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Modeling acute and chronic vascular adaptations to a major arterial occlusion

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Modeling acute and chronic vascular adaptations to a major arterial occlusion

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Peripheral arterial disease (PAD) is a serious illness in which major arteries become occluded, causing reduced blood flow to peripheral tissues. Developing improved treatment strategies for PAD requires a more complete understanding of the vascular changes that occur both proximal and distal to the site of occlusion. Mathematical modeling provides a useful tool to predict the role of collateral arteries in flow compensation following occlusion. In this work, a vascular wall mechanics model is used to simulate acute and chronic vascular adaptations in the collateral arteries and collateral-dependent arterioles of the rat hindlimb. On an acute timeframe, the vascular tone of collateral arteries and distal arterioles is determined by responses to pressure, shear stress, and metabolic demand. On a chronic timeframe, arteriogenesis (outward vessel remodeling) is modeled by increased passive vessel diameter, and angiogenesis (growth of new capillaries) is assumed to depend on venous oxygen saturation levels. The model predicts that acute responses only restore post-occlusion flow to 24% of non-occluded blood flow, while the addition of chronic responses (structural adaptation) yields blood flow that is 84% of the non-occluded level. Ultimately, the model predictions indicate that interventions which enhance collateral arteriogenesis would have the greatest potential for restoring blood flow to healthy levels.