Link between numbers, pictures, and physiological tests

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TO THE EDITOR: As physiologists with a keen interest in understanding ventilation heterogeneity via model simulations, we are constantly on the lookout for whatever quantitative morphometric or physiological information can be had from emerging imaging techniques, or alternatively, from advanced analyses of existing techniques. In this respect, we share the enthusiasm conveyed by the editorial [5] lauding the study by Horn et al. [3] who were able to obtain 3D fractional ventilation (r) maps of the whole human lung with MRI.

Our own excitement for these data is even greater when we actually translate these r-histograms into physiological parameters that can be measured with a multiple breath washout (MBW) by inert gas measurement at the mouth [2]. Indeed, by feeding the r-histograms from the four healthy subjects (see Fig. 3 in Ref. 3) into a 10-compartment model, determining the washout for each compartment with a given r, and then recombinating the washout curves of each compartment according to ventilation into each compartment, the predicted washout curve at the mouth can be readily computed (e.g., Ref. 6) and compared with that obtained with inert MBW tests. The MBW parameter that is particularly suitable for comparing degree of specific ventilation heterogeneity is the curvilinearity of the semilog washout concentration curve; for instance, Curv as defined in (6) is 0 for uniform lung ventilation and 1 in the presence of an infinitesimally slowly emptying lung unit.

The similarity of Curv values that can be obtained on basis of the 3D r-histograms in four normal subjects [0.19 ± 0.05 (SD)] and the Curv values previously obtained experimentally with MBW tests in 25 normal subjects [0.18 ± 0.07] (6) is stunning. Upon closer inspection of the individual subjects in Horn et al. [3], Curv(subjects 1, 2, 3, 4) = 0.26, 0.18, 0.13, 0.19 it is unsurprising that subject 3 with the lowest Curv is also the one with the lowest coefficient of variation on r (16% for subject 3 derived from Table 2 in Ref. 3). The CF patient (10 yr; FEV₁ = 99%pred) shows an r-histogram that corresponds to Curv = 0.25, similar to subject 1, who had the greatest Curv out of the four normal subjects; for the sake of comparison, in adult CF patients Curv can vary widely (0.20–0.70) (6). More importantly, the comparison of images from this one particular CF patient and subject 1 highlights the key question that the imaging technique of Horn et al. [3] can potentially answer: for a given overall lung ventilation heterogeneity measurable by physiological tests (i.e., same Curv), at what resolution scale is ventilation heterogeneity being generated under different (patho)physiological conditions?

When Xe scintigraphy images from Milic-Emili et al. [4] and Anthonisen et al. [1] emerged in the late sixties, the physiologist’s reflex was to link specific ventilation and its dependence on lung inflation (and thus potentially, flow asynchrony) to washout tests and understand the basic physiological mechanism operational at a regional level. With current MRI techniques we are now ready to zoom in, in a quantitative way, down to the resolution scale where the major determinant of convection-dependent ventilation heterogeneity is operational in normal humans and for which the exact mechanisms remain elusive.

DISCLOSURES

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AUTHOR CONTRIBUTIONS

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