

MINIMAL CARDIOVASCULAR SYSTEM MODEL INCLUDING PHYSIOLOGICAL MITRAL VALVE OPENING

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Abstract

This research describes a new closed-loop cardiovascular system (CVS) model including a model of the left atrium and a model describing the progressive aperture of the mitral valve.

Keyword: modeling of physiological systems.

1 Introduction

A minimal cardiovascular system (CVS) model has been previously validated *in silico*, and in several animal model studies [1]. It accounts for valve dynamics by means of a Heaviside function to simulate the “open on pressure, close on flow” law. However, this model does not describe the progressive valve opening and therefore, it is not suitable for studying valve dysfunctions.

2 Method

At first, the CVS model consisted of 6 elastic chambers [1]. To describe the mitral valve more accurately, a new elastic compartment modeling the left atrium is added. Mitral valve opening and closing is modeled by a forced harmonic oscillator [2], coupled to the CVS model (Fig. 1) to simulate cardiac hemodynamics with valve dysfunction.

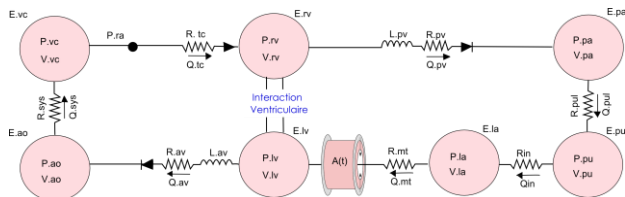


Fig. 1 : Closed loop CVS model consisting of 7 elastic chambers.

3 Results

Simulations of the new model allow us to plot the pressure-volume (PV) loops for both ventricles. The left ventricle PV loop is shown in Fig. 2. Fig. 3 shows the simulated transmitral flow with both the

E- and the A-waves, as expected physiologically. Hence, the model realistically describes mitral valve opening and closing in the context of this validated full circulatory cardiovascular system model.

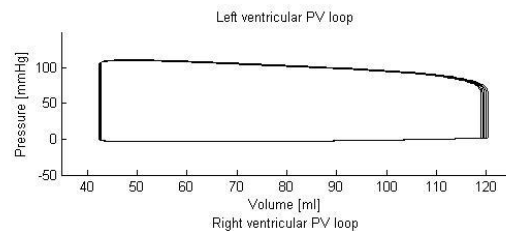


Fig. 2 : Pressure-volume loop of the left ventricle

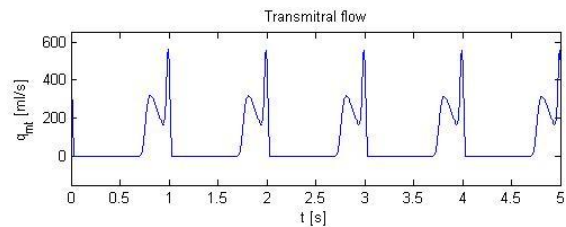


Fig. 3 : Transmitral flow evolution

4 Conclusions

This work describes a new CVS model that accounts for progressive opening and closing of the mitral valve to enable the study of valve dysfunction on overall hemodynamics. Simulations show physiologically expected hemodynamic behaviour for healthy valves, and provide initial validation for its further use to monitor, diagnose and control valvular pathologies.

References

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