CORRESPONDENCE

CONTROLLED VENTILATION WITH A MAPLESON A (MAGILL) BREATHING SYSTEM

Sir,—Tyler and colleagues used a lung model to assess the effect of changing ventilatory variables on the end-tidal carbon dioxide concentration during use of a Mapleson “A” breathing circuit for positive pressure ventilation [1]. The authors concluded that a large tidal volume and prolonged expiratory phase are recommended “to improve (the) efficiency and predictability of the system”. Whilst this is probably so, it cannot be deduced from the data presented.

Consider first the term “efficiency”. The authors used this term to signify the effect of the ventilatory pattern on end-tidal carbon dioxide concentrations. A ventilatory pattern producing a lower end-tidal carbon dioxide concentration is considered more efficient. Thus figure 2 showed increasing “efficiency” with increasing tidal volume.

In the experiment which generated the data for figure 2 (experiment A), the lung model was ventilated at a constant 15 b.p.m. and constant fresh gas flow of 10 litre min⁻¹, whilst the tidal volume varied from 300 to 700 ml. Thus the minute ventilation varied from 4.5 to 10.5 litre min⁻¹. With a constant carbon dioxide production of 210 ml min⁻¹, it is hardly surprising that the end-tidal carbon dioxide concentrations decrease at the higher tidal volumes; it is simple dilution.

If the authors’ serial deadspace volume of 130 ml is used, the alveolar ventilation at the two extremes (300 and 700 ml tidal volume) can be calculated (VA = (VT - VD) x RR) as 2.55 and 8.55 litre min⁻¹. Using figure 2 and the square wave ventilatory pattern, the end-tidal carbon dioxide concentrations at these two tidal volumes are 13.2% and 4.5%. Thus at 300 ml tidal volume the lung is exhaling carbon dioxide at 0.132 x 2550 ml (336.6 ml) min⁻¹. As the total flow of carbon dioxide into the lung is 210 ml, 126.6 ml is from rebreathing. Performing the same analysis at 700 ml tidal volume, the total carbon dioxide rebreathed is 174.75 ml. I would argue that the circuit is more efficient at the lower tidal volume. Extending this analysis to a tidal volume of 1000 ml the lung is exhaling carbon dioxide at 0.132 x 5000 ml (660 ml) min⁻¹. As the total flow of carbon dioxide into the lung is 210 ml, 450 ml is from rebreathing. Performing the same analysis at 700 ml tidal volume, the total carbon dioxide rebreathed is 174.75 ml. I would argue that the circuit is more efficient at the lower tidal volume. Extending this analysis to a tidal volume of 1000 ml the lung is exhaling carbon dioxide at 0.132 x 5000 ml (660 ml) min⁻¹. As the total flow of carbon dioxide into the lung is 210 ml, 450 ml is from rebreathing. Performing the same analysis at 700 ml tidal volume, the total carbon dioxide rebreathed is 174.75 ml. I would argue that the circuit is more efficient at the lower tidal volume. Extending this analysis to a tidal volume of 1000 ml the lung is exhaling carbon dioxide at 0.132 x 5000 ml (660 ml) min⁻¹. As the total flow of carbon dioxide into the lung is 210 ml, 450 ml is from rebreathing. Performing the same analysis at 700 ml tidal volume, the total carbon dioxide rebreathed is 174.75 ml. I would argue that the circuit is more efficient at the lower tidal volume. Extending this analysis to a tidal volume of 1000 ml the lung is exhaling carbon dioxide at 0.132 x 5000 ml (660 ml) min⁻¹. As the total flow of carbon dioxide into the lung is 210 ml, 450 ml is from rebreathing. Performing the same analysis at 700 ml tidal volume, the total carbon dioxide rebreathed is 174.75 ml. I would argue that the circuit is more efficient at the lower tidal volume.

I am concerned also regarding the validity of the model lung system used. The Magill system cannot work in controlled ventilation without variations from “plug” flow (i.e. straight gas interfaces), or the spill valve failing to act as a true threshold resistor. If the spill valve is a perfect threshold resistor and plug flow applies, 100% rebreathing occurs. Whilst the gas interface wavefront shapes are not defined in the system, the end-tidal carbon dioxide concentrations decrease at the higher tidal volumes; it is simple dilution.

Sir,—Dr Young has clearly misunderstood the article “Controlled ventilation with a Mapleson A (Magill) breathing system: reassessment using a lung model”. The A system classically has been considered as unsuitable for use with manual ventilation. Sykes [1] found that the performance of the A system was influenced by ventilation and assumed an influence of the pattern of ventilation. In theory, a prolonged expiratory pause should render the A system more efficient (defined by us in terms of carbon dioxide elimination from the system).

We have used a similar, but different, lung model to confirm Sykes’ findings. In addition, we have demonstrated that a prolongation of the expiratory time allows more carbon dioxide to be removed from an A system when tidal volume and fresh gas flow are varied.

Dr Young is correct in asserting that increasing minute ventilation of the model would be predicted to have a dilutional effect on the concentration of carbon dioxide instilled at a fixed rate. However, the extent of re-breathing is not predictable, as no dilutional element exists within the complete model as the fresh gas flow is fixed. In addition, his mathematical analysis has the appeal of simplicity, but fails to take into account the fact that gas composition leaving the expiratory valve differs at high and low tidal volumes.

We deliberately did not attempt to extrapolate our findings to man. We are aware of the limitations of the lung model. However, we believe that the experiment described helps to explain how normal end-tidal carbon dioxide concentration can be attained when using the A system for controlled ventilation.

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REFERENCE


Sir,—We were interested to read the paper by Drs Tyler, Barnes and Rafferty [1] in which they described an analysis of controlled ventilation with a Mapleson A breathing system using a lung model. They conclude that the Mapleson A “must be considered a system with a largely unpredictable performance when used during controlled ventilation”, but we suspect that use of the system in this way, if only for short periods, has been widespread in British anaesthesia for many years.

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