Sensitivity analysis of a cardio-respiratory model for the study of responses to apnea.

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Context: Sleep apnea syndromes are characterized by the occurrence of respiratory events during the night (apnea or hypopnea), that generate acute cardio-respiratory responses. The interpretation of these acute responses may be difficult because of the variety of processes involved, which should be jointly considered for an appropriate analysis.

Methods: An integrated model of cardiovascular, respiratory and autonomic interactions is proposed in this work. Specific interfaces are proposed to couple a set of components adapted from the literature, representing: 1) cardiovascular system, 2) respiratory system, 3) gas exchange/gas transport and 4) neural control. A sensitivity analysis of the integrated model, specifically on the parameters of the chemoreflex and tissue gas exchange components, was performed using the Morris elementary effects method (Morris, 1991) during the simulation of a 20-seconds apnea episode.

Results and Discussion: Sensitivity analysis was applied on 19 parameters. Parameter ranges were selected from the nominal literature values ±30%, except for the gains of the chemoreflex. During apnea, the most influent parameters were those related to the metabolic O2 consumption rate and CO2 production rate in the tissue gas exchange. In the 15-second window after and before the apnea, the most relevant parameters were the one related to the pulmonary muscular activity control of the central and peripheral chemoreflex. A first qualitative comparison has shown a close behavior between experimental and simulated cardio-respiratory responses to apnea. These results highlight the influent components of chemoreflex control and the metabolic rates and provides key information towards the definition of patient-specific parameters.

Conclusion: Results highlight the most sensitive parameters of an integrated mathematical model representing cardiovascular, respiratory and autonomic interactions during apnea. Further work will focus on a patient-specific identification of these parameters in order to reproduce data observed from polysomnographic studies.