Appendix: Response time measurement of the Datex Ohmeda M-CAIOV-X, and consideration of previous rebreathing results.

Background.

Observation of a recording of the gas composition during rapid rebreathing showed that the S5 monitor response was not fast enough to follow faithfully the changes in gas composition.

Figure 1, panel A, shows the response to slow expiration followed by a sudden change from slow expiration to rapid deep breathing. The response of the analyser is not able to measure the full change in gas composition.

Methods.

To measure the response time a subject breathed through a D Lite sensor held in the mouth. Responses to a composition change caused by a sudden change from slow steady expiration to a sharp inspiration were recorded using Collect software. The data were transferred to Spike software for analysis. This software allows accurate cursor setting on expanded displays of the recording.

Results

The time from the flow reversal to 5%, 50%, and 95% of the full scale response was measured (Figure 1, panel B). The mean time for carbon dioxide concentration change, from 5% to 95%, was 480 mSec. Figure 2 shows the delay and response times for oxygen and carbon dioxide measurements.

Conclusions and implications
Clearly the Datex Ohmeda M-CAIOV-X cannot be used to measure end-tidal values satisfactorily during the rapid breathing needed for mixed venous estimates by rebreathing.

Because we found that difficulties with apparatus response time may reduce the capacity to adequately assess the presence of an equilibrium during the rebreathing manoeuvre, we re-inspected the data provided by Collier.\textsuperscript{1} The breathing frequencies shown in the examples in this paper are very rapid, and the assessment of “equilibrium” from two identical adjacent samples is the result of two very similar breaths very close together. Collier himself suggested that the accuracy of the method he described was not sufficiently accurate for some purposes, such as cardiac output estimates. We plotted the data provided in his paper using the modern convention of Bland and Altman. It can be seen that the 95% confidence interval of the estimate is as great as the usual difference between arterial and mixed venous partial pressures. (Figure 3) No other estimates of the precision of the rebreathing method are available. This calls into question the use of rebreathing methods for accurate estimation of mixed venous carbon dioxide tension, irrespective of the fact that recirculation may affect later values.
References

Captions to figures.

1. Panel A: Recordings of flow and carbon dioxide. Note the time delay between flow change and onset of gas concentration change, and the slow response of carbon dioxide concentration to the sudden inspiration of room air. The end-tidal CO$_2$ is not faithfully measured when frequency of breathing is increased.

Panel B. Method of measurement of analyser response time using slow expiration followed by sudden inspiration through the D-Lite sensor. The gas mixture composition changes with the onset of inspiratory flow at the arrow A. The times taken to achieve 5%, 50%, and 95% of the change to air composition are measured for carbon dioxide and for oxygen.

2. Median and 95% confidence intervals for oxygen and carbon dioxide measurements.

These are the times taken to reach 5, 50, and 95% of the complete change in composition from expired concentrations to room air, after a rapid inspiration through the D Lite sensor.

Figure 3. Bland Altman plot from data of Collier.$^1$ Dashed lines indicate 95% confidence intervals. Note the large range of differences between directly sampled blood and rebreathing estimates, which are of the same magnitude as the difference between arterial and mixed venous partial pressures.
Appendix figure 1
Oxygen

Carbon dioxide

appendix figure 2
Appendix Figure 3