns have **the potential for clinical implementation**, aiding in diagnosis or serving as a decision-making tool to determine the necessity of further CT scans.

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