Acute Hypercapnia and Gas Exchange in ARDS

To the Editor:

Sinclair et al1 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 In contrast, Mancini et al3 demonstrated improved oxygenation and reduced shunting in eight ARDS patients in whom hypercapnia had been induced by decreasing tidal volumes from 10 to 12 mL/kg to 5 to 7 mL/kg. However, it would appear that improvement4 or deterioration2 in oxygenation and shunting correlated with changes in mean airway pressure rather than acute hypercapnia per se.

Sinclair et al1 hypothesized that the effects of hypercapnia on gas exchange in lung injury were largely unknown and may be advantageous in patients with heterogeneous lung injury which 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 al1 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.

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To the Editor:

We appreciate the interest in our study on the effects of hypercapnic acidosis on gas exchange after saline solution 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 reoxygenation and exercise curvatures 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
problems of the response format of the airways questionnaire 20
this work nor in previous literature has the number of subjects
an “unable” response in these items. Nevertheless, neither in
“yes”). Only a minority of subjects (5.9%) in this study endorsed
an “unable” response that was given a score of 1 (equivalent to
applicable,” yielding a lower total score and, then, underestimat-
with the greatest disability were more likely to respond “not
the answer “not applicable,” which is equivalent to “no”). Patients
choose the option “not applicable” being reported.

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 literature has the number of subjects
who choose the option “not applicable” been reported.

In our Spanish validation study of the AQ20, in a sample of
208 patients with asthma and COPD we detected a high per-
centage of subjects who answered “not applicable,” particularly
in two of the items modified by Chen et al (item 3, 43%; item 11,
56%). Choosing this response does not relate to the degree of
impairment measured by the following other parameters: dys-
pnea 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 Question-
naire: 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.

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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) 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, 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, underestimat-
ing 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
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this work nor in previous literature has the number of subjects
who choose the option “not applicable” been reported.

In our Spanish validation study of the AQ20, in a sample of
208 patients with asthma and COPD we detected a high per-
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56%). Choosing this response does not relate to the degree of
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2–6, 2006; Munich, Germany

To the Editor:

We appreciate the insightful comments provided by Blanco-
Aparicio and Vázquez 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, 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 appli-
cable” 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

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