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

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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 cardiovascular 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

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

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

Introduction of the atria adds ten new parameters. Six of them ($E_{\text{active}}, \Delta t$ 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).

$\Delta t$ is estimated as the duration of ventricular systole. $E_{\text{active}}$ is proportional to the atrial a wave, which is proportional to the ventricular peak pressure during atrial systole. Finally, $R$ is proportional to the minimum of ventricular pressure during atrial systole.

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 ($\sim 10\%$).

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