Editorial

Will we ever have a universal anaesthetic breathing system?

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In this issue of the JOURNAL, Humphrey and his colleagues describe a version of the A.D.E. anaesthetic breathing system[1,2] which they feel is optimal for all patients. Humphrey *et al.* have shown that the "A.D.E. low-flow universal" system functions as a modified D (Mapleson's classification[3]) or Bain circuit for controlled ventilation and, with the switch of a single lever, as a modified Mapleson A system (or Lack circuit) for spontaneous respiration.

The data presented are largely consistent with previous studies using the "D mode". With controlled ventilation (Part II)[2] and the D mode (A.D.E.) the arterial PCO_2 of ten patients was predictable with a FGF of 70 $ml \cdot kg^{-1} \cdot min^{-1}$ and a tidal volume of 10 $ml \cdot kg^{-1}$ with a respiratory rate of 12–15 breaths/minute (i.e., controlled rebreathing).

During spontaneous respiration (Part I)[1] the authors suggest that rebreathing could be eliminated with FGF rates of only 50 $ml \cdot kg^{-1} \cdot min^{-1}$, when the A.D.E. system was used in the "A mode" (A.D.E.).

Several variables determine rebreathing during spontaneous respiration. These considerations are important to the clinician because, as Nunn[4] stated, "it may become almost impossible to determine the composition of the gas inspired." Therefore clinicians must ask two questions: first, does the A.D.E. system always allow predictable inspired gases, thus safer anaesthesia, at these economically low FGF rates of 50 $ml \cdot kg^{-1} \cdot min^{-1}$; secondly, what potential risks might offset any such advantage?

Humphrey *et al.*[1] studied only healthy (ASA physical status I) patients breathing halothane through an endotracheal tube. The influence of other factors that are known to determine rebreathing and hence alveolar CO_2 tensions were not evaluated. Such factors as mask anaesthesia with an increase in deadspace,[5] respiratory waveform changes with various anaesthetic agents,[6] and the effect of altering the resistance of relief valves within the breathing system have not been considered. The universal application of a single breathing system requires that this technique be equally safe for all patients when used with a standardized FGF rate.

What are safe levels of carbon dioxide found in inspired gases and what is the best measurement technique for determining inspired PCO_2? Humphrey *et al.*'s conclusions are based on midstream samples measured at the mouth. Some authors[6] have chosen to measure inspired CO_2 sampled at the carina to minimize sampling error and assess the volume of the CO_2 inspired beyond the upper airway. Humphrey[7] himself recognizes that "determination of the point at which rebreathing becomes clinically significant will continue to present a problem." He has chosen to use the point at which the minimum inspired CO_2 tension reached 2 mmHg (0.3 per cent). Conway has objected to this definition of rebreathing.[8] Humphrey's end-point means that some CO_2 is inhaled into the upper airway throughout the inspiratory phase and may participate in gas exchange. Just how much CO_2 reaches the alveoli was not determined in this study. Is this degree of rebreathing always associated with elevated $PaCO_2$ levels without other factors being altered? Before one can generalize that no rebreathing occurs with the A.D.E. circuit in the "A mode" at a FGF of 50 $ml \cdot kg^{-1} \cdot min^{-1}$, more investigation is needed.

The most efficient use of fresh gas with any circuit during spontaneous ventilation occurs when flows are set such that rebreathing is just detected. If

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this flow equals the patient's alveolar ventilation then all fresh gas participates in alveolar gas exchange, none is wasted, and fractional utilization is unity (100 per cent). In the current study, when rebreathing was detected, Humphrey *et al*,[1] calculated the A.D.E. utilized 73 per cent of the fresh gas ($51.4 \pm 5.2\ ml \cdot kg^{-1} \cdot min^{-1}$ FGF) compared to 51 per cent for the Magill circuit ($71.2 \pm 6.0\ ml \cdot kg^{-1} \cdot min^{-1}$ FGF).

By adding tubing for an expiratory limb and moving the expiratory valve downstream the functional characteristics and efficiency of Mapleson's[3] original A system appear to have been improved. However do these lower flows and improved fractional utilization mean increased risks or benefits? A mean fresh gas flow value of $51.4 \pm 5.2\ ml \cdot kg^{-1} \cdot min^{-1}$ (mean ± SD) derived from ten patients does not guarantee that CO_2 free inspired gas nor normal minute ventilation will be obtained when a standardized flow of $50\ ml \cdot kg^{-1} \cdot min^{-1}$ is used in every patient. Even though better utilization of fresh gas is achieved in this circuit, this standard deviation implies that some of these healthy patients would have been rebreathing CO_2 if a FGF of only $50\ ml \cdot kg^{-1} \cdot min^{-1}$ had been used. One must recognize that the data imply that a FGF of $50\ ml \cdot kg^{-1} \cdot min^{-1}$ prevents rebreathing. This is not an absolute guarantee, but rather an average approximation. The rule still must be "user beware" when selecting a FGF rate for spontaneous breathing.

What are the potential risks of using a convertible "universal" anaesthetic breathing system? Problems such as errors in lever placement could be avoided with experience. However, how is the "A mode" coaxial system checked for leaks? Since the reservoir bag is on the inspiratory side the Pethick test used for modified "D" systems will not apply. Manual ventilation can only be achieved in the "A mode," yet the exact fresh gas flow requirements, the amount of ventilation and other limitations have not been fully defined.

Humphrey's ingenuity and progress in simplifying the more complex dual lever system should be applauded. He has eliminated several sources of error and reduced the complexity of the system. As with other systems only in time will all problems be defined. In Canada there are no minimum safe standards of either function or structure of anaesthetic breathing systems. Canadian Standards Association (C.S.A.) approval is not necessary prior to marketing new breathing systems. C.S.A. guidelines for breathing systems are to be released in the near future. The Canadian Anaesthetists' Society and its members must address this issue to ensure elimination of faults before new equipment is used in Canada as we do for new pharmaceutical products. To state that technology should be made as safe as possible helps very little. The safety of machines can almost always be improved but, at some point, the price of safety is increasing complexity and cost.

A major message stressed by Humphrey *et al.*[1] is that anaesthetists should choose their breathing system and FGF as carefully as they choose their anaesthetic drugs. The Humphrey A.D.E. system will be useful only if the clinical anaesthetist understands the functional characteristics of both the A and D mode and the limitations are fully documented.

Aurions-nous un système de circuit anesthésique universel?

Dans ce numéro du Journal, Humphrey et collègues décrivent une version du circuit anesthésique A.D.E.[1,2] qui serait selon eux optimale pour tous les patients. Humphrey *et al.* ont démontré que le système "A.D.E. universel à bas flow" fonctionne comme un système D modifié (classification de Mapleson[3]) ou comme un circuit de Bain pour la ventilation contrôlée et lors de la mise en marche d'un interrupteur unique comme un système A de Mapleson (ou circuit Lack) pour la respiration spontanée.

Les données présentes sont en accord avec les études préalables utilisant le mode D. En ventilation contrôlée (partie II)[2] et mode D (A.D.E.) la PCO_2 artérielle de dix patients était prévisible avec un flot de gaz frais de $70\ ml \cdot kg^{-1} \cdot min^{-1}$ et un volume courant de $10\ ml \cdot kg^{-1}$ et une fréquence respiratoire de 12 à 15/minute (i.e., la ventilation contrôlée).