Title: REAL-TIME CONTINUOUS ESTIMATION OF GAS EXCHANGE BY DUAL OXIMETRY

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Introduction. We designed the ventilation-perfusion index (VQI) to estimate venous admixture (Qv/Qo) in a real-time fashion using simultaneous pulse and pulmonary artery oximetry and determined its reliability in 17 patients with acute respiratory failure. Changes in Qv/Qo were produced by altering the level of CPAP. The accuracy of VQI was compared with conventional bedside estimates of Qv/Qo: PaO2/FiO2, PaO2/PaCO2, and PaO2/FiO2.

Methods. In medication was obtained from the families of 17 patients who had acute lung injury that responded to change in CPAP with a change in Qv/Qo. A fiberoptic pulmonary artery catheter was inserted and connected to a mixed venous oxyhemoglobin saturation monitor. A pulse oximeter finger probe was attached to an appropriate finger.

CPAP was changed in steps of 2.5 cmH2O to cover a range of 14.5 cmH2O from the previously selected level. FiO2 initially was adjusted to produce arterial blood oxygen saturation between 94-96% and was not changed during data collection. Cardiopulmonary function was assessed and arterial and pulmonary artery oximeter readings were obtained after 5 minutes for equilibration at each level of CPAP. Arterial and mixed venous blood samples were analyzed for blood gases and pH, oxygen saturations, oxygen contents, and Qv/Qo were calculated. VQI was defined as:

$$Qv/Qo = 100 \times \frac{1.52 - Hgb(1 - SaO2) + 0.0033 \cdot PaCO2}{1.52 - Hgb(1 - SaO2) + 0.0033 \cdot PaCO2}$$

and was calculated from saturations obtained by oximetry.

Pearson's correlation coefficients were used to assess the strength of correlations between the measured and calculated variables. Inter-subject correlations were calculated using one randomly selected value for each patient.

Results. Essential results are shown in Figure 1. Changes in peripheral circulation were small in individual patients, but large between subjects. Within patient change in arteriovenous oxygen content difference ranged from 0.5 to 2.5 ml/dl, while the total range was from 2.0 to 7.2 ml/dl.

Discussion. Until now, accurate assessment of gas exchange has depended on complex and time consuming calculation of Qv/Qo from arterial and mixed venous blood samples. The conventional estimates of Qv/Qo have been shown to be accurate only if FiO2 is constant, if SaO2 is sufficiently high, and if peripheral oxygen remains unchanged, because they do not account for the nonlinearity of the oxyhemoglobin dissociation curve or for changes in mixed venous oxygen content. Variations in FiO2 and arteriovenous oxygen content difference between patients resulted in unacceptably low overall correlations between Qv/Qo and the conventional indices, thus revealing their vulnerability to changes in peripheral circulation and oxygen therapy. Since VQI is calculated from arterial and mixed venous saturations, it responds linearly to changes in Qv/Qo, and is relatively insensitive to changes in peripheral oxygen utilization. Thus, VQI gave an accurate estimate of Qv/Qo without blood sampling, regardless of whether measurements made in different patients or sequential values from one patient were considered.

Therefore, pulse and pulmonary artery oximetry permit instant, accurate, and cost-effective assessment of the response of gas exchange to alterations in respiratory support. Real-time monitoring of gas exchange likely will reveal sudden changes in lung function that may not be detected, even by frequent, but of necessity, sporadic blood sampling.

Fig. 1. Relationship between Qv/Qo and its estimates in 17 patients with respiratory failure.