DIRECT PARAMETER IDENTIFICATION IN A MODEL OF THE CARDIOVASCULAR SYSTEM

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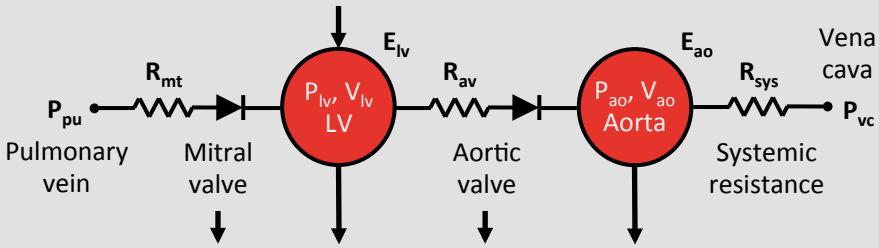
Introduction

- Parameter identification is crucial if models are to be used to track an individual patient's condition.
- In cardiovascular system modeling, *model-dependent identification methods* can find the best set of parameters, whereas in general nonlinear regression methods cannot*.
- In this work, a model-dependent method is developed which allows computing model parameters without requiring any model simulation.

Methods

Lumped model of the left ventricle (LV) and systemic circulation*
Model inputs: LV driver function e(t), heart rate HR



Model outputs:

- left ventricle pressure $P_{lv}(t)$,
- aortic pressure $P_{ao}(t)$,
- stroke volume SV,
- opening time of the mitral valve t_{MVO},
- closing time of the mitral valve t_{MVC},
- opening time of the aortic valve t_{AVO},
- closing time of the aortic valve t_{AVC}.

Equations for direct parameter computation:

$$P_{pu} = P_{lv}(t_{MVO}) = P_{lv}(t_{MVC})$$

$$R_{mt} = \frac{\int_{t_{MVO}}^{t_{MVC}} P_{pu} - P_{lv}(t)\,dt}{SV}$$

$$R_{av} = \frac{\int_{t_{AVO}}^{t_{AVC}} P_{lv}(t) - P_{ao}(t)\,dt}{SV}$$

$$R_{sys} = \frac{\bar{P}_{ao} - P_{vc}}{HR \cdot SV}$$

$$E_{ao} = \frac{R_{sys}}{t_{AVO} - t_{AVC}} \ln\left(\frac{P_{ao}^{max} - P_{vc}}{P_{ao}^{min} - P_{vc}}\right)$$

$$E_{lv} = \frac{1}{SV}\left(\frac{P_{ao}(t_{AVO})}{e(t_{AVO})} - \frac{P_{ao}(t_{AVC})}{e(t_{AVC})}\right)$$

Results

- The equations permit us to directly and exactly retrieve model parameters without any model simulation.
- This work proves that the model is **structurally globally identifiable** from the selected model outputs.
- Finding bounds on the equations provides physiological limits on the parameter values.

Conclusion

- This method is not clinically applicable as it relies on ventricular pressure, which is not available in a clinical setting.
- This invasive measurement can easily be replaced by the result of model simulations, implying iterations of the method*.

Reference

*Hann, C. E. *et al*. Unique parameter identification for cardiac diagnosis in critical care using minimal data sets. *Comput Methods Programs Biomed,* 99(1), 75-87, 2010.

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