TITLE: ALVEOLAR GAS MIXING DEPENDS UPON PULMONARY BLOOD FLOW NOT CARDIOGENIC OSCILLATIONS

AUTHORS: William J. Brampton, M.B., B.Chir., FFARCS, Colin F. Mackenzie, M.B., Ch.B., FFARCS, Robert C. Moorman, B.S., Robert J. Watson, M.B., B.Chir., FFARCS

AFFILIATION: Anesthesiology Research Laboratories, Department of Anesthesiology, University of Maryland Medical System and Medical School, 22 South Greene Street, Baltimore, Maryland 21201.

Introduction. In the presence of cardiac activity, pulmonary gas mixing is increased up to ten times during conventional mechanical ventilation (CMV) and four times during continuous flow ventilation (CFV).[1,2] Improved gas mixing may be due to the effects of pulmonary blood flow (PBF) or transmission of extra-pulmonary cardiogenic oscillations (COs). Identification of the role of PBF and COs may enable new approaches to improving gas exchange during artificial ventilation.

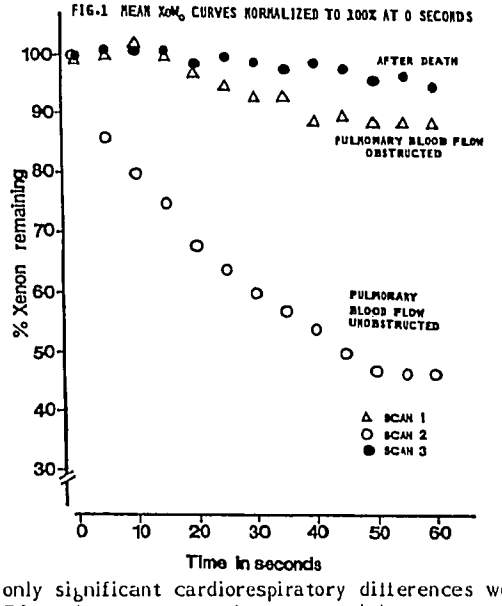
To determine the contributions of PBF and COs to alveolar gas mixing in dogs with closed chests, we compared the rate of washout of alveolar xenon 133 (Xe) during and after regional pulmonary artery (PA) obstruction and following death.

Methods. Five dogs, average 22 kg, were anesthetized with 30 mg/kg pentobarbital and intubated with two 2.5 mmID endobronchial catheters (tips placed 3.5 cm beyond the carina) and a 9.5 mmID tracheal tube. They were ventilated with CMV (FIO_2 1.0, Vt 12-15 ml/kg) to $PaCO_2$ 32-40 mmHg. Systemic and pulmonary arteries were cannulated and airway, esophageal and vascular pressures displayed. Anesthesia and paralysis were maintained using a continuous infusion of thiamylal (3 mg/kg/hr) and pancuronium (0.1 mg/kg/hr). Two balloon tipped catheters were advanced into different branches of the PA. One PA catheter was used to produce PA obstruction and to introduce alveolar Xe, after balloon (PAB) inflation, the other to monitor pressure and waveforms and sample blood gases. Anger gamma camera scintillation scans (GCS) following Xe injection were analyzed using gamma II software. Two 1 minute, apneic perfusion scans with and without PAB inflation, using injections of 0.5-1.0 mCi Xe 30 cm from the catheter tip, confirmed the site and extent of PBF occlusion. Three dynamic GCS were performed during CFV with 1 L/kg/min O_2 through the endobronchial catheters. CFV enabled lung volume and pressures to remain constant for the 6 min GCS and provided oxygenation and CO_2 removal.[3] Scan 1 measured Xe washout (XeWo) with PA occlusion and assessed COs alone. Scan 2 measured XeWo after return of PBF to determine the effects of COs and PBF. Scan 3 measured XeWo after death when there were no COs or PBF. During live CFV at 0, 5 and 10 mins, recordings of vascular pressures, thermodilution cardiac output, esophageal and airway pressures were made and arterial and mixed venous blood sampled. Alveolar Xe was introduced after 5 mins of CFV by injecting 0.5-1.0 mCi Xe dissolved in 2 ml saline through the distal PA catheter following PAB inflation.

Paired t-testing was used to compare cardiorespiratory data and XeWo curves (after correction of scan 2 for Xe blood uptake).

Results. PAB inflation resulted in occlusion of 22% (range 7-38%) of the PBF. Analysis of the first 60 secs of XeWo revealed significantly faster washout in scan 2, ($p < 0.01$) compared with scans 1 and 3 which were not different (see Fig 1).

After 1 min, mean XeWo (± SE) was 58% (± 5%) in scan 2, 11% (± 7%) in scan 1 and 5% (± 3%) in scan 3.



The only significant cardiorespiratory differences were that PA wedge pressure and mean arterial pressure were higher ($p < 0.05$) during scan 1 with PA occlusion.

Discussion. The presence of PBF resulted in 5-10 times faster XeWo over the first min compared with no PBF and post mortem. This XeWo may be a result of alveolar pressure and volume changes secondary to pulsatile PBF and/or alveolar-capillary respiratory gas exchange. We do not believe XeWo was due to removal of Xe remaining in the blood after return of PBF because the amount available for washout was greater and the rate of XeWo much slower than would be expected if such were the case.

Increasing the pulsatility or magnitude of PBF may be a means of improving gas exchange by enhancing alveolar mixing. COs causing direct compression of lung parenchyma have little significant role in alveolar gas mixing in dogs with closed chests.

Conclusions. (1) Pulsatile pulmonary blood flow enhances alveolar gas mixing by 5-10 times. (2) There is no significant alveolar mixing due to transmission of extra-pulmonary cardiogenic oscillations.

References.

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