

Title: SHUNT DEVELOPMENT IN YOUNG ADULT SURGICAL PATIENTS DUE TO INHALATION ANESTHESIA

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Introduction: Shunt development due to inhalation anesthesia, in relation to changes in lung volume and the distribution of ventilation was examined in eighteen young adult surgical patients. The subjects were 21 to 34 years of age. All had a normal pulmonary history, chest x-ray, spirometry (VC, TLC, FEF₅₀), and were within normal limits for height-weight relationship, ie body mass index (BMI = weight (Kg) ÷ height (m)²).

Methods: Approval of the protocol was obtained from the University Human Research Committee and written informed consent was obtained from each subject. Subjects were premedicated with diazepam 10 mg PO. Distribution of ventilation with respect to perfusion (V_A/Q, multiple tracer inert gas method), arterial and mixed venous (pulmonary artery) blood gas tension, functional residual capacity (FRC, closed circuit helium dilution method) and multi-breath helium washout were determined with the subjects supine while awake and during anesthesia. Inspired oxygen concentration was maintained at 30%. Anesthesia was induced and maintained with halothane 0.75 to 0.85% end-tidal concentration with either nitrogen or nitrous oxide as the balance gas (alternate studies, 9 subjects in each group). Muscle paralysis (pancuronium 0.1 mg/Kg), endotracheal intubation, and mechanical ventilation were then provided, using minute volume equal to awake values, and tidal volume 10 ml/Kg. Measurements during anesthesia were obtained at 45 to 60 minutes after induction. Multibreath helium washouts were obtained following a 5 to 7 minutes closed circuit FRC determination (10 subjects). Multibreath helium washout curves were analyzed using a two compartment exponential peeling procedure. The ratio of the time constant for washout of the slow and fast compartments was used as a measure of the degree of inequality of ventilation relative to lung volume. A vital capacity maneuver was intentionally not used during the FRC determination so as not to alter the distribution of ventilation.

Results: Mean (± SD) values of shunt, ventilation-perfusion inequality (logarithmic standard deviation (log SD) of blood flow distribution with respect to V_A/Q), FRC (% of predicted seated FRC), arterial P_{O2} and ratio of slow to fast washout time constants while awake and during anesthesia are tabulated in Table I. Awake shunt ranged from 0 to 2.6%. Awake inequality of V_A/Q (log SD of blood flow) ranged from 0.27 to 0.78. During anesthesia a wide range of shunt was observed (0 to 23%). Blood flow to areas with low V_A/Q could not be distinguished as a separate V_A/Q mode. Inequality of V_A/Q during anesthesia was nearly double the awake value. FRC decreased in 15 of 18 subjects, with an average 18% reduction. Of the variables in Table I, shunt, FRC, and P_{aO2} during anesthesia showed a correlation with their respective awake values. Development of shunt with anesthesia showed a significant correlation with BMI (r=0.68, p < 0.002, Figure 1a). However,

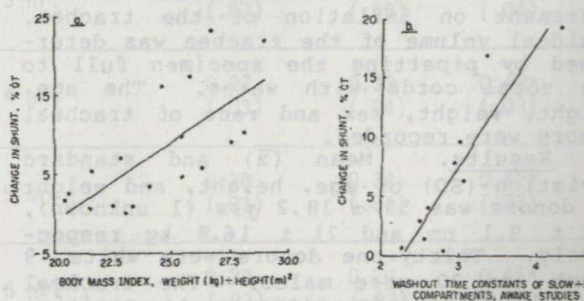
neither FRC nor the change in FRC correlated with BMI (r=-0.13, r=-0.32, respectively). Shunt development did not show a significant correlation with either awake FRC (r=-.27), FRC during anesthesia (r=-0.39) or change in FRC (r=-0.30). The increase in shunt did show a correlation with the awake washout time constant ratio (r=0.90, p < 0.001, Figure 1b), but not with the time constant ratio during anesthesia (r=0.25, p > 0.1). The change in FRC correlated with the calculated volume change of the fast washout compartment (r=-.94, p < 0.001).
Discussion: The correlation of shunt during inhalation anesthesia with body mass index and inequality of ventilation with respect to lung volume, but not with overall lung volume (FRC), suggests that relative obesity and degree of ventilation distribution inequality were the primary determinants of shunt development. The marked variability in severity of shunt and V_A/Q inequality seen in these subjects contrasts with that seen by Rehder et al, using thiopental and methoxyflurane anesthesia. We suspect that there were significant patient population differences in addition to the differences in anesthetic agents employed.

Table I: Mean ± SD values for awake (AW) and anesthesia (AN). Shunt given as % cardiac output. FRC given as % of predicted seated FRC.

	Shunt % QT	Log SD blood flow	FRC % predicted	P _{aO2} torr	slow/fast time constant ratio
AW	0.8 ± 0.7	0.43 ± 0.15	63 ± 11	133 ± 31	2.93 ± 0.57
AN	7.8 ± 7.3*	0.80 ± 0.32*	52 ± 12**	113 ± 37	3.52 ± 1.83

* ANOV - F ratio significant at p < 0.001 from awake
** ANOV - F ratio significant at p < 0.02 from awake

Figure 1



References;

1. Rehder K, Knopp TJ, Sessler AD, Didier EP: Ventilation-perfusion relationship in young healthy awake and anesthetized-paralyzed man. *J. Appl. Physiol.* 47:745-753, 1979.

Supported in part by National Institutes of Health and in part by the Veterans Administration.