

corticosteroids. It is our belief therefore that continued therapy could result in an increase in the eventual survival rate. (Supported in part by a grant from the Upjohn Company, Kalamazoo, Michigan.)

**Effect of Lung Denervation on Pulmonary Embolism.** WALTER H. MASSION, M.D., *Department of Anesthesiology, University of Oklahoma Medical Center, Oklahoma City, Oklahoma.* The mechanism of death due to pulmonary embolism has been explained either as mechanical blockade or reflex vasospasm of the lesser circulation. *Method:* In order to determine which of these two factors plays the dominant role, the following experiments were carried out: 22 anesthetized dogs were intubated with a tracheal divider for bronchospirometric measurements of hemilateral oxygen consumption, physiological deadspace and static chest compliance. Thereafter, a left-sided pneumonectomy was performed followed by immediate reanastomosis of the severed lung to the hilus with reanastomosis of the pulmonary artery, the bronchus and the pulmonary veins. No attempt was made to re-establish bronchial circulation. Three weeks after surgery the pulmonary function studies were repeated. Eighteen animals regained essentially normal pulmonary function of the reimplanted lung when compared with the preoperative control values. In these animals the left or right pulmonary artery was embolized selectively through an indwelling cuffed catheter. The embolization material consisted of 2 g. of glass microspheres  $50 \pm 10$  micra in diameter suspended in 10 ml. of saline. The triad of systemic hypotension, tachypnea and pulmonary hypertension was considered as a positive embolization response; its absence as a negative response. *Results:* Embolization of the denervated lung gave no significant response and was survived by all animals. Embolization of the control lung consistently produced an increase in pulmonary arterial pressure and respiratory rate and a fall in systemic blood pressure. One animal died after embolization of the control lung. Doubling of the dosage from 2 to 4 g. of emboli produced a moderate increase in pulmonary arterial pressure and respiratory rate but no significant fall in systemic blood pressure if the denervated lung was

embolized. The same amount of emboli injected into the control lung killed 2 out of 4 animals studied. There is some question as to whether or not the interruption of the bronchial circulation may have changed the hemodynamics of the reimplanted lung by obliteration of normally patent connecting capillary beds. Data presented by Bruner and Schmidt (*Amer. J. Physiol.* 148: 648, 1947) suggest that the peak total flow from the bronchial circulation draining into the pulmonary veins of the normal dog is less than 1 per cent of the cardiac output. This is considered insufficient to render the transplant hemodynamically different from the control lung. *Conclusion:* It is concluded that small amounts of embolization material trigger a reflex vasospasm in the normal lung which is not operative after denervation. Embolization with larger amounts of material will bring the mechanism of mechanical blockade into play. There is evidence to suggest that the sympathetic nerves can mediate reflex vasoconstriction of the pulmonary vascular bed. The unilateral lung autograft in the dog constitutes an effective denervation of one lung while the contralateral lung can serve as a normal control. (Supported by USPHS grants 5-K3-NB-17,651 and HE 08329.)

**The Effects of Halothane, Fluroxene, and Cyclopropane on Ventilation: A Comparative Study in Man.** EDWIN S. MUNSON, M.D., C. PHILIP LARSON, JR., M.D., ARTHUR A. BABAD, M.D., MICHAEL J. REGAN, M.D., DONALD R. BUECHEL, M.D., and EDMOND I. EGER, II, M.D., *Department of Anesthesia, University of California Medical Center, San Francisco, California.* The effects of halothane, fluroxene, and cyclopropane on ventilation and ventilatory response to CO<sub>2</sub> have been measured in 23 nonpremedicated subjects. To allow for comparison of anesthetic impact, measurements were made utilizing the concept of the minimum anesthetic (alveolar) concentration (Saidman, L. J., and others: *ANESTHESIOLOGY* 25: 302, 1964; Munson, E. S., and others: *ANESTHESIOLOGY* 26: 134, 1965). *Methods:* CO<sub>2</sub> response curves were obtained on each patient: (1) awake, and (2) during equipotent alveolar concentrations of halothane, fluroxene, or cyclopropane. Values for the minimum anesthetic (alveolar) concentra-

tion (MAC) for each agent are: halothane 0.74 per cent; fluroxene 3.4 per cent; and cyclopropane 9.0 per cent (Saidman, L. J., and others: *ANESTHESIOLOGY*, in press). Constant alveolar concentrations were maintained for each agent at multiples of MAC ranging from 1.1 to 2.5 (1.1 MAC equals 1.1 times MAC). End-expired halothane and fluroxene concentrations were monitored with a Beckman infrared analyzer. Alveolar cyclopropane concentration was estimated from inspired cyclopropane concentration determined by oxygen difference. Alveolar anesthetic and CO<sub>2</sub> partial pressures were maintained constant for an interval calculated to allow for cerebral equilibration. Ventilation was measured with a recording ventimeter. The slope of CO<sub>2</sub> response (liters/minute/mm. Pa<sub>CO<sub>2</sub></sub>) during anesthesia was expressed as a fraction of the awake control slope. No surgical stimulation was present during this study. *Results:* Mean ventilatory slope values (liters/minute/mm. Pa<sub>CO<sub>2</sub></sub>) awake were: halothane 1.08 ± 0.42; fluroxene 1.32 ± 0.64; and cyclopropane 1.59 ± 5.3. With a few exceptions (cyclopropane) all subjects showed a progressive reduction in CO<sub>2</sub> response with increasing depth of anesthesia. Mean fraction of awake slope values for halothane were 0.48 ± 0.22 ( $P < 0.05$ ) at 1.1 MAC; 0.17 ± 0.17 at 2.0 MAC, and 0.06 ± 0.09 at 2.5 MAC. Values for fluroxene were 0.72 ± 0.28 ( $P > 0.05$ ) at 1.1 MAC; 0.45 ± 0.18 ( $P < 0.05$ ) at 2.0 MAC, and 0.03 ± 0.02 at 2.5 MAC. Values for cyclopropane were 0.92 ± 0.21 ( $P > 0.05$ ) at 1.3 MAC; 0.67 ± 0.24 ( $P < 0.05$ ) at 1.9 MAC; and 0.54 ± 0.09 at 2.4 MAC. Differences between halothane and cyclopropane were significant at each level of MAC. Similarly a difference was demonstrated between halothane and fluroxene at 2.0 MAC and between fluroxene and cyclopropane at 2.5 MAC. Mean Pa<sub>CO<sub>2</sub></sub> values during awake determinations were: halothane 35.5 ± 2.9 mm. of mercury; fluroxene 34.4 ± 3.7 mm. of mercury; and cyclopropane 37.7 ± 2.2 mm. of mercury. Pa<sub>CO<sub>2</sub></sub> values during spontaneous ventilation increased progressively with increasing levels of anesthesia in almost every instance. Mean Pa<sub>CO<sub>2</sub></sub> values for halothane were 48.2 ± 6.5 mm. of mercury ( $P < 0.05$ ) at 1.1 MAC; 63.5 ± 11.2 mm. of mercury at

2.0 MAC, and 74.3 ± 11.6 mm. of mercury at 2.5 MAC. Values for fluroxene were 40.9 ± 3.7 mm. of mercury ( $P < 0.05$ ) at 1.1 MAC; 41.9 ± 5.6 mm. of mercury at 2.0 MAC, and 54.2 ± 8.8 mm. of mercury at 2.5 MAC. Values for cyclopropane were 45.0 ± 4.3 mm. of mercury ( $P < 0.05$ ) at 1.3 MAC; 52.1 ± 12.9 mm. of mercury at 1.9 MAC, and 52.6 ± 13.1 mm. of mercury at 2.4 MAC. Differences between halothane and fluroxene were significant ( $P < 0.05$ ) at each level of MAC. Similarly a difference was demonstrated between halothane and cyclopropane at 2.5 MAC. *Conclusion:* At equipotent anesthetic concentrations halothane and fluroxene are more potent ventilatory depressants than cyclopropane.

**Effects of Anesthetics on Cardiovascular Responses to Hypothalamic and Mesencephalic Stimulation in Dogs.** S. H. NGAI, M.D., and PER BOLME, M.D., *Department of Anesthesiology, College of Physicians and Surgeons, Columbia University, New York City, and Department of Pharmacology, Karolinska Institute, Stockholm, Sweden.* Available evidence indicates that anesthetic action on neural regulatory mechanisms plays an important role in producing circulatory changes. While there is general agreement that halothane and barbiturates depress the vasomotor centers, opinions differ as to the mechanism of action of cyclopropane (Price, and others: *ANESTHESIOLOGY* 24: 1, 1963; Markee and Wang: *Fed. Proc.* 22: 187, 1963; and Bartelstone: *Fed. Proc.* 23: 179, 1964). The use of basal narcosis or decerebration in acute experiments has often led to difficulties in the interpretation of observations. *Method:* In the present study, dogs with chronically implanted aortic catheters, electromagnetic flowmeter probes around the external iliac artery and stimulating electrodes in the hypothalamus and mesencephalic tegmentum, were used. The electrodes were placed stereotaxically to give a pressor response or to activate the sympathetic cholinergic vasodilating mechanisms to skeletal muscles upon stimulation. In some animals bilateral carotid loops were also prepared. After recovery from these operations, arterial pressure, external iliac arterial blood flow and their responses to central stimulation or caro-