Title : FLOW TO LUNG COMPARTMENTS WITH DIFFERING TIME CONSTANTS

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Introduction. Although mechanical ventilators with widely differing flow patterns have long been available, it is still unclear as to what is the effect of changes in such flow patterns in the pressure of diseased lungs. Herzog and Norlander[1] developed a two compartment mechanical model with equal compliances and unequal resistances. Their model included a shunt between the two alveolar (capacitance) compartments in an attempt to simulate a decrease in compliance in poorly ventilated areas caused by pressure from well ventilated areas. They claimed that an accelerating inspiratory flow gave a more even gas distribution than a constant flow. With a constant flow generator, the flow to the compartment with the shorter time constant was greater than that with a longer time constant. This difference approached a constant as inspiratory time increased. Jansson and Jonson[2] criticized the use of a shunt resistance as being "unphysiologic". We have developed mathematical models to determine whether Herzog's conclusions were dependent on the inclusion of such a shunt.

Methods. Figure 1 shows an electrical analog of our model. The resistance, R, is equivalent to Herzog's shunt. Equations of this model, with and without the shunt resistance, were solved for cases of constant flow and accelerating flow for various values of R1, R2, C1, C2 and R using methods we have previously described.[3]

Results. The general equation for I1 for a constant flow generator was found to be:

$$I1 = I\left[\frac{C1}{C1 + C2}\right]\left[1 - \frac{(R1\ C1 - R2\ C2)}{C1(R + R1 + R2)} - \frac{e^{-t/\tau}\ R\ (R1\ C1 - R2\ C2)}{C1(R1 + R2)\ (R + R1 + R2)}\right]$$

The system time constant, τ, is given by:

$$\tau = \frac{R(R1 + R2)}{(R + R1 + R2)} \cdot \frac{C1\ C2}{(C1 + C2)}$$

I2 is given by: I2=I-I1.

With the shunt, the flows are as described by Herzog (fig. 2). However in the absence of the shunt resistance, the difference between the flows to the two compartments approaches zero as the inspiratory time increases (fig. 3). The difference between these flows is always greater for the accelerating flow generator.

Discussion. A constant flow generator produces a more uniform ventilation than an accelerating flow generator in a two compartment model lung. The uniformity of gas distribution is favored by longer inspiratory times. Previous models incorporating a shunt between the alveolar compartments lead to contrary results.

References.

1. Herzog P, Norlander OP: Distribution of alveolar volumes with different types of positive pressure gas-flow patterns. Opusc Med 13:3-18, 1968
2. Jansson L, Jonson B: A theoretical study on flow patterns of ventilators. Scand J Resp Dis 53:237-246, 1972
3. Epstein MAF, Epstein RA: Airway flow patterns during mechanical ventilation of infants: A mathematical model. IEEE Trans Biomed Eng 26:297-304, 1979

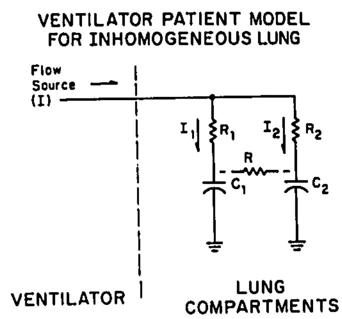

Figure 1

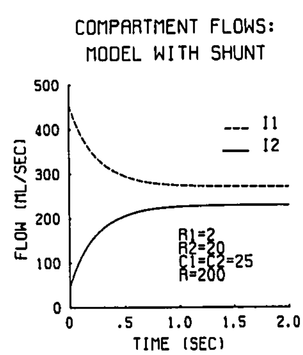

Figure 2

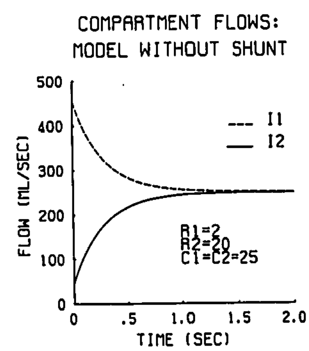

Figure 3