ALVEOLAR HYPOVENTILATION FOLLOWING AN INCREASE IN F_IO_2 DURING MECHANICAL VENTILATION.

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Continuous analysis and volume measurement of expired gases are frequently used, as a research and monitoring tool in intensive care units. In this study, the effect on these variables of a step change in inspired oxygen concentration (F_IO_2) was examined. We had noted that an increase in F_IO_2 resulted in a parallel increase in end-expired carbon dioxide tension ($PÉCO_2$) and in arterial carbon dioxide tension ($PaCO_2$).

Methods

Fourteen patients with acute respiratory failure, being passively ventilated with a Siemens ventilator, were studied as folows. A pneumotachograph, giving a linear response at the flow rates studied, was connected to a demodulator and integrator and the integrated volumes were stored continuously in a computer. A mass spectrometer sampled gases at the airway and this data was also stored in the computer. Instantaneous volume and gas tensions were aligned by correcting for system lag time. The expired volumes were corrected continuously for viscosity, by comparing the known viscosity of the measured gas mixture with that of the pneumotachograph calibrating gas and adjusting proportionately. Expired carbon dioxide was integrated to give breath-by-breath VCO_2. $PÉCO_2$ was the CO_2 tension of the last one percent of the expired volume. All values were computed by averaging ten or more breaths, during steady state.

Following base line measurements, a step change in F_IO_2 was made. After a minimum of 20 minutes, measurements were repeated. Since patients started at various levels of F_IO_2, all data were corrected by linear proportion to represent a change in F_IO_2 of 0.5. The study was approved by the Human Research Committee.

Results

Table I
Percent Change in Gas Tensions and Volumes Following a Step Increase in F_IO_2 of 0.5 (N = 14; m ± SD).

$\%\Delta V_T$	$\%\Delta PaCO_2$	$\%\Delta PÉCO_2$	$\%\Delta VCO_2$
-4.2±6.2	+4.6±10.9	+10.1±13.1	+5.9±15.6
P<0.02*	P<0.01	P<0.05	N.S.

*Wilcoxon signed rank test

The observed effects (Table I) included an increase in $PaCO_2$ and $PÉCO_2$ with a parallel decrease in V_T. VCO_2 was unchanged. This decrease in V_T was not anticipated. Therefore, we examined the Siemens ventilator and noted that its "constant" volume is determined by flow delivered for a preset time. Flow is sensed by a pneumotachograph, which is not corrected for gas viscosity. (The viscosity of 100% oxygen is 13% greater than that of air). We evaluated 3 Siemens ventilators, using a Med-Science wedge spirometer and found that, at constant settings, the mean decrease in V_T following an increase in F_IO_2 of 0.5 was 5.5±1.4 percent.

Discussion

Ventilators have previously been shown to change their performance unexpectedly. For example, those incorporating a venturi in the gas mixture delivery system give various levels of F_IO_2 dependent upon outlet pressure. In this instance, an apparent change in the patient's CO_2 exchange secondary to an increase in F_IO_2 was, in fact, due to an alteration in ventilator performance. At constant frequency, a decrease in V_T resulted in an increase in whole body CO_2 and therefore in $PaCO_2$ and $PÉCO_2$. VCO_2 would not be expected to change. These data represent a generic problem common to all ventilators employing a pneumotachograph as a flow sensing and control device, unless appropriate correction is employed. Although small, the described changes are sufficient to cause erroneous conclusions particularly when the data are used as part of mathematical computations.