ROLES OF HYPOXIA AND BLOOD FLOW IN MODULATING $V_A/Q$
HETEROGENEITY IN THE LUNGS

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INTRODUCTION

The distribution of ventilation to perfusion ratio ($V_A/Q$) within the lungs is heterogeneous due to the influence of gravity as well as local factors. $V_A/Q$ heterogeneity is critical in determining the efficiency of $O_2$ transfer by the lungs. In recent years, data have been accumulated revealing a minimal role of gravity, with respect to both ventilation and perfusion. Other factors such as vascular resistance, airway resistance, lung compliance, hypoxic vasoconstriction, hypercapnic bronchodilation, etc., dominate. This report presents an accumulation of several experiments$^{1,2,3,4}$ designed to assess the role of hypoxia and blood flow in regulating local $V_A/Q$ ratio.

METHODS

Mongrel dogs of either sex (23 - 28 kg) were anesthetized with pentobarbital sodium (30 mg/kg iv, supplemented with 25-50 mg hourly), had their trachea intubated, and were ventilated with a tidal volume of 15 ml/kg. Respiratory rate was adjusted to maintain arterial PCO$_2$ between 30 and 35 Torr, and diaphragmatic paralysis was secured with succinylcholine (100 mg im, supplemented with 20-40 mg iv hourly).
An isolated left lower lobe preparation was used which allows separate and simultaneous determinations of $V_A/Q$ distributions in the LLL and in the right lung using the multiple inert gas elimination technique. Carotid and pulmonary arterial catheters were placed via peripheral cut-down. Bilateral thoracotomies were performed. To facilitate isolation of the left lower lobe (LLL) pulmonary venous circulation, the left upper lobe was surgically resected. The LLL pulmonary vein was cannulated retrograde via the left atrial appendage. Because the LLL pulmonary vein has two to four contributory branches, the catheter was positioned in the main trunk of the lobar vein just proximal to its junction with the left atrium. The sampling line was positioned midstream within the lumen of a 1-cm-long 5-mm-ID 9-mm-OD rigid tube. Previous work has demonstrated that a mixed sample of pulmonary venous blood is obtained from the LLL pulmonary venous catheter.

LLL pulmonary blood flow ($Q_{\text{LLL}}$) was measured by an electromagnetic flow probe placed around the left main pulmonary artery. The flow probe was precalibrated in situ. Adjustable vascular snares were placed around the right pulmonary artery and left pulmonary artery distal to the flow probe. LLL pulmonary arterial pressure ($P_{\text{pa}_{\text{LLL}}}$) was measured by a catheter inserted into the left pulmonary artery distal to the flow probe and vascular snare. Both thoracotomies were covered with plastic to conserve heat and moisture. $Q_T$ was obtained in triplicate by the thermodilution method with the use of iced 5% dextrose in water.

With the animal supine, a bronchial divider was placed through a tracheostomy to allow separate ventilation of the LLL and right lung (RL). The RL was ventilated with an $F_{1O_2} = 0.5$ at a tidal volume of 9 ml/kg. The LLL was ventilated with a relatively greater volume per lung mass to permit constant alveolar CO$_2$ when LLL perfusion was increased. CO$_2$ was not added when $Q_{\text{LLL}}$ was increased. Five centimeters of water PEEP was administered to compensate for the absence of distending transpulmonary pressure with the chest open. Tidal volume of LLL and RL was measured by spirometer and minute ventilations of LLL and RL were calculated. After completions of the surgical preparation, heparin (7500 U iv followed by 500 U iv hourly) was administered.

In some animals the effect of acute oleic acid pulmonary edema on the response to LLL alveolar hypoxia was studied. In these animals, gas exchange of the LLL was studied before injury and 1 h following intravenous injection of 0.05 ml/kg of oleic acid into the right atrium over 10 min (post-