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Modelling transport in the placenta: scaling models to simulate organ level function

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The placenta is critical for our first nine months of life, as it provides nutrients from mother's blood and clears waste from the fetal circulation. The main structures that make up the placenta are villus trees, so called because they form a complex branching structure, like the branching of a tree, to provide a large surface area for exchange. Many pregnancy complications are associated with alterations in the structure of the villus trees and the blood vessels that reside within them. This potentially leads to poor matching of maternal and fetal blood flow rates at the site of exchange, and so impaired placental efficiency. Most computational models 'smooth out' the structure of the villous trees, or are limited to functional subunits of the placenta (placentomes) comprising just one of the 60-100 villous trees that comprise the placenta. Here I will present computational techniques to allow simulation of placental exchange at the whole organ scale, which include heterogeneity in villous structure. I will present evidence that the structure of the placenta is such that consideration of isolated placentomes is not always appropriate in simulation, and an analysis of how structural perturbations in the placenta (for example cord insertion at the periphery of the placenta) may impact on its exchange function.

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