Sir,—We are grateful to Drs Brimacombe and Berry for pointing out the omission of a discussion about hypertonic solutions. These authors have eloquently stated the advantages for hypertonic solutions and I agree with them. However, as they say, these solutions are still at an early stage of clinical investigation and I would further agree that more work is needed before they can be recommended routinely.

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METAL PARTICLE GENERATION CAUSED BY THE COMBINED SPINAL-EYADRUDURAL TECHNIQUE

Sir,—Recent letters in this journal [1, 2] have raised the question of potential damage to spinal or extradural needles when the needle-through-needle combined spinal-extradural technique is used. It has even been suggested that metal particle generation may arise because of this method [3].

Portex Ltd would like to take the opportunity to inform clinicians of an independent evaluation conducted to investigate this issue [4]. The aims of the study were: to assess any damage to the spinal and extradural needles produced by this technique; and to determine if the technique produces metal particulate contamination.

The trial tested the technique against different variables which could occur in clinical practice: two types of 26-gauge spinal needle with different tip profiles (lancet or pencil point); two different sizes of Portex Tuohy needles (16- and 18-gauge); two different rotations of the spinal needle during insertion (0° and 360°).

Each type of spinal needle was inserted through a Tuohy needle as during the needle-through-needle technique. A new spinal and extradural needle set was used in each case. When the lancet version was tested, it was introduced with the leading edge “running along” the base of the Tuohy curve in order to maximize any possible scraping effect.

Five millilitres of 0.45–0.8 μm-filtered sterile saline was flushed through the Tuohy needle under test and collected on a 0.45-μm membrane filter. A control sample of saline was taken also. Each membrane was examined under an Olympus BH binocular light microscope with ×10 objective. Any particles present were counted and sized.

Identification of any particles found on the membranes was made by energy dispersive x-ray analysis (EDX) in conjunction with a scanning electron microscope: the electron beam in the microscope strikes a surface and generates x-rays which have energy levels characteristic of the chemical elements present in the surface. The x-rays are detected and plotted out as energy level spectra which carry peaks which may be related unambiguously to specific elements. The technique is semi-quantitative, in that peak heights give an indication of the amount of each element present.

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Stainless steel particles are easily recognized using EDX analysis, by their high chromium content. Both the extradural and stainless steel particles.

The study showed no evidence to support the supposition that metal particles are produced as a consequence of utilizing the needle-through-needle technique.

Subsequent examination of both spinal and Tuohy needle tips showed no damage attributable to the technique.

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4. Institute for Biomedical Equipment Evaluation and Services, Sheffield University and Health Authority (Lodge Moor Hospital, Sheffield S10 4LH). Report No. R301; May 22, 1992.

BRITISH JOURNAL OF ANAESTHESIA

FRACTIONAL UTILIZATION OF FRESH GAS BY BREATHING SYSTEMS WITHOUT CARBON DIOXIDE ABSORPTION

Sir,—We have been following with interest the articles by Drs Beatty, Meakin and Healy and their colleagues [1–3] concerning analysis of an Ohmeda EAR system, as we ourselves are analyzing the fresh gas utilization of breathing systems without carbon dioxide absorption. The authors of these articles have termed this “fractional utilization” (Fu) of fresh gas. The fresh gas utilization of any system has to be calculated as the fraction of the fresh gas delivered to the patient against the total fresh gas flow into the system. This is independent of patient characteristics and is determined only by the physical characteristics of the system.

We have been calculating the fresh gas utilization of breathing systems without carbon dioxide absorption by first calculating the fraction of fresh gas that does not reach the patient, but is wasted in the system. This fresh gas wastage is calculated using the equation:

\[ \text{PECO}_2 = \text{PEV}_\text{CO}_2 \]

where \( \text{PECO}_2 \) = mean expired carbon dioxide tension at the tracheal tube end of the system; \( \text{PEV}_\text{CO}_2 \) = mean expired carbon dioxide tension at the valve end of the system.

The change in the mean expired carbon dioxide tension at the valve end of the system is caused only by dilution of the expired gas by the fresh gas that has come out of the system without reaching the patient.

This equation is similar to that used for calculating the physiological deadspace, in which the fraction of gas that has diluted the ideal alveolar gas is calculated:

\[ V_D = \frac{\text{PB} - \text{PEV}_\text{CO}_2}{\text{PB} - \text{PEV}_\text{CO}_2} \]

The fresh gas utilized by the system (Fu) is the fraction of fresh gas that is not wasted, but reaches the patient and is calculated as:

\[ \text{Fu} = \frac{\text{PB} - \text{PEV}_\text{CO}_2}{\text{PB} - \text{PEV}_\text{CO}_2} \]

Rewriting the above equation, we get

\[ \text{Fu} = \frac{\text{PB} - \text{PEV}_\text{CO}_2}{\text{PB} - \text{PEV}_\text{CO}_2} \]

The value \( \text{PECO}_2 \) can be taken as the same as the end-tidal carbon dioxide tension. \( \text{PB}_\text{CO}_2 \) can be measured easily by attaching a corrugated tube and an open-ended reservoir bag to the scavenging port of the valve and sampling continuously from the tail end of the bag.

The authors of the above mentioned articles have used complicated calculations from data collected by equally complicated means to derive the fractional utilization of fresh gas of the EAR system. They have analyzed the fraction of fresh gas that takes part in the alveolar gas exchange by using the equation:

\[ \text{Fu} = \frac{\text{PB} - \text{PEV}_\text{CO}_2}{\text{PB} - \text{PEV}_\text{CO}_2} \]

This fraction is not determined by the physical characteristics of the breathing system, but by many factors such as age of the patient, smoking, lung pathology, \( V/Q \) mismatch. This should be termed the fractional utilization by the patient, and not by the system.

The authors have shown how variations in patient utilization adversely affect the calculated Fu of the system, in their studies using the EAR system in adults, children and lung models.

In their recently published article [4], they seem to have understood the problems encountered by their approach and have tried to correct it by coining a new term—fractional delivery of fresh gas (Fd)—which is actually the same as the fractional utilization of fresh gas by the system. Here again, they have used a complicated equation:

\[ \text{Fd} = \frac{\text{PB} - \text{PEV}_\text{CO}_2}{\text{PB} - \text{PEV}_\text{CO}_2} \]
CORRESPONDENCE

They have derived \( V_{\text{CO}_2} \) by accurately measuring the fresh gas flow and multiplying it by \( FEV_{\text{CO}_2} \). \( FE_{\text{CO}_2} \) is taken to be the same as the end-tidal carbon dioxide concentration.

Expanding equation (6) we get:

\[
F_d = \frac{V_F \times FEV_{\text{CO}_2}}{V_F \times FE_{\text{CO}_2}} = \frac{PEV_{\text{CO}_2}}{PE_{\text{CO}_2}} \tag{7}
\]

(8)

It is apparent that equations (4) and (8) are the same. These values can be obtained easily using the same side-stream analyser; accurate measurement of the fresh gas flow is not necessary.

In view of this simplicity, the authors should change their equation to the simpler one. Using two terminologies is confusing and we think that they should use the well accepted terminology of fractional utilization of fresh gas (\( Fu \)) of the system.

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Sir,—Thank you for the opportunity of replying to the letter by Drs Ravishankar and Chatterjee.

The purpose of our paper [1] was to draw attention to the fact that fractional utilization of fresh gas (\( Fu \)) with a semi-closed breathing system is not constant, but varies with the arterial to end-tidal carbon dioxide partial pressure difference of the patients being studied. We noted that if end-tidal carbon dioxide measurements were used in place of arterial measurements in the equations for \( Fu \), a different parameter resulted which was independent of patient factors. This we termed fractional delivery of fresh gas (\( F_d \)), as it was a measure of the proportion of fresh gas delivered to the patient’s alveolar compartment, whether or not it took part in gas exchange.

Drs Ravishankar and Chatterjee have used a different approach than ours to arrive at an equation for calculating breathing system efficiency from measurements of end-tidal and mixed vented carbon dioxide concentrations (equations (1)–(4)). However, as arterial measurements of carbon dioxide are not used, we suggest that the efficiency index they have calculated is fractional delivery and not fractional utilization of fresh gas. This explains why, when simplified, both their equation (3) and ours for \( F_d \) (6) yield the same result (8).

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