Can one predict arterial PCO₂ from end-tidal PCO₂?

Sir,—The variation in the arterial to end-tidal PCO₂ difference (P(arterial CO₂) - P(end-tidal CO₂)) during anaesthesia in an adult population is wide (0.3—2.5 kPa). Preoperative spirometry cannot discriminate between patients with large and small (P(arterial CO₂) - P(end-tidal CO₂)) values in the supine or lateral position [1,2]. I was interested to read about a simple non-invasive manoeuvre described by Fletcher which may allow us to identify those patients with an increased (P(arterial CO₂) - P(end-tidal CO₂)) [3]. In 18 patients (mean age 63 yr) presenting for coronary artery bypass surgery, I applied the same manoeuvre in the period before bypass. The patients' lungs were ventilated with oxygen at 20 b.p.m. via a Carden ventilator. PeCO₂ was measured using a Datex Capnomac calibrated before each case. At steady state, PeCO₂ was noted (mean of five successive breaths) and arterial blood obtained for analysis. Immediately after blood sampling, ventilator frequency was reduced to 10 b.p.m. and the mean PeCO₂ of the next five breaths noted.

In 12 patients, PeCO₂ increased by a mean of 0.26 (± 0.21) kPa when ventilatory settings were reduced to 10 b.p.m., doubling tidal volume. There was no change in two patients and in four, PeCO₂ decreased by mean 0.15 (0.17) kPa. There was a linear relationship between the change in PeCO₂ brought about by the change in ventilatory settings and (P(arterial CO₂) - P(end-tidal CO₂)) at 20 b.p.m. (r = 0.49, P = 0.04) (fig 1); patients whose PeCO₂ value increased the most had greater (P(arterial CO₂) - P(end-tidal CO₂)) values. Mean (P(arterial CO₂) - P(end-tidal CO₂)) in the ‘risers’ was 1.01 (0.47) kPa and 0.83 (0.32) kPa in the ‘fallers’.

In patients with poor lung function, who have a large V/Q spread and increased (P(arterial CO₂) - P(end-tidal CO₂)), increased tidal volume improves ventilation of low V/Q, high PCO₂ regions (P(end-tidal CO₂) increases). In efficient lungs, this manoeuvre generates more carbon dioxide at a smaller partial pressure (P(end-tidal CO₂) decreases). These findings appear to support those of Fletcher. However, in the two patients who had no change in PeCO₂ with this manoeuvre, (P(arterial CO₂) - P(end-tidal CO₂)) were 1.0 and 0.6 kPa, respectively.

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Incidence of aspiration with the laryngeal mask airway

Sir,—We read the useful comments of Haden, Pinnock and Campbell on the laryngeal mask airway (LMA) for intraocular surgery, but were particularly interested in the comparisons between the LMA and tracheal tube [1]. From data collected from over 9600 patients, they found a significantly lower incidence of difficult placement and laryngospasm with the LMA than with the tracheal tube (0.9 vs 3.4 %). Whilst their method of data collection was not described, this represents the biggest documented series of LMA usage and could provide other valuable information.

Of great concern is the theoretical possibility that the LMA may increase the risk of aspiration by reducing lower oesophageal sphincter tone [2—7]. Only limited information is available about the incidence of aspiration with the LMA. Cumulative data from two large prospective surveys suggested an incidence of 1:4300 [8,9] and this is comparable with that found for elective [10] and outpatient general anaesthesia [11] before the availability of the LMA.

We believe that the data of Haden, Pinnock and Campbell may shed more light on this important issue and hope the authors could comment on their method of data collection and the incidence of regurgitation, aspiration, or both, in their series.

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9. Langer A, Hempel V, Ahlhelm T, Heipertz W. Die...
Our data suggest that the incidence of both regurgitation and aspiration may be greater with the LMA than with either face mask or tracheal tube: chi square = 635.73; vs "emergency" categories than elective and scheduled (LMA performed. Alternatively (and preferably), the gas mixture should be related to the barometric pressure at which the study has been performed. Consequently, as altitude increases the partial pressure of nitrous oxide decreases and at altitudes in the region of 5000 ft, the partial pressure of any given concentration of nitrous oxide is reduced by approximately 20% [2]. For a 50% mixture of nitrous oxide in oxygen, this results in a reduction of its analgesic potential of approximately 50% [3]. In his Editorial, Cormack states that "We know from the Breman study, for example, that if nitrous oxide is used correctly, that alone guarantees 98% success". This statement is true only for barometric pressures approximating to those at sea level and clearly cannot be extrapolated to areas of moderate or high altitude. As much of the earth's surface, including the Central African Plateau (which stretches from the Northern Cape to Ngorongoro) is at 5000 ft or higher, there is a vast population likely to be anesthetized at reduced barometric pressures. In an unpublished study which I abandoned after 30 cases, I found six patients had factual recall of intraoperative events after anaesthesia with nitrous oxide. We abandoned the use of unsupplemented nitrous oxide for Caesarean section performed at moderate altitude. None of these patients complained of pain but all found the procedure unpleasant. We abandoned the use of unsupplemented nitrous oxide for Caesarean sections thereafter.

All comments regarding the effectiveness of a given concentration of nitrous oxide as an anaesthetic agent should be related to the barometric pressure at which the study has been performed. Alternatively (and preferably), the gas mixture should be defined in terms of partial pressures rather than concentrations.


Sir.—In our department the patient’s anaesthesia record is marked preoperatively on a proforma which contains a number of prompts related to medical history, anaesthetic management and any associated problems, such as critical incidents. There is also space for long hand comments. Data from the record are entered into a computer by a trained clerk. The software, written in early 1991 (R. M. H.), includes a flexible set of search and analysis programs biased towards the particular interests of the department, notably local and regional anaesthesia and airway management. We have recently developed a parallel and original system of clinical audit to improve reporting of critical incidents [1].

Our data on regurgitation, aspiration and vomiting are shown in table I. Eight of the 10 episodes of regurgitation and vomiting occurred in the hands of trainees, and may reflect the "learning curve" (particularly in respect of the "deceptively simple" laryngeal mask airway [2]). Six of the 10 were in CEPOD "elective" or "scheduled" categories [3]. The laryngeal mask airway (LMA) was used less frequently in CEPOD "urgent" and "emergency" categories than elective and scheduled (LMA vs tracheal tube: chi square = 635.73; P < 0.001). In 14% of the urgencies and emergencies, the airway was self-maintained, surgery being carried out under peripheral or central neural block with or without sedation. One patient vomited without aspirating (1:2600) and another aspirated in the early postoperative period (1:2600).

Critical incidents are universally under-reported [4-6] but for those that are reported, audit of our record system suggests that the information extracted has less than 1% factual errors. Therefore, we can be reasonably confident of the data in table I. With respect to the concerns of Brimacombe and Berry on the possibility that the LMA may increase the risk of aspiration [7, 8], our data suggest that the incidence of both regurgitation and aspiration may be greater with the LMA than with either face mask or tracheal tube. Awake patients under local anaesthesia may also aspirate. The precise relevance of these findings to clinical management is debatable.

Sir,—Dr R. Cormack elegantly reviewed the data on conscious levels in anaesthesia in his recent Editorial [1], but in his comments on nitrous oxide he failed to make allowance for the effects of altitude. In interpreting outcome studies on conscious awareness, it is crucial to bear in mind that it is the partial pressure of an anaesthetic agent that produces anaesthesia and not its concentration. This does not affect the performance of volatile anaesthetic agents at altitude because the volatile agents vaporize in relation to their saturated vapour pressures which are largely independent of barometric pressure. Consequently, the partial pressure of vapour produced by a given vaporizer setting remains constant for the volatile anaesthetic agents within the range of altitudes likely to be encountered in clinical practice, although the concentrations change. However, for nitrous oxide, which is, for all intents and purposes, a gas at room temperature and pressure, the partial pressure is dependent directly on atmospheric pressure. Consequently, as altitude increases the partial pressure of nitrous oxide decreases and at altitudes in the region of 5000 ft, the partial pressure of any given concentration of nitrous oxide is reduced by approximately 20% [2]. For a 50% mixture of nitrous oxide in oxygen, this results in a reduction of its analgesic potential of approximately 50% [3]. In his Editorial, Cormack states that "We know from the Breman study, for example, that if nitrous oxide is used correctly, that alone guarantees 98% success". This statement is true only for barometric pressures approximating to those at sea level and clearly cannot be extrapolated to areas of moderate or high altitude. As much of the earth's surface, including the Central African Plateau (which stretches from the Northern Cape to Ngorongoro) is at 5000 ft or higher, there is a vast population likely to be anesthetized at reduced barometric pressures. In an unpublished study which I abandoned after 30 cases, I found six patients had factual recall of intraoperative events after anaesthesia with nitrous oxide. We abandoned the use of unsupplemented nitrous oxide for Caesarean sections thereafter.

All comments regarding the effectiveness of a given concentration of nitrous oxide as an anaesthetic agent should be related to the barometric pressure at which the study has been performed. Alternatively (and preferably), the gas mixture should be defined in terms of partial pressures rather than concentrations.

<table>
<thead>
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<th>Airway management</th>
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<th>Regurgitation</th>
<th>Aspiration</th>
<th>Vomiting</th>
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<tr>
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<td>1 (1:4700)</td>
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</tbody>
</table>

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1. Cormack RS. Conscious levels during anaesthesia.