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Understanding Blood Pressure Regulation through Mathematical Modeling

Understanding the cardiovascular control system is crucial for gaining perspective on the physiology of a healthy individual as well as in detecting abnormalities. In recent years the modeling of various aspects of the cardiovascular system has been especially insightful. In particular, heart rate models reveal underlying mechanisms of blood pressure regulation. The baroreflex has been identified as an important contributor to the short-term blood pressure control mechanism. This is a negative feedback system that aims to maintain a constant range for blood pressure. It involves specialized neurons, called baroreceptors, which are stretch sensors that respond to arterial pressure and are predominantly located in the aortic arch and carotid sinus.

Throughout the years, various mathematical models have been developed which quantify the pressure-response relationship. Recently a unified model has been proposed that reflects all the known characteristics of baroreceptor response including: saturation, threshold, adaptation, post-excitatory depression and sensitivity to the rate of change of pressure. We demonstrate how parameters of the model are altered due to conditions that affect baroreceptors such as aging or hypertension. Further we augment the baroreceptor model to include the description of the sympathetic and parasympathetic outflow to predict the heart rate.