Mathematical Modeling and Simulation of Cardiovascular Systems Based on Electrical Circuit Analogy

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Abstract

Model of the human cardiovascular system, in which the blood pulse manifests, would be helpful in understanding the system in depth. Cardiovascular mathematics is a challenging and considerably active branch of applied and computational mathematics. The complexity of the computational domain, the deformable nature of vessels and the different scales involved force the adoption of a multi-scale approach. The aim of this project is to formulate and construct an equivalent mathematical model of the cardiovascular system with the similar activity as real human system. The model is mainly made up of left heart, right heart, systemic circulation, pulmonary circulation and the controller, a functional description of mechanisms working on systemic resistance, venous unstressed volume, heart rate, heart pressure and blood flow rate. In this paper, the modeling approach is based on differential equations which in turn are presented as a nonlinear electric circuit. A lumped parameter model of human cardiovascular circulatory systems can be analogously represented by an e.g. 11th order electric circuit. Moreover the control theory, e.g. stability is used for closed-loop electric models of the cardiovascular system. The model consists of analog and digital parts which enable changing of some important parameters of the model according noninvasively measured true cardiovascular parameters of the patient. The advantage of the cardiovascular model constructed as nonlinear adaptive analog-digital electronic circuit is possibility of real time operation and physiological parameters identification. The presented model provides a powerful tool to study still unresolved aspects of cerebral blood flow physiology, as well as several venous pathologies. The results could be useful in a clinical environment and proposes an integrative model of cardiovascular control suitable for future research purposes.

References

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