An indirect calorimetry system for ventilator dependent very low birthweight infants

Sir,—While the need for measurement of energy expenditure and nutrient utilisation in sick ventilator dependent infants is undisputed, we have several reservations about the indirect calorimetry system described by Forsyth and Crichton.1 On p316 the inspired or expired minute ventilation? The equations given appear to take these to be equal, even though this amounts to assuming that the respiratory quotient (RQ) is 1. If instead the inspired and expired volumes of inert gas, are assumed equal the oxygen consumption (VO2) can be found as

\[ VO_2 = V_{\text{inspired}} \times F_{\text{I}} - F_{\text{E}} - F_{\text{CO}_2} \]

with true RQs of 0-7 and 1-2 being computed as 0-80 and 1-11 respectively.

In the gas infusion studies reported in table 1 it is unclear how to assess the values calculated for VO2 when nitrogen is infused into the system. This part of the study calculates VO2 as if the results were from a patient; the first equation on p318 then allows the calculated VO2 1-2 to be calculated in terms of nitrogen flow rate and FiO2. If VO2 is calculated correctly then this check equation is

\[ VO_2 = V_{\text{inspired}} \times F_{\text{I}} - F_{\text{E}} - F_{\text{CO}_2} \]

1- FiO2

If the equations on p316 are used then this becomes:

\[ VO_2 = V_{\text{inspired}} \times F_{\text{I}} - F_{\text{E}} - F_{\text{CO}_2} \]

For the nitrogen flow rates given in table 1 (10-10, 14-10 ml/min) and FiO2 is 0-40, the expected values of VO2 would be, from the first equation, 6-73, 9-40 ml/min and from the approximate version of the second equation, 4-04, 5-64 ml/min. From the results for the higher nitrogen infusion rate (p319) it appears that the second equation has been used (as would be consistent with the earlier part of the paper) but the agreement is poor at the lower flow rate.

Finally, we were disappointed that gas infusion studies were performed using only one ventilator setting. Increasing the inspired oxygen concentration (while keeping VO2 constant) causes a reduction in the inspired—expired oxygen difference (FiO2 - VO2). Thus,FiO2 - VO2 decreases, the error sensitivity in the measurement of VO2 is magnified. It is not uncommon for sick ventilated infants to need FiO2 1-2 and the errors in the measurement of energy expenditure at high oxygen concentrations will be markedly increased and this must be acknowledged.

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Dr Forsyth comments: Although the general principles of indirect calorimetry may apply to all systems and subjects, there are some features which require specific consideration depending upon the nature of the system and the size of the subject being studied. In our system for ventilated low birthweight infants,1 there are at least two important aspects which differ from adult systems, first the effect of changes in RQ on expiratory flow volume (VE) and second, the validity of excluding FCO2 from the calorimetry calculations.

Adult calorimetry systems commonly use an inspiratory flow volume (Vi) in the region of 40 l/min, and for a 70 kg individual with an oxygen consumption (VO2) of 320 ml/min and RQ of 0-7, the difference between Vi and VE will be 96 ml (0-24% of Vi). In our system Vi is 6 l/min (inspiratory flow from the ventilator), and for a 150 g ventilated infant with a VO2 of 90 ml/min and RQ of 0-7, the difference between Vi and VE is 2-7 ml, that is 0-045% of Vi. In order to correct for this difference, Drs Matthews and Matthews offer a formula based on adult data,1 and which involves the value of four different measurements. Not only is there a risk that the overall error of these measurements may exceed the error induced by the difference in the Vi and VE flow volumes but their equation is not accurate in the infant system. If it is applied to the 1500 g infant, the 'corrected' VO2 will be 7-79 ml/min compared with the actual VO2 of 9-0 ml/min (an underestimate of 13-3%). This underestimate is constant, and not limited to the margins of RQ. Using their simpler equation the calculated VO2 at RQ 0-7 is 7-9 ml/min underestimate (12%), but this error reduces to 0% as the RQ approaches 1-0. The large persistent error with the Matthews' equation is due to the omission of FCO2. In adults this is usually less than 1% of FCO2 and commonly ignored, but for a low birthweight infant in our system the FCO2 account for up to 22% of the total output. The formula should therefore be corrected to

\[ VO_2 = \frac{F_{\text{I}} - F_{\text{E}} - F_{\text{CO}_2}}{1-F_{\text{I}}-F_{\text{CO}_2}} \]

A simpler and potentially more accurate adjustment is the traditional Haldane correction, VE = VE.PFEn/FN2, and as our system is continually measuring inspiratory and expiratory nitrogen this can be easily accommodated.

Our nitrogen infusion system was designed so that the mean FIO2 was 0-421 and VE 5-257 l/min. By using the measured values for VE, FIO2, and FCO2 the predicted VN2 were compared with the actual VN2, and using our last equation the actual oxygen consumption as opposed to the simulated VO2 was confirmed to be zero. The VO2 data reported with the nitrogen infusions were calculated as for an infant study using the described software calculation and were included, albeit with the limitations as discussed above, to relate the infusion data to actual levels of VO2 which are seen in low birthweight infants. Unfortunately we did not do the wrong comparison point for the VO2 for the nitrogen infusion of 10-1 ml/min and this should have been 4-20 (0-22) ml/min. We are grateful for this being drawn to our attention.

Although we will not be using clinical and technical data on the use of our system with higher levels of FIO2, it is our experience that in the present surfactant era considerably fewer babies are requiring a very high FIO2 for a long period of time. We realise that some babies do require an FIO2 as high as 1-0, but we believe that for those babies there are more urgent priorities than a measurement of energy expenditure.


Impaired upper airway obstruction and covert video surveillance

Sir,—Covert video surveillance (CVS) may be extremely useful and is often the only method to prove that some cases of apparent life threatening events (ALTE) are caused by impaired upper airway obstruction. Samuels
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