

Patient specific model of the cardiovascular system during septic shock

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Introduction

Sepsis is a most complex and serious systemic response to infection and is one of the leading causes for morbidity and mortality in the critical care setting.

In this research, a porcine model of induced endotoxic shock without hemofiltration is analyzed and the parameters of a previously validated cardiovascular system (CVS) model are identified. For the first time the identification process is applied to strictly right ventricle signals and no left ventricle signals were measured. This significantly reduced data set is of particular clinical importance, as often only limited data, such as data from only one of the ventricles, is available in Intensive Care Units (ICU).

Methods

The model consists of 8 elastic chambers including the heart and circulations. Identification of the parameters is made only from measured pressures in the aorta and pulmonary artery, and the volume in the right ventricle. Septic shock was induced in (N=6) healthy pigs with endotoxin infusion over 30 min. Right ventricular pressure-volume loops were recorded by conductance catheter and end-systolic ventricular elastance was assessed by varying right ventricular preload. Consent was obtained from the University of Liege Medical Ethics Committee.

Results

Errors for the identified model are within 8% when the model is identified from data, re-simulated and then compared to the clinically measured data. Even with a limited amount of available experimental data to identify the parameters of the model, all simulated parameters trends match physiologically expected changes during endotoxic shock. Fig. 1 shows that similar right ventricular end-systolic elastances trends are obtained when compared to previously reported experimental results [1].

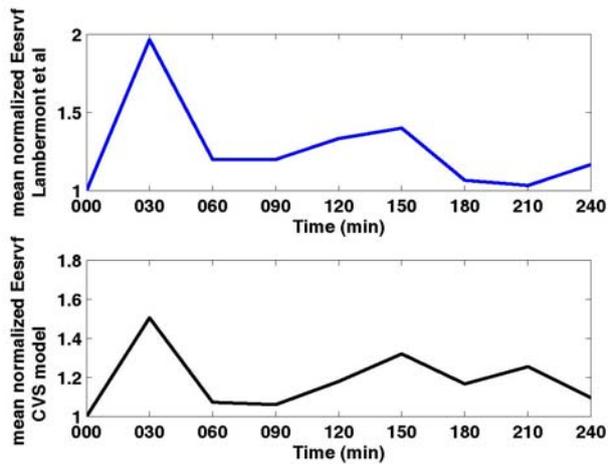


Fig. 1 Mean normalized right ventricular end-systolic elastance E_{esrvf} over all analyzed pigs during the septic shock experiment. Upper panel: results as obtained by [1], lower panel: results obtained with CVS model and identification process.

Conclusions

We identified pig-specific parameters for the CVS model using a significantly reduced data set. This research shows the ability of the model to adequately and realistically capture the impact of pressure-volume changes during endotoxic shock. In particular, the model is able to aggregate diverse measured data into a clear, clinically and physiologically relevant diagnostic picture as the condition develops. This research thus increases confidence in the clinical applicability and validity of this overall diagnostic monitoring approach.

Reference

1. Lambermont B, Ghuysen A, Kolh P, Tchana-Sato V, Segers P, Gerard P, Morimont P, Magis D, Dogne JM, Masereel B, and D'Orio V (2003) Effects of endotoxic shock on right ventricular systolic function and mechanical efficiency. *Cardiovasc Res* 59: 412-418