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Plasma microcirculation in alveolar capillaries: effect of parachute-shaped red cells on gas exchange.

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Summary: The effects of plasma microcirculation speed and red blood cell (RBC) shape on CO exchange in alveolar capillaries is numerically investigated. In this study, blood is modeled as an inhomogeneous, two-constituent substance, with one of the constituents being the blood plasma, treated as a homogeneous Newtonian fluid, and the other being the RBCs, treated as discrete, suspended particles (i.e., solid bodies) flowing with the plasma. The RBC shape and blood speed effects on the alveolar diffusion process is observed not only by the variations in the iso-lines along the alveolar capillary but also by changes in the lung diffusing capacity. The simulations include varying the capillary blood speed from 1.0 to 10 mm/s and the capillary hematocrit from 3% to 55%. The RBC shape effect is established by comparing results obtained for circular RBCs to results for which the RBCs have a more realistic, parachute shape when flowing with the plasma. Results reveal the parachute-shaped RBCs yield higher lung diffusing capacity compared to the circular ones. Moreover, blood flow can increase the lung diffusing capacity by almost 50% in certain cases, with the effect being more predominant at high blood speed and low hematocrit. Finally, the effect of blood speed for parachute-shaped RBCs is quantified in terms of percentage-increase lung diffusing capacity and presented in a simple predictive equation.

Keywords: alveolus; gas exchange; capillary; blood flow
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