

TITLE: INFLUENCE OF THE HALDANE EFFECT ON MEASUREMENT OF INTERMITTENT HYPOXIC PULMONARY VASOCONSTRICTION

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INTRODUCTION: Hypoxic pulmonary vasoconstriction (HPV) reduces systemic hypoxemia by directing blood flow away from hypoxic lung regions. The Haldane effect increases total CO₂ in blood with unsaturated hemoglobin; and therefore CO₂ excretion decreases in regions of the lung where blood is not oxygenated. The present study compared left lung blood flow determined by an inert gas technique using SF₆ excretion (1) to assess the magnitude of the Haldane effect error in measurement of lung blood flow by differential CO₂ excretion (2).

METHODS: 8 female dogs of mixed breed weighing 16.5 ± 0.4 kg received a pentobarbital/pancuronium anesthetic. Each lung was ventilated separately via an endobronchial tube. The right lung was continuously ventilated with 100% O₂, while the left lung was ventilated either with 100% O₂ (normoxia) or with a hypoxic gas mixture (hypoxia). Inspired, end-tidal, and mixed-expired O₂ and CO₂ were recorded using a mass spectrometer. End-tidal CO₂ was held at 35.8 ± 0.7 mmHg throughout and end-tidal O₂ at 27.3 ± 0.7 mmHg during hypoxia. Airway, pulmonary (PAP) and systemic arterial (SBP), pulmonary capillary wedge (PCWP), and central venous (CVP) pressures; arterial and mixed venous blood gases; and thermodilution cardiac output (C.O.) were measured. Blood flow to each lung was measured by: (1) a differential CO₂ elimination method; and (2) an inert gas SF₆ technique. Alveolar oxygen tension and percent venous admixture (%VA) were calculated. The sequence for the left lung was 100% O₂ alternating with hypoxia for 4 hypoxic exposures. These data were analyzed by a one-way within-subjects analysis of variance with Tukey's test; p < 0.05 was considered significant.

RESULTS: In these closed chest dogs, the initial value for HR, CVP, SBP, PaCO₂, Temp, Hb, C.O., and SVR did not change significantly throughout the subsequent study. After fitting the percent left lung blood flow (%Q_L/Q_T) lines through the origin, the regression line for normoxia was (%Q_L/Q_T)VCO₂ = 0.946 (%Q_L/Q_T)SF₆ and for hypoxia (%Q_L/Q_T)VCO₂ = 0.734 (%Q_L/Q_T)SF₆. The standard deviation of

regression for both lines was 9.8 (figure 1). Between each normoxic phase and its paired hypoxic trial, there were significant differences in pulmonary perfusion pressure, PAP, PaO₂, P_vO₂ and %VA (table).

DISCUSSION: In these closed chest dogs (figure 1), the regression line for normoxia is not different from the line of identity. During hypoxic left lung ventilation the regression line is significantly below the normoxic line and is included in the envelope of a theoretical line describing the Haldane effect. The theoretical line is determined based on assumptions regarding the effect

of reduced hemoglobin on pH and standard bicarbonate (3); blood in an hypoxic lung will retain CO₂ and therefore CO₂ excretion decreases from that lung. The theoretical line is described for an Hb of 10 g/dl, 70% saturation, and a pH of 7.42 with the upper and lower borders of the envelope described by a pH 7.41 and 7.43 respectively. The Haldane effect introduces a consistent error into the measurement of CO₂ excretion when hypoxia is regional. In addition, this study has confirmed (4) that a maximal HPV response is to be expected with the first hypoxic stimulus in the absence of surgical trauma associated with thoracotomy (figure 2).

REFERENCES: 1. Wagner PD, et al.: JAP 36:600-605, 1974. 2. Williams JJ, et al.: Anesthesiology 59:A496, 1983. 3. Kelman GR: Clin Chim Acta 22:227-280, 1968. 4. Chen L, et al.: Anesthesiology 59:A497, 1983.

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	Normoxia #1	Hypoxia #1
PPP (mmHg)	8 ± 1	11 ± 1
PaO ₂ (mmHg)	587 ± 15	121 ± 12
%VA ₂	5 ± 1	28 ± 3
PAP (mmHg)	16 ± 1	21 ± 1
P _v O ₂ (mmHg)	68 ± 4	54 ± 2

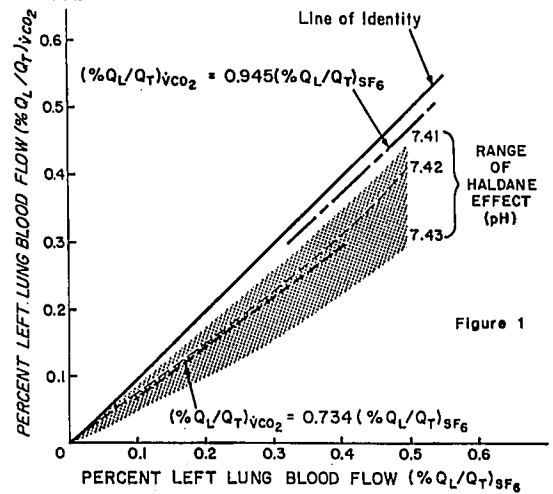


Figure 1

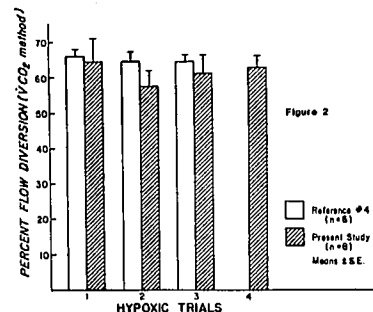


Figure 2