TITLE : PULMONARY VASCULAR RESISTANCE AND P_{pad}-P_{1a} GRADIENTS

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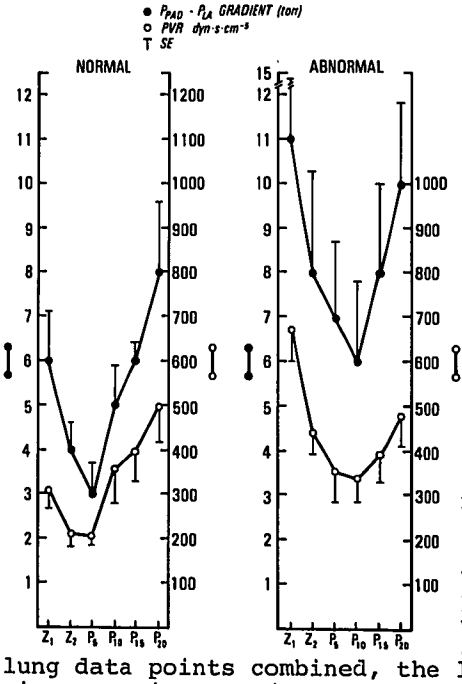
Introduction. At the end of diastole the pulmonary and aortic valves are closed and the mitral valve is open. Thus, there is an uninterrupted fluid-filled chamber composed of pulmonary arteries, capillaries and veins and the left atrium and ventricle and end-diastolic pressure should be equal throughout the chamber. However, if pulmonary vascular resistance (PVR) is high during diastole, then normal diastolic time period is insufficient to allow pulmonary artery diastolic pressure to decrease to left heart filling pressure by the end of diastole and an end-diastolic pulmonary artery diastolic-left atrial pressure gradient (the pulmonary diastolic gradient) will exist. Similarly, a pulmonary diastolic gradient will be caused by a tachycardia with a normal PVR. Resistances in the pulmonary circulation that have been shown to individually and separately cause a pulmonary diastolic gradient are obliterative lung disease, alveolar hypoxia and thromboembolism. The purpose of this experiment was to quantitate the pulmonary diastolic gradient as a function of systematic changes in pulmonary vascular resistance in normal and abnormal lung.

Methods. Seven mongrel dogs were anesthetized with pentobarbital 25 ml/kg, paralyzed with pancuronium 0.1 mg/kg, tracheally intubated and mechanically ventilated with F_IO_2=1.0, tidal volume (V_t)=15 ml/kg, and a ventilatory rate so that end-tidal CO_2=5% and P_aCO_2=40 torr. Cardiac output ($\dot{Q}_t$) was continuously measured by an electromagnetic flow probe placed around the main pulmonary artery. Pulmonary artery diastolic (P_{pad}); left atrial (P_{1a}) and airway (P_{aw}) pressure were directly measured and following chest closure were referenced to pleural pressure (P_{pl}). PVR was calculated as PVR=[(P_{pa}-P_{1a})/$\dot{Q}_t$]79.9. Normal lung was converted to abnormal lung by the administration of oleic acid 0.06 ml/kg intravenously and 5 ml 0.1N HCL acid intratracheally. The experimental sequence consisted of measurement of the above values at: (Z_1) Zero end-expiratory pressure (ZEEP), V_t= 7½ ml/kg, and the chest strapped to cause a 5-8 torr increase in P_{pl}; (Z_2) ZEEP, V_t=15 ml/kg; (P_5),(P_{10}),(P_{15}),(P_{20}) Positive end-expiratory pressure (PEEP) of 5, 10, 15 and 20 torr and V_t=15 ml/kg. Steps Z_1, Z_2, P_5, P_{10}, P_{15} and P_{20} were repeated 2 hours after oleic and HCL acid administration. All results are expressed as mean ± SE and were analyzed by paired t analysis with $p<0.05$ considered significant.

Results. We found that PVR and the pulmonary diastolic gradient were both "U" shaped functions of a progressively increasing end-expiratory distending pressure (Z_1, Z_2, P_5, P_{10}, P_{15}, P_{20}) in both normal and abnormal lung. The nadir of each normal lung curve occurred at P_5, whereas the nadir of each abnormal lung curve occurred at P_{10}. The correlation between the pulmonary diastolic gradient and PVR was highly positive; with normal and abnormal lung data points combined, the linear regression equation was (P_{pad}-P_{1a})=0.016(PVR)+0.740 with r=0.694 and $p<0.001$. Heart rate in normal and abnormal lung ranged 142-167 beats/min. At Z_1 the PVR and pulmonary diastolic gradient were much greater in abnormal lung than in normal lung ($p<0.01$). As end-expiratory pressure increased the differences between abnormal and normal lung PVR and pulmonary diastolic gradient decreased, and were not significantly different at P_{10}, P_{15} and P_{20}.



Discussion. These results show that the pulmonary diastolic gradient has a positive correlation with PVR. At Z_1 in normal lungs the pulmonary diastolic gradient may have been due to an increased large extra-alveolar resistance (active vasoconstriction, mechanical obstruction) and the presence of tachycardia. The application of PEEP to P_5 may have reduced the large extra-alveolar resistance, thereby decreasing PVR and the pulmonary diastolic gradient. The further application of PEEP (P_{10},P_{15},P_{20}) probably increased small intra-alveolar resistance and directly increased PVR and the pulmonary diastolic gradient. The increased PVR and pulmonary diastolic gradient in abnormal lung at Z_1, Z_2 and P_5 probably reflects the presence of additional factors such as acid-induced obliteration of lung, thrombus formation and increased degree of alveolar hypoxia. These findings strongly indicate that the pulmonary diastolic gradient may be used as a simple continuous index of PVR.