Mechanical interface of a computer lung model, based on bipolar pneumatic supply

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1. Introduction

In medical engineering there is a lot of devices and software, which allow modeling different features and structures of human organs, including lungs. Especially we have numerous physical or computer models representing lungs.

We can divide lung models into two main groups: physical models and mathematical (computer based) models. Physical models consist of various kinds of bellows, pipes, pistons and valves. Mathematical models describe the mechanical process of breathing by means of relatively sophisticated mathematical equations.

All the models mentioned above have their pros and cons. The most important advantage of a physical model is that it can be connected to a real device (e.g. respirators). Among their main disadvantages we can specify their limited capacity for any structural changes like resistance, volume or compliance. On the other hand mathematical models have excellent flexibility in main parameter changes and can consist of really sophisticated structures, but they cannot be connected to any real device.

In this paper a device combining advantages of both those models is proposed. The interface between a mathematical model and a real device is shown allowing creation of any real model of the human lung.

2. Methods

The proposed mechanical interface of computer lung model is presented in Fig. 1. That is designed using three way valve supplied with bipolar pressure ±p, with electronically controlled flow feedback, and is connected with a mathematical model of the lungs (implemented on a PC). Thanks to interfacing the mathematical model and the physical valve we can achieve a lung model combining all advantages of the models mentioned above – with a greater flexibility in structure and parameters changes, and ability to be directly and easily connected to respirators, as well as pressure and flow-meters.

Fig. 1 Block scheme of the interface for Lung model purposes. “PID/Amp” – controller (proportional-derivative-integral regulator and amplifier) on electronic board; “Math. Model” - computer based lung model; “P” – pressure to voltage converter; “V” – Flow-meter
3. Results

In this study an interface for a physical – computer lung model has been created. That enables to connect a mathematically described lung model to any real measuring or controlling device (e.g. ventilators). The device consists of (Fig. 1) a computer part which, by means of mathematical equations, describes a lung model (Math. Model); a control and measurement IO card; a specially designed valve based on an electromagnetic linear (spiker-like) motor, and an electronic board for valve work control (PID/Amp). The bipolar pneumatic supply allows modeling those phenomena which are difficult or impossible to be modelled in other devices (e.g. bellows model).

4. Discussion

First examination results show that it is possible to create an interface that allows to connect a mathematical lung model with the real world. First tests with Siemens Dräger Servo Ventilator 900 and simple RC lung model showed will corresponding with clinical data and meeting the expectations of the researchers.

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