Interplay between geometry and flow distribution in an airway tree

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Uniform fluid flow distribution in a symmetric volume can be realized through a symmetric branched tree. It is shown here, however, that the flow partitioning can be highly sensitive to deviations from exact symmetry if inertial effects are present. This is found by direct numerical simulation of the Navier-Stokes equations in a 3D tree geometry. The flow asymmetry is quantified and found to depend on the Reynolds number. Moreover, for a given Reynolds number, we show that the flow distribution depends on the aspect ratio of the branching elements as well as their angular arrangement. Our results indicate that physiological variability should be severely restricted in order to ensure uniform fluid distribution in a tree. This study suggests that any non-uniformity in the air flow distribution in human lungs should be influenced by the respiratory conditions, rest or hard exercise.