Quantification of smoking-related airway remodelling in COPD, using a novel fast-response capnometer

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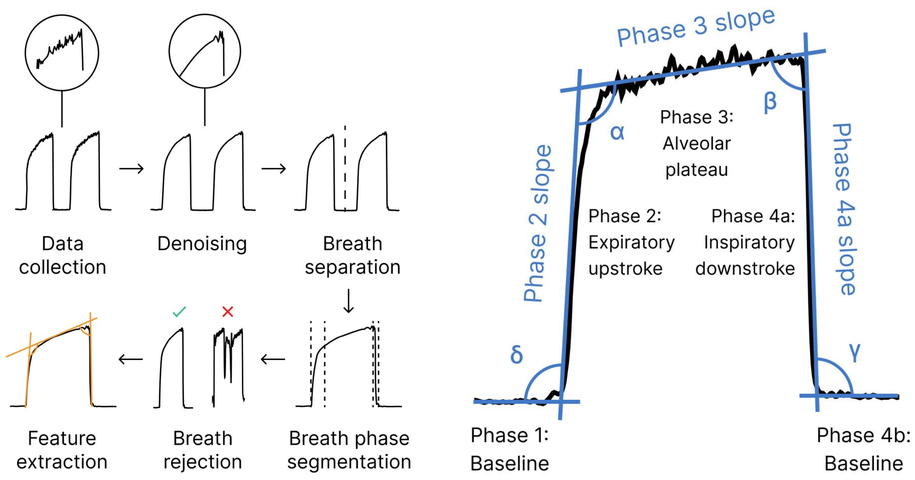
Introduction

Tobacco smoking is widely considered as one of the strongest risk factors for the development of chronic obstructive pulmonary disease (COPD), as it causes the emphysematous destruction of the lung parenchyma and the narrowing of the peripheral airways. There is a well-established dose-response relationship in smokers who develop COPD, though this has been historically difficult to quantify using non-specific methods such as spirometry.

Capnography is an increasingly popular technique in the assessment of pulmonary health. This analysis evaluated the relationship between smoking history and features of small/medium-sized airway obstruction in COPD subjects using TidalSense's fast-response N-Tidal™ capnometer, which can measure CO_2 concentration reliably and accurately at an unprecedented resolution.

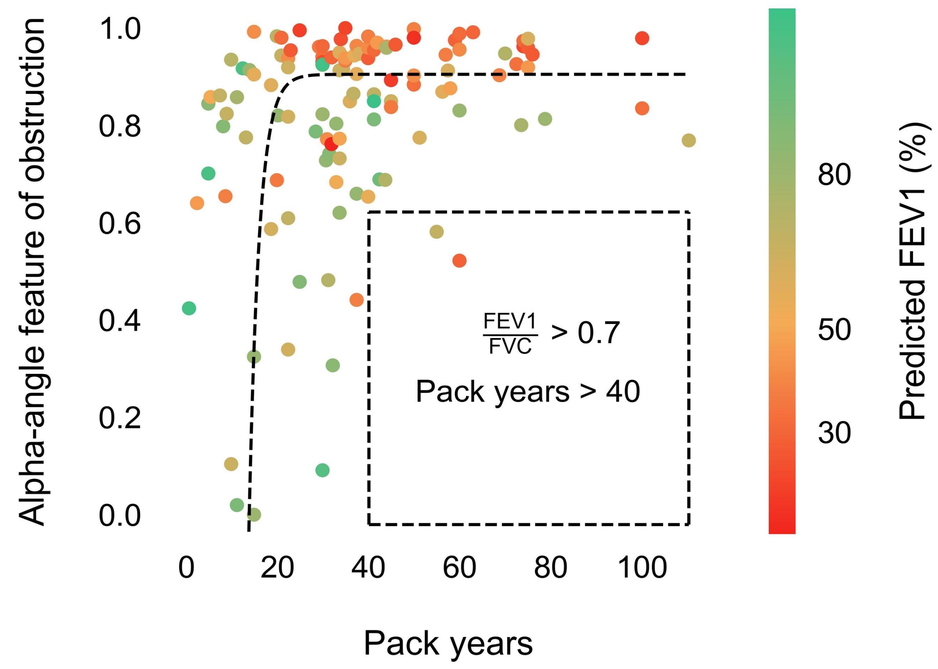
Methods

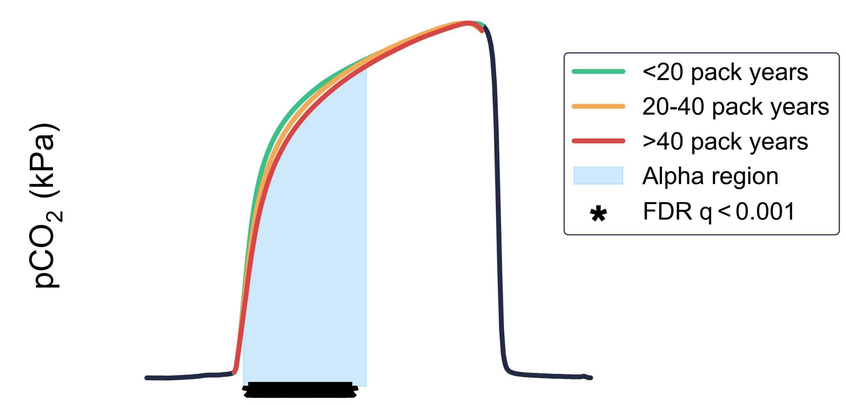


Data was collected using the N-Tidal™ capnometer from 305 COPD GOLD 3/4 subjects across three longitudinal observational studies conducted in the UK. Each participant performed two recordings daily for up to 6 weeks.

Each capnogram underwent a data processing pipeline, which included denoising, breath separation, breath phase segmentation and featurisation steps. A total of 82 features were extracted from each capnogram. Examples of these features include durations, angles, and gradients that describe the δ, α, β, and γ regions of the capnogram. The relationship between these features and smoking history was investigated using a range of statistical methods using Python (version 3.10.7).

Results





Discussion

Higher smoking pack years was associated with greater curvature in the alpha-angle region, which is hypothesised to relate to airway remodelling following a dose-response relationship. The alpha-angle region demonstrated a significantly altered CO_2 waveform geometry beyond 40 pack years.

The average capnogram waveforms for each cohort corroborated this observation, with the waveforms from subjects with greater cumulative smoking exposure exhibiting greater alpha-angle curvatures.

In the context of a diagnosis of COPD, these results demonstrate the ability of CO_2 waveform geometric analysis to predict a subject's lifetime tobacco smoking exposure. This could, in the future, be extended to estimate a patients' risk of developing smoking-related airway remodelling, to support preventative intervention. The delineation of the exposure risk-profile using the N-Tidal™ capnometer provides valuable mechanistic insights and could also be used in the future to inform tobacco cessation strategies.

TidalSense

Capnographic waveform features of airway obstruction demonstrate a dose-response relationship with cumulative smoking history. The N-Tidal™ capnometer may be able to directly probe airway remodelling as a result of smoking, and be used to predict a subject's lifetime tobacco smoking exposure.