Finite Element Simulations of Short-Range $^3$He Diffusion in a Model of Branching Acinar Airways: Implications for In Vivo Lung Morphometry

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Introduction
A method for in vivo $^3$He MR lung morphometry (“cylinder model”) has been developed [1] which estimates airway dimensions from $^3$He diffusion experiments using expressions obtained from computer simulations in simplified models of alveolar ducts. Limitations of this method caused by partially relying on the Gaussian phase approximation were recently reported [2] and it was also suggested that further limitations may arise from the geometrical assumptions in simplified models of alveolar ducts (Fig.3), which once of the limitations of the method so far have been systematics [3]. Limitations of this method caused by parameters (e.g. fixed) from the simulated data on fit starting parameters and varied widely, showing that several not unique solutions exist. This raises serious questions on the ability of the cylinder model to extract all its parameters from the measured diffusion signals.

Conclusions
Branching effects have significant influence in $^3$He diffusivity, even at short diffusion times. The expressions of the cylinder model theory do not account for significant dependences upon diffusion time and branching geometry and airway length, as a consequence of the incorrect treatment of branching effects.

References

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