Abstract Submitted
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A computational reproduction of Murray's law using surrogate-based design optimization[1] ALISON MARSDEN, UCSD — Murray's law describes the optimal relationship between the radius of a parent and daughter blood vessel in a bifurcation. In his 1926 paper, Murray determined the optimal radius and angle via an analytical optimization problem in which the cost function was the sum of a pressure loss term and a metabolic cost term. In this work, we present a computational investigation of Murray's law using derivative-free optimization and a 3-D finite element Navier-Stokes solver. The optimization method relies on Kriging surrogates and mesh adaptive direct search (MADS). The bifurcation geometry is parameterized so that the parent and daughter radii and bifurcation angle are optimized simultaneously. This framework also avoids the need for a steady Poiseuille flow assumption, as in Murray's original work. We will present results using a range of metabolic parameter values, illustrating the trade-off between energy dissipation and vessel size. These results demonstrate that Murray's solution can be reproduced with a particular choice of metabolic parameter (Taber, Biophys J., 1998). In addition, we will explore the effect of using a pulsatile inflow condition on the optimal solution. Finally, we will discuss the potential for broad impact of optimization methods in a range of cardiovascular design problems.

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