A Lumped Parameter Model of Airway/Lung Mechanics

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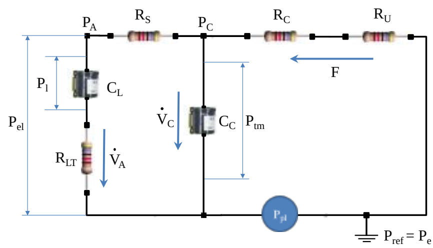
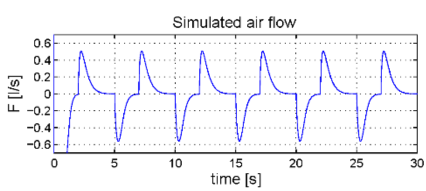
Introduction: In this work we present a nonlinear lumped parameter model of the airway/lung mechanics. The model is able to reproduce the time evolution of the fundamental variables (pressure, flow and volume) within each compartment of the respiratory system during normal breathing. A particular attention is given to the pleural pressure that is the driving force of the system.

Methods: Lungs are considered as a unique alveolar region connected to the external environment by means of the airways which divide into the upper airway, the collapsible airway and the small airways. The pneumatic-electrical analogy allows to represent the respiratory system by employing an electrical circuit composed by four resistances, two capacitors and a generator. The resistances simulate the friction of air in the airways and the lung tissue viscous property. The capacitors simulate the lung and the collapsible airway compliances which express their elasticity, i.e. their ability to expand when a pressure change occurs. All these elements are defined by nonlinear analytical expressions. The generator simulates the pleural pressure (P_{pl}) which drives the respiration process. The governing equations of the model are nonlinear first order ordinary differential equations. The model has been tested with three pleural pressure waveforms reproducing the regular breathing and two kinds of quiet breathing.



Electric analogue of airway/lung dynamics.

Results: The response of the model to each P_{pl} waveform is analyzed in terms of flow, volumes and pressures. In particular, the simulation results show how the different pleural pressure waveforms influence the time evolution of air flow, alveolar volume and flow-volume loop.



Conclusions: The model presented in this work can be a tool for the description of the main physiological quantities involved in the respiration with the final goal of a complete description of the respiratory system and its interaction with the cardiovascular system.