peated 20 minutes after atropine premedication and the arterial samples analyzed for arterial oxygen saturation. All the control arterial-blood measurements were greater than 95 per cent saturation. No significant change occurred in the arterial oxygen saturations after atropine.

Since dead space increases with lung volume, it is well when determining the effect of pharmacologic agents on the dead space to insure that the observed changes were not produced by lung volume increases. The data indicate that no significant volume changes occurred in these experiments. *Conclusion:* We were unable to demonstrate any significant difference in either tidal volume or anatomic dead space with change in body position. The injection of 0.8 mg. atropine caused a 25 per cent increase in anatomic dead space regardless of body position. Premedication with atropine was not followed by a change from the control arterial oxygen saturation measurements.

Minimum Alveolar Concentrations of Methoxyflurane, Halothane, Ether, Fluroxene, Cyclopropane and Nitrous Oxide in Man. LAWRENCE J. SAIDMAN, M.D., EDWIN S. MUNSON, M.D., EDMOND I. EGER, II, M.D., and ARTHUR A. BABAD, M.D., *Department of Anesthesia, University of California Medical Center, San Francisco, California.* The minimum alveolar concentrations (MAC) of halothane and fluroxene required to prevent movement in response to a skin incision have been previously determined (Saidman, L. J., and others: ANESTHESIOLOGY, *25:* 302, 1964; Munson, E., and others: ANESTHESIOLOGY, *26:* 143, 1965). Seventy per cent nitrous oxide reduced the MAC for halothane and for fluroxene. MAC values obtained in these studies without nitrous oxide were—halothane 0.74 per cent and fluroxene 3.4 per cent, while with nitrous oxide added they were—halothane 0.23 per cent and fluroxene 1.2 per cent. If it may be assumed that the effect of nitrous oxide was additive to that of the other agents, then a MAC of 101 per cent for nitrous oxide may be predicted. This study was performed to determine the MAC's for methoxyflurane, ether, and cyclopropane in man. *Methods:* The methods for ether and methoxyflurane studies were similar to those of the fluroxene study. Predetermined alveolar tensions of the agent being studied were held constant in surgical patients for a sufficiently long period to insure a brain tension of at least 95 per cent of that in the alveoli. When the skin incision was made the patient was observed for movement. MAC was defined as that concentration below which 50 per cent of the patients moved and above which 50 per cent failed to move. Inspired cyclopropane concentrations corrected for dilution by water vapor were measured rather than alveolar concentrations. This was considered valid since uptake of cyclopropane at the time of incision was low and balanced in part by an R/Q of less than one. *Results:* MAC for cyclopropane was 9.2 per cent, for ether 2.6 per cent, and for methoxyflurane 0.16 per cent, although more recent studies in our laboratory would indicate an ether MAC closer to 2.0 per cent. These results along with those for halothane, fluroxene, and nitrous oxide illustrate the relation between anesthetic potency and lipid solubility. The product of these two factors for each agent studied varies from 106 for cyclopropane to 174 for diethyl ether, a remarkably low range considering that these products are derived from anesthetic concentrations that vary over a 630 fold range. If this relation holds true for all general anesthetics, the average of these products (146) may be used to predict the approximate potency of any new anesthetic, given the oil solubility. *Conclusions:* The primary importance of MAC is in the establishment of what we believe are equipotent doses of anesthetic agents. With these doses comparative studies may be made of the circulatory, respiratory, metabolic or other effects of anesthetics. Thus 0.16 per cent methoxyflurane may be compared with 3.4 per cent fluroxene, each of these being equivalent anesthetic doses. (Supported in part by USPHS Grant 5R01 HE07946, 5-K3-GM-17, and 5T1-GM-63).

Halothane, Peripheral Vascular Resistance, and Respiratory Acidosis. RICHARD M. SCHLOBOUM, M.D., F. NORMAN HAMILTON, B.S., PETER J. TOMLIN, M.B., LUCIEN E. MORRIS, M.D., *Anesthesia Research Laboratories, Providence Hospital, Seattle, Washington.* Pe-

ripheral resistance is calculated from blood flow and arterial blood pressure. Of these three parameters, only blood pressure is monitored during clinical anesthesia, and the importance of vascular resistance is often overlooked. Severinghaus and Cullen (ANESTHESIOLOGY *19:* 165, 1958) reported an increase in total peripheral resistance in halothane anesthetized man. Johnstone (Brit. J. Anaesth. *30:* 435, 1958) believed that vasodilation continues as halothane anesthetic depth is lowered. Nunn (Modern Trends in Anaesthesia by Frankis T. Evans and T. Cecil Gray, Butterworth's, 1962, p. 68) believed that respiratory acidosis causes a weakening of ventricular contraction in the dog. Carson (J. Appl. Physiol. *20:* 948, 1965) demonstrated that cardiac output arises logarithmically with Pa_{CO_2} in the dog. Studies were initiated to explore further peripheral resistance and cardiac output relations to halothane and carbon dioxide in the dog. *Methods:* Studies of cardiac output were made with the use of square wave electramagnetic flowmeter probes implanted on the ascending aorta of 7 dogs. A minimum 6-day recovery period was observed before experimentations; 159 cardiac outputs were paired with simultaneous arterial determinations of *p*H, P_{CO_2}, P_{O_2} and arterial and right atrial pressures in 12 experiments. Anesthesia was induced and maintained with halothane and oxygen. End-expiratory halothane concentrations were 0.75, 1.5, and 2.25 per cent. Stepwise production and elimination of respiratory acidosis was accomplished with up to 20 per cent carbon dioxide at each concentration of halothane. Each step occupied not less than 15 minutes. Spontaneous, unassisted respirations were allowed throughout each study. *Results:* At the deeper concentrations of halothane, total peripheral resistance decreased to 80 per cent of baseline values obtained during initial 0.75 per cent halothane anesthesia. Total peripheral resistance decreased along a predictable slop at all three concentrations of halothane when respiratory acidosis was produced. Cardiac output decreased with deeper concentrations of halothane, but increased at each concentration when respiratory acidosis was produced. Heart rate remained stable. Mean arterial blood pressure dropped from higher values or remained at its original low value upon production of respiratory acidosis. *Conclusions:* Blood flow is increased in respiratory acidosis in light or deep halothane anesthesia in dogs because of a decreased vascular resistance. Respiratory acidosis in the intact dog does not produce myocardial depression. (Supported in part by the Hartford Foundation and the Washington State Heart Association.)

Metabolic and Circulatory Aspects of Halothane Anesthesia. ALAN D. SESSLER, M.D., and RICHARD A. THEYE, M.D., *Section of Anesthesia, Mayo Clinic and Mayo Graduate School, Rochester, Minnesota.* Halothane appears to have no effect on O_2 uptake in man when moderate concentrations are employed and when compensatory heat-producing mechanisms are blocked by muscle relaxants (Theye, R. A., & Tuohy, G. F.: ANESTHESIOLOGY *25:* 627, 1964). In an effort to explore further the effect of halothane on O_2 uptake, additional studies have been carried out in the laboratory both in intact and in artificially perfused dogs. *Method:* Intact, unpremedicated, paralyzed dogs (13) were studied at 0.8 and 3.2 per cent halothane inspired concentrations. After induction (halothane-air) and intubation, ventilation was maintained artificially (Harvard pump). O_2 uptake was determined by conventional open-circuit spirometric technique with analysis by gas chromatography (Theye, R. A.: ANESTHESIOLOGY *25:* 75, 1964). Additional measurements included cardiac output (dye-dilution), arterial and right atrial pressures (strain gauge), arterial and pulmonary artery blood gas levels (electrodes and reflection oximeter) and esophageal temperature. At the greater halothane concentration (3.2 per cent), both O_2 uptake and cardiac output were less than at 0.8 per cent halothane. These reductions were, respectively, 10–30 per cent (O_2 uptake) and 30–60 per cent (cardiac output). With a return to 0.8 per cent halothane, both O_2 uptake and cardiac output returned to levels previously observed. Additional hemodynamic and metabolic data are available to complement these major findings. In the perfusion studies (11), O_2 uptake was studied both as a function of flow (halothane constant) and as a function of halothane