# Preliminary Implementation of Novel Bifurcation Pressure Loss Model in a Reduced-Order Cardiovascular Flow Model

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**Background:** Computational models of cardiovascular flows are valuable for the study and treatment of cardiovascular disease, but high-fidelity finite-element simulations that solve the Navier-Stokes equations in three dimensions (3D) can have a prohibitive computational cost. Reduced-order models simulate cardiovascular flows at a cost orders of magnitude lower than that of 3D simulations, but their simplified formulations can introduce significant error. One source of error is the assumption of constant pressure over vascular bifurcations. The recently proposed resistor-resistor-inductor (RRI) model, which predicts the pressure differences over bifurcations so that they can be accounted for in reduced-order models.

**Aims:** We tested the RRI model's performance in a zero-dimensional (0D) cardiovascular flow model on a two-bifurcation test geometry. The RRI model has previously been validated for isolated bifurcations, but not tested in a solver.

**Methods:** The 0D model considered models a vasculature as an electric circuit, where flow and pressure are analogous to current and voltage, respectively, and the vessels are represented by circuit elements. The RRI model formulates the pressure difference over a bifurcation as the voltage difference over a serially connected linear resistor, quadratic resistor, and inductor, whose resistances and inductances are determined from the bifurcation geometry using a neural network.

We predicted the RRI resistances and inductances for each bifurcation from their geometries with neural networks. We compared the accuracy of the 0D model with the RRI bifurcation handling and standard bifurcation handling in steady and transient flows. Errors were defined by comparison to high-fidelity 3D simulations.

**Results:** We found that the 0D model was more accurate using the RRI model for bifurcation handling than using the standard bifurcation handling. The inclusion of the RRI model reduced error in the inlet pressure of our test geometry by 92% for steady flow and 67% for transient flow.