

Inert-gas washout and forced oscillation technique show sensitivity to the degree of regionalisation of bronchoconstriction.

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Introduction

The Multiple-breath washout (MBW) and Forced Oscillation Technique (FOT) are both experiencing increased uptake as clinical measures of lung function and airway constriction. However, due to the complex nature of test outputs, there is still uncertainty about exactly how test indices respond to specific types of bronchoconstriction. Through the analysis of hundreds of bronchoconstriction scenarios, we investigated the sensitivity of MBW and FOT indices to the degree of regionalisation of airway constriction.

Methods

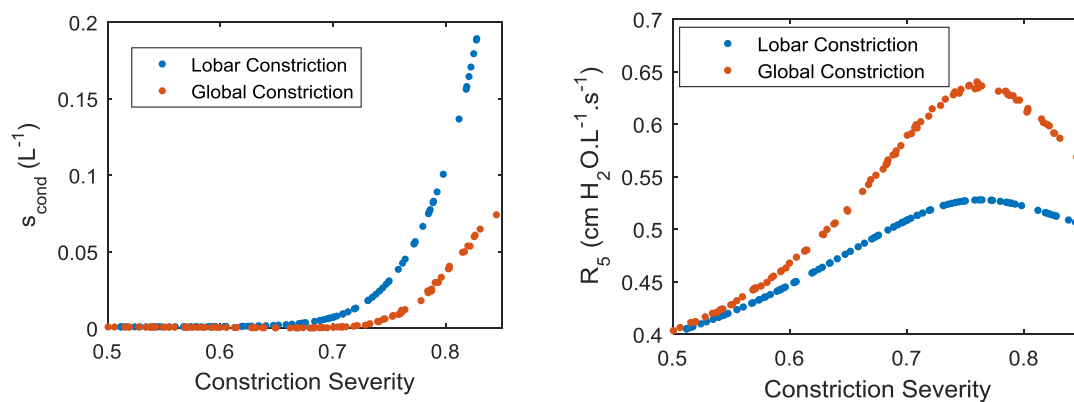
Simulations were performed on a virtual 1-D model of the conducting airways, derived from CT imaging data (from prior published work), consisting of 78,834 branches. The MBW was simulated using a gas transport model over the conducting zone, with each terminal bronchiole connected to an independently expanding acinar region. Flow rates were driven pressure gradient between the trachea and the pleural cavity, limited by Pedley's airway resistance model, with a temporally sinusoidal pleural pressure. The FOT was simulated using an electrical circuit analogous model, with branch impedance due to oscillatory flow, and a constant-phase, viscoelastic model for the acinar regions. For each simulation a constriction severity (0-85%) and a location (lower left lobe, anywhere in the lungs) was chosen. Constrictions were applied by reducing the radius of 5000 small airways, chosen randomly from the location group, by the chosen severity. For each MBW simulation s_{cond} was calculated, and for each FOT simulation resistance at 5Hz (R_5), 20Hz, and inertance at 5Hz was calculated.

Results

All indices showed a positive response to increasing constriction severity. The MBW showed strong sensitivity to regionalisation, with lobar-focused constriction producing more rapid increases in s_{cond} (Figure 1A). Conversely, the FOT showed lowered-responses under regionalisation, with the global-focused constriction producing higher index values (Figure 1B).

Conclusions

The responses of both tests demonstrate high levels of sensitivity to the degree of regionalisation of bronchoconstriction in the small conducting airways. The fact that the sensitivities of the two tests are inverted from each other suggests potential to gather more information through joint application. This highlights an interesting avenue for future basic and clinical study.



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