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A Mathematical Model of Intimal Thickening: an Application to Atherosclerosis

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ABSTRACT:
Atherosclerosis is an inflammatory disease of the artery characterized by an expansion of the intimal region. Intimal thickening is usually attributed to the migration of smooth muscle cells (SMCs) from the surrounding media and proliferation of SMCs already present in the intima. Intimal expansion can give rise to dangerous events such as stenosis (leading to stroke) or plaque rupture (leading to myocardial infarction). We propose and study a mathematical model of intimal thickening, posed as a free boundary problem. Intimal thickening is driven by damage to the endothelium, resulting in the release of cytokines and migration of SMCs. By coupling a boundary value problem for cytokine concentration to an evolution law for the intimal area, we reduce the problem to a single nonlinear differential equation for the luminal radius. We analyze the steady states, perform a bifurcation analysis and compare model solutions to data from rabbits whose iliac arteries are subject to a balloon pullback injury. In order to obtain a favorable fit, we find that migrating SMCs must enter the intima very slowly compared to cells in dermal wounds. This cell behavior is indicative of a weak inflammatory response which is consistent with atherosclerosis being a chronic inflammatory disease.

Host: Tom Chou, Ph.D.

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