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Modeling Oxygen Transport in the Human Placenta ALEXANDER SEROV, MARCEL FILOCHE, Physique de la Matiere Condensee, Ecole Polytechnique, CNRS, 91128 Palaiseau Cedex, France, CAROLYN SALAFIA, Placental Analytics LLC, 93 Colonial Avenue, Larchmont, New York 10538, USA, DENIS GREBENKOV, Physique de la Matiere Condensee, Ecole Polytechnique, CNRS, 91128 Palaiseau Cedex, France — Efficient functioning of the human placenta is crucial for the favorable pregnancy outcome. We construct a 3D model of oxygen transport in the placenta based on its histological cross-sections. The model accounts for both diffusion and convention of oxygen in the intervillous space and allows one to estimate oxygen uptake of a placentone. We demonstrate the existence of an optimal villi density maximizing the uptake and explain it as a trade-off between the incoming oxygen flow and the absorbing villous surface. Calculations performed for arbitrary shapes of fetal villi show that only two geometrical characteristics - villi density and the effective villi radius - are required to predict fetal oxygen uptake. Two combinations of physiological parameters that determine oxygen uptake are also identified: maximal oxygen inflow of a placentone and the Damköhler number. An automatic image analysis method is developed and applied to 22 healthy placental cross-sections demonstrating that villi density of a healthy human placenta lies within 10% of the optimal value, while overall geometry efficiency is rather low (around 30-40%). In a perspective, the model can constitute the base of a reliable tool of post partum oxygen exchange efficiency assessment in the human placenta.

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