PARAMETER IDENTIFICATION IN A MODEL OF THE CARDIOVASCULAR SYSTEM INCLUDING THE ATRIA

A. Pironet[1], J. A. Revie[2], S. Paeme[1], P. C. Dauby[1], J. G. Chase[2], T. Desaive[1]

[1] Cardiovascular Research Center, University of Liège, Liège, Belgium

[2] Department of Mechanical Engineering, University of Canterbury, Christchurch, New Zealand.

Abstract

This research describes the extension of an existing lumped computer model of the cardiovascular system and an associated parameter identification method to the atria. It is found that the introduction of the atria supplies new useful information while causing only a moderate increase of the errors.

Keywords: modeling of physiological systems

1 Introduction

Models can be useful for clinicians as they can provide a clear physiological picture from data hard to understand at first. As the atria play an important role, introducing them in a model of the cardio-vascular system can provide useful information.

2 Methods

Two new elastic chambers representing the atria are added to the initial six-chamber model of the cardiovascular system proposed by Smith *et al.* [1].

Pressure and volume in the atria are related by means of a time-varying elastance $E(t)$ defined as

$$E(t) = E_{passive} + E_{active}.e(t - \Delta t),$$

where $e(t)$ is the ventricular driver function and Δt is the delay between atrial and ventricular contraction.

Introduction of the atria adds ten new parameters. Six of them (E_{active}, Δt and the flow resistance, R, for both atria) have been estimated by extending the identification method proposed by Revie *et al.* [2]. According to this method, to identify a parameter, one has to find a proportional relationship between this parameter and an output variable of the model. The parameter is then updated using the ratio of this output and the corresponding measurement. It is worth to note that we only use reference data coming from ventricular measurements (Fig. 1).

Δt is estimated as the duration of ventricular systole. E_{active} is proportional to the atrial a wave, which is proportional to the ventricular peak pressure during atrial systole. Finally, R is proportional to the mini-mum of ventricular pressure during atrial systole.

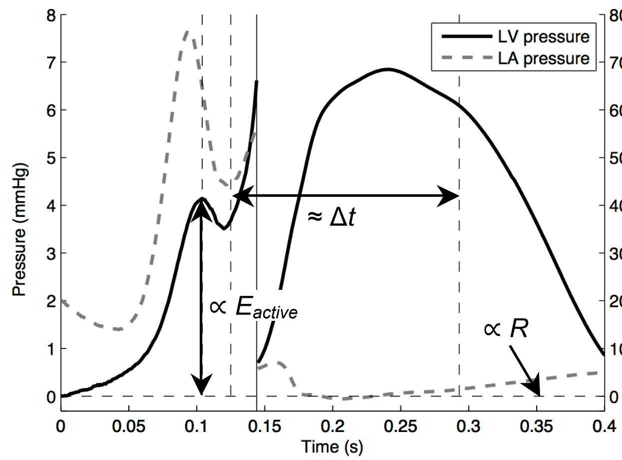

Fig. 1 – Summary of the identification process for (left) atrial parameters. The black line represents left ventricular (LV) pressure and the dashed grey line represents left atrial (LA) pressure. The vertical full line separates the two pressure scales used for the graph. The vertical dashed lines indicate maximum of ventricular pressure during atrial contraction, beginning and end of ventricular systole, respectively.

3 Results

Using experimental data on pigs, we compared both the original and the extended identification methods. Adding the atria in the model does not cause an important increase of the errors (~ 10 %).

4 Conclusion

The interest of the method developed in this work is significant since it gives supplementary information (about the atria) without introducing the need for new measurements.

References

[1] Smith, B. et al. Minimal haemodynamic system model including ventricular interaction and valve dynamics (2004). Medical Engineering & Physics, 131:139.

[2] Revie, J. A. et al. Clinical detection and monitoring of acute pulmonary embolism: proof of concept of a computer-based method (2011). Annals of Intensive Care, 1:33.