Modeling the Human Circulatory System Using System Dynamics: Possibilities, Benefits, and Practical Applications

Victor Iapascurta [1,2]
[1] Technical University of Moldova, victor.iapascurta@doctorat.utm.md, ORCID: 0000-0002-4540-7045 www.utm
[2] N.Testemitanu University of Medicine and Pharmacy, www.usmf.md

Keywords: system dynamics modeling, circulatory system, myocardial infarction, integrated development environment.

Abstract. System dynamics is a robust methodology for understanding the behavior of complex systems over time. Employing feedback loops, stocks, flows, and time delays provides a framework for simulating and analyzing dynamic systems. Applying system dynamics to the human circulatory system offers numerous possibilities, benefits, and practical applications that can significantly enhance our understanding and management of cardiovascular health. This article presents experimental results of modeling myocardial infarction conditions based on system dynamics with a six-compartment model built using NetLogo integrated development environment, including BehaviorSpace as part of this environment for simulations. For the analysis of the results, specialized packages in R programming language, Python environment, and Wolfram Mathematica were used. The results show promising fidelity when compared with data described in the literature, as well as real-time patient data.

Fig.1 below presents the user interface for the created system dynamics model, which can be personalized for a specific patient.

Table 1 represents the numerical output of an experiment using the model to simulate the myocardial infarction conditions. The table illustrates the dynamics of six physiological circulatory parameters over time.

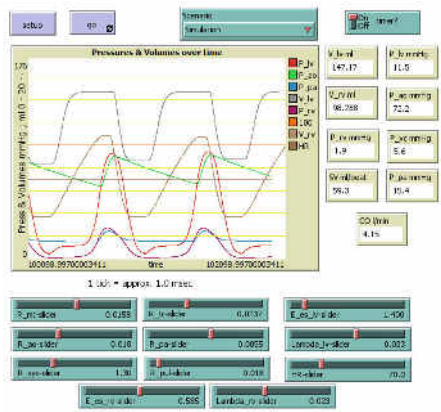

Fig.1. The appearance of the model's user interface.

Table 1. A small portion of the simulation results

Left ventric. press.	Left ventric. output	Right ventric. output	Right ventric. volume	Aortic press.	Vena Cava press.
(mmHg)	*(L/min)*	*(L/min)*	*(mL)*	*(mmHg)*	*(mmHg)*
69.24	4.14	4.14	96.68	91.25	4.81
70.32	4.14	4.14	96.54	91.20	4.81
71.42	4.14	4.14	96.36	91.16	4.81
72.52	4.14	4.14	96.13	91.11	4.81
73.65	4.14	4.14	95.87	91.07	4.81
74.78	4.14	4.14	95.58	91.02	4.81
75.93	4.14	4.14	95.26	90.97	4.81
77.09	4.14	4.14	94.92	90.93	4.81
78.26	4.14	4.14	94.54	90.88	4.82
79.45	4.14	4.14	94.15	90.84	4.82

References

[1] L. Garber, S. Khodaei and Z. Keshavarz-Motamed, “The critical role of lumped parameter models in patient-specific cardiovascular simulations,” Arch Computat Methods Eng, vol. 29 (2022), 2977–3000.

[2] U. Wilensky. “NetLogo.” Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL. Dec 12, 2018, ccl.northwestern.edu/netlogo/index.shtmlL.

[3] V. Iapascurta. “Cardiac_output-Simple_Model_01_01,” NetLogo Modeling Commons.[Online]. Available: www.modelingcommons.org/browse/one_model/5361