MULTICOMPARTMENTAL ANALYSIS OF PULMONARY FUNCTION USING SYSTEM IDENTIFICATION TECHNIQUES

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Multicompartmental analysis of pulmonary gas exchange is of great interest since it offers a more realistic description of the exchange of gas than the analysis of the lung as a single homogeneous unit.1,2 It might be expected that the multicompartmental analysis of other lung function variables, e.g. those of mechanical properties, offers similar advantages. The present study was undertaken to develop a non-invasive, bedside method for multicompartmental analysis of lung mechanics, ventilation and blood flow.

The approach was that of systems indentification which can be described accordingly.3 Consider a lung being fed by a certain input signal, e.g. gas flow. It responds with an output signal, e.g. pressure. A lung model can be constructed, incorporating parameters such as compliance, resistance lung volume, etc., described by algorithms which link the lung function parameter to certain input and output signals. If this lung model is fed by an input signal identical to the one feeding the lung (e.g. flow), the parameters in the lung model are assigned values by an iterative optimigation procedure so that the model responds with an output signal as similar to the one recorded in the lung as possible (e.g. pressure).

The procedure used in the present study involved the recording of the input signals tracheal gas flow and the inspired nitrogen and carbon dioxide concentrations while corresponding output signals were tracheal pressure and expired nitrogen and carbon dioxide concentrations. These signals were recorded during a step change in the inspired N₂ and CO₂ concentrations so that a partial N₂ wash-out and CO₂ wash-in was produced. The signals were sampled: at a frequency of 40 Hz for 4-5 breaths, i.e. during a period shorter than that for recirculation of blood.
The compartmentation has so far been based on time constants. From these are calculated the resistance and compliance of each compartment. In succeeding calculations compartmental values are assigned for dead space, alveolar volume, ventilation, alveolar CO₂ tension and blood flow. So far the analysis has been restricted to a two compartment model. However, it is theoretically possible to use more compartments in the analysis.

A limited number of measurements has been done in supine middle-aged lung healthy men during inhalation anaesthesia. A typical result is shown in Fig. 1. As can be seen, one compartment is assigned a 10 times higher resistance than for the other compartment. The dead space ventilation is also unevenly distributed with almost all delivered to the low-resistive compartment. Slightly uneven distributions of compliance, ventilation, alveolar volume and blood flow can also be seen. This report does not pretend to explain these data but ongoing work is directed towards airway closure and collateral ventilation as possible causes to the second compartment.