MODELING THE INSTANTANEOUS PRESSURE-VOLUME RELATIONSHIP IN THE LEFT VENTRICLE

A. Lucas[1], J.-W. Lankhaar[2], P. Steendijk[2], Ph. Kolh[1], Th. Desaive[1] and P.C. Dauby[1]

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

[2] Institute for Cardiovascular Research, VU University Medical Center, Amsterdam, The Netherlands

Abstract

Models and simulations are very useful to study interactions between anatomic structures and physical cardiac phenomena. In this work, we are interested in models of the instantaneous pressure-volume relationship, i.e. isochrone models. More precisely, we concentrate on the 6 models considered by Lankhaar *et al.* [1]. We propose a critical analysis of the work of these authors and suggest some improvement of their procedure.

Keyword: modeling of physiological systems

1 Introduction

Pressure-volume loops are a common modeling tool of the cardiovascular system. They are very useful because they characterize the global function of the cardiac pump and can also be analyzed by considering the various phases of the cardiac cycle and marking each point of a cycle with the corresponding time. When several loops are considered, the points corresponding to the same time *t* in each loop can be joined to define a curve named isochrone. This concept does not have to be mixed up with the theoretical concept of isophase. The latter is a curve that links the points corresponding to the same relative time in the considered phase. These points do not necessarily occur at the same time in the different cycles.

2 Methods

Lankhaar *et al.* have estimated the parameters characterizing six different isochrones models from experimental data measured in five sheep. Using these models with the obtained values of the parameters, they simulated each experimental loop. To test the procedure developed by these authors to identify parameters, we estimate model parameters but this time from the simulated loops. If these parameters are equal to the parameters found by Lankhaar *et al.*, the procedure is consistent. If not, we will try to identify the origin of this inconsistency. Figure 1 summarizes schematically the global procedure used in this research.

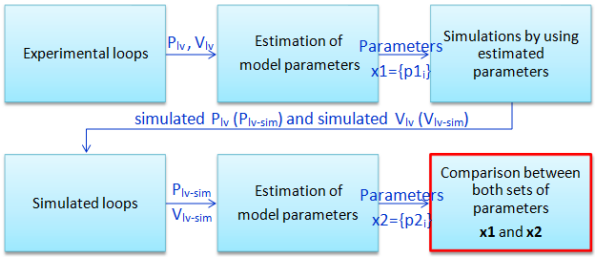

Figure 1 - Test realized in order to verify the consistency of the procedure.

3 Results

Our tests have shown inconsistencies for some of the six models. The principal cause is the use of the ESPVR defined as an isophase, and not as an isochrone, to estimate parameters of some isochrone models. Another cause of inconsistencies is the lack of uniformity between the programs of parameters estimation and those for loops simulation. More precisely, important landmarks in the cardiac cycle, such as start of ejection, start of filling, and end systole, are determined in different manners in these models.

4 Conclusion

The ESPVR commonly defined as an isophase is not adapted in isochrone models. We think it is better to define an end-systolic isochrone, namely the closest isochrone to the ESPVR. Furthermore, we redefine the identification of important landmarks in P-V loops, paying attention to the uniformity.

References

[1] Lankhaar J.-W. et al. Modeling the Instantaneous Pressure–Volume Relation of the Left Ventricle: A Comparison of Six Models. *Annals of Biomedical Engineering,* Volume 37, Number 9, 1710-1726, 2009.