Acute Hypercapnia and Gas Exchange in ARDS

To the Editor:

Sinclair et al.1 recently reported in CHEST (July 2006) the effects of acute hypercapnia on ventilation-perfusion matching in an animal model of acute lung injury. The authors cited two studies2,3 of ARDS patients in which the effects of acute hypercapnia, produced by low-tidal volume ventilation, on gas exchange were examined. While in experimental models hypercapnia improves gas exchange in normal lungs (where CO₂ is usually added to inspired gases), hypercapnia as a consequence of protective lung ventilation led to impaired oxygenation as a result of increased shunting.2,3 In contrast, Mancini et al.4 demonstrated improved oxygenation and reduced shunting in eight ARDS patients in whom hypercapnia had been induced by reducing tidal volumes from 10 to 12 mL/kg to 5 to 7 mL/kg. However, it would appear that improvement or deterioration in oxygenation and shunting correlated with changes in mean airway pressure rather than acute hypercapnia per se.

Sinclair et al.1 hypothesized that the effects of hypercapnia on gas exchange in lung injury were largely unknown and may be beneficial, although they subsequently found no significant change. In their model, hypercapnia was induced by adding CO₂ to inspired gases or adjusting minute ventilation through changes in rate rather than tidal volume (keeping the mean airway pressure constant). In our institution, we have used another method, the addition of dead space, to induce hypercapnia in ARDS patients.5 This approach also has the advantage that mean airway pressure is unaltered. No significant alteration was observed in PaO₂, PaCO₂/fraction of inspired oxygen ratio, or shunting when acute hypercapnia was compared to normocapnia.6 Sinclair et al.1 postulated that lung injury produced by the homogeneous depletion of a surfactant may abrogate the beneficial effects of CO₂ on gas exchange that is observed in normal lungs; however, hypercapnia may be advantageous in patients with heterogeneous lung injury such as that caused by pneumonia. Although only two patients in our study had pneumonia as a cause of ARDS, neither showed improvement in gas exchange when they were acutely hypercapnic.

References

5. Findlay GP, Smithies MN. The response to inhaled nitric oxide at normocarbia and hypercarbia [abstract]. Intensive Care Med 1997; 23(suppl):S20

To the Editor:

We appreciate the interest in our study on the effects of hypercapnic acidosis on gas exchange after saline lavage-induced lung injury. Findlay and Wise1 mention a study by Mancini and colleagues2 and correctly conclude that the changes in gas exchange in this study (ie, decreased shunt) are likely due to the differences in positive end-expiratory pressure (PEEP) [9 vs 16 cm H₂O, respectively] and mean airway pressure [18 vs 21 cm H₂O, respectively], and not due to modest differences in PaCO₂ [39 vs 57 mm Hg, respectively] compared with other studies cited in their letter and in our article.3

In our study,3 although no significant differences in the clinical measurements of gas exchange were observed, low minute ventilation, which is produced by the reduction of respiratory rate, significantly reduced mean ventilation/perfusion distributions compared with inhaled carbon dioxide and eucapnia. Log SDs of ventilation and combined retention and excretion curves of the dispersion index were both increased during low minute ventilation, indicating the presence of unfavorable changes in ventilation distribution. Because tidal volumes and PEEP were kept constant between groups, there was no difference in shunt achieved by the technique of multiple inert gas elimination. Our protocol was designed to assess the effects of hypercapnic acidosis itself without the confounding effects of different tidal volumes, PEEP, or mean airway pressure.

In the study by Findlay and Smithies,4 hypercapnic acidosis was induced by adding dead space to the ventilatory circuit while keeping mean airway pressure constant. They reported no differences in PaO₂, PaCO₂/fraction of inspired oxygen ratio, or shunt between the increased dead space group and control subjects. Rebreathing of dead space gas would dilute the fresh gas that reaches the alveolus, reducing the effective alveolar PO₂. Therefore, the PaCO₂/fraction of inspired oxygen ratio would underestimate gas exchange in the increased dead space group. It would

George Findlay, MB ChB
Matt Wise, DPhil
University Hospital of Wales
Cardiff, Wales, UK

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Correspondence to: Matt Wise, DPhil, University Hospital of Wales, Adult Critical Care, Heath Park, Cardiff, CF14 4XW, Wales, UK; e-mail: mattwise@doctors.org.uk

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therefore be difficult to make meaningful comparisons between these groups without some independent method of assessing gas exchange efficiency.

Scott E. Sinclair, MD, FCCP  
University of Tennessee Health Sciences Center  
Memphis, TN

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Correspondence to: Scott E. Sinclair, MD, FCCP, University of Tennessee, Department of Medicine, 956 Court Ave, H314, Memphis, TN 38163; e-mail: ssincla1@utmem.edu  
DOI: 10.1378/chest.130.6.1950a

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Considerations About the Response Format of the Airways Questionnaire 20

To the Editor:

We have read with interest the recently published article by Chen et al in CHEST (June 2006)1 warning about the potential problems of the response format of the airways questionnaire 20 (AQ20). The original AQ20 was a simple, reliable, and valid instrument.2–4 which allowed the following three possible responses: “yes”; “no”; and “not applicable” (with a score of 0 for the answer “not applicable,” which is equivalent to “no”). Patients with the greatest disability were more likely to respond “not applicable,” yielding a lower total score and, then, underestimating actual impairment.5

In order to correct this drawback, the authors modified seven activity-based items (items 3, 4, 10, 11, 12, 13, and 14) to include an “unable” response that was given a score of 1 (equivalent to “yes”). Only a minority of subjects (5.9%) in this study endorsed the “unable” response in these items. Nevertheless, neither in this work nor in previous literature2–4 has the number of subjects who choose the option “not applicable” been reported.

In our Spanish validation study of the AQ20,6 in a sample of 208 patients with asthma and COPD we detected a high percentage of subjects who answered “not applicable,” particularly in two of the items modified by Chen et al6 (item 3, 43%; item 11, 56%). Choosing this response does not relate to the degree of impairment measured by the following other parameters: dyspnea MRC; FEV1 percent predicted; illness severity, according to the Global Initiative for Asthma classification for asthma and the Global Initiative for Chronic Obstructive Lung Disease classification for COPD; the St. George Respiratory Questionnaire; the Juniper asthma quality of life questionnaire; the chronic respiratory disease questionnaire; and the short form-12 questionnaire (p > 0.05).

These results suggest that, despite the inclusion of the “unable” option, items 3 and 11 could also be representing a high rate of “not applicable” responses, so further studies are needed to investigate this subject in more detail.

Marina Blanco-Aparicio, MD  
Hector Verea-Hernando, MD  
Hospital Universitario Juan Canalejo  
A Coruña, Spain  
Isabel Vázquez, PhD  
Santiago de Compostela University  
Santiago de Compostela, Spain

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Correspondence to: Marina Blanco-Aparicio, MD, Hospital Universitario Juan Canalejo, Pneumología, Xabías Arriba, 84, A Coruña 15006, Spain; e-mail: mba@mundo-r.com  
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To the Editor:

We appreciate the insightful comments provided by Blanco-Aparicio and Vázquez2 regarding our recent article in CHEST (June 2006). We agree that the frequency of “not applicable” responses is an interesting question. Among the seven modified items (n = 352 subjects), 391 of the 2,464 responses were “not applicable.” As reported in our original article,1 there were 39 “unable” responses. Thus, of all non-“yes/no” responses to the modified items nearly 10% were “unable.” Since we did not coadminister the Airways Questionnaire 20 (AQ20) and AQ20-revised, it is not possible to determine what proportion of subjects who responded “unable” would have chosen “not applicable” in the original format.

Consistent with the findings of Blanco-Aparicio and Vázquez,1 we observed a higher frequency of “not applicable” responses for item 3 (“gardening”) and item 11 (“activities at work”) relative to the other five modified items (Table 1). In addition, we also observed a high frequency of “not applicable” responses for item...