Title : ANESTHESIA PRODUCES SHUNT AND LOW $\dot{V}_A/\dot{Q}$ AREAS BY REDUCING FRC

Authors : R. Dueck, M.D., M. L. Rathbun and E. McTigue

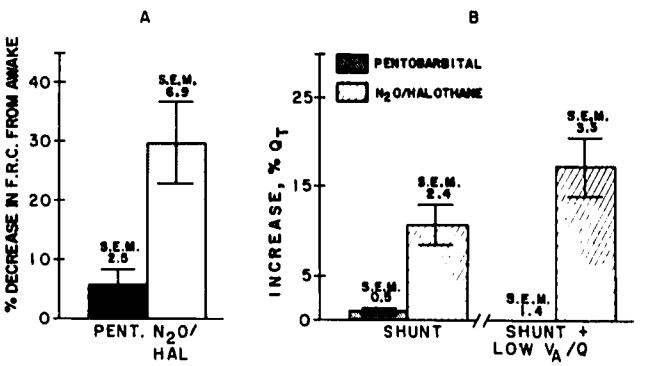
Affliation: Department of Anesthesiology, University of California, San Diego and Veterans Administration Medical Center, San Diego, California 92161.

Introduction. Reduction in lung volume, increased intrapulmonary shunt, and development of low $\dot{V}_A/\dot{Q}$ regions have all been demonstrated as a consequence of anesthesia. Studies in the sheep have suggested minimal increases in shunt and low $\dot{V}_A/\dot{Q}$ areas with I.V. pentobarbital in comparison to N_2O and halothane inhalation anesthesia (1). We therefore tested the hypothesis that this difference was due to differences in lung volume (functional residual capacity, FRC).

Methods. Four healthy adult sheep (40-60 kg), surgically prepared with a chronic tracheostomy and carotid artery subcutaneous tunnel, were studied during steady state awake control and anesthesia conditions, during either (i) pentobarbital 10 mg/kg + 50 mg increments I.V. on day one, and (ii) 68% N_2O and 0.6-1.0% end-tidal halothane concentration on day two, or the alternate sequence a minimum of 6 days later.

All studies were performed at F_IO_2 = 0.3. Anesthesia studies were performed first during spontaneous ventilation, followed by mechanical ventilation with tidal volumes of 10 ml/kg and frequency adjusted to produce minute ventilation equal to awake, using pancuronium 0.1 mg/kg I.V. to prevent spontaneous respiratory efforts. Distributions of $\dot{V}_A/\dot{Q}$ ratios were assessed with multiple tracer inert gas elimination using Ridge regression analysis (2). Closed circuit helium dilution was used to measure FRC following each $\dot{V}_A/\dot{Q}$ determination with a Quintron model H-3 thermal conductivity detector gas chromatograph.

Results. Awake studies showed low levels of retention of the least soluble tracer gases, indicating a mean shunt of 1.3 ± 0.4% (S.E.M.) and 1.6 ± 0.7% of pulmonary blood flow to low $\dot{V}_A/\dot{Q}$ ($0.005 > \dot{V}_A/\dot{Q} < 0.1$) regions. FRC was 1797 ± 327 ml (BTPS) during awake studies, with an average 5.9 ± 2.5 (S.E.M.) % reduction during pentobarbital and 29.9 ± 6.9 % reduction during N_2O and halothane anesthesia (both significant at $p < 0.01$, paired-t analysis). No significant increases in either shunt or low $\dot{V}_A/\dot{Q}$ regions were seen during pentobarbital anesthesia, whereas all 4 sheep demonstrated increases in shunt and 3 had increased low $\dot{V}_A/\dot{Q}$ regions (see below for mean ± S.E.M.) during N_2O and halothane anesthesia. No consistent differences were noted in FRC, shunt and low $\dot{V}_A/\dot{Q}$ regions for spontaneous versus mechanical ventilation.



*$p < 0.01$, pentobarbital vs. N_2O and halothane anesthesia, paired-t analysis.

Discussion. An average 5-fold greater reduction in FRC during N_2O and halothane in comparison to pentobarbital anesthesia, with increases in shunt and low $\dot{V}_A/\dot{Q}$ regions seen only during inhalation anesthesia, suggests that FRC reduction is the primary mechanism responsible for gas exchange impairment during anesthesia.

References.

1. Dueck R, Austin B, Rathbun M: The sheep as a model of impaired pulmonary gas exchange due to anesthesia. Abstracts of Scientific Papers, American Society of Anesthesiologists Annual Meeting, pp 461-462, 1978.

2. Evans JW, Wagner PD: Limits on $\dot{V}_A/\dot{Q}$ distributions from analysis of experimental inert gas elimination. J Appl Physiol 42: 889-898, 1977.