The Respiratory Effect of Methoxyflurane on Dog and Man. KARL L. SIEBECKER, M.D., MARVIN JUMES, M.D., BETTY J. BAMFORTH, M.D., AND O. S. ORTH, M.D., *Department of Anesthesiology, University Hospital, University of Wisconsin School of Medicine, Madison, Wisconsin.* Methoxyflurane is a potent, non-explosive anesthetic agent. It is one of several fluorinated hydrocarbons investigated for anesthetic properties by the Cornell University group. Methoxyflurane (1,1-dichloro-2,2-difluoro-2-methoxyethane) produces adequate relaxation for any surgical procedure, and for endotracheal intubation. No halogenated hydrocarbon studied or used clinically has been found free of all physiological and pathological effects which make it undesirable for routine clinical use. In clinical use methoxyflurane resembles diethyl ether in its effects on the circulatory system, particularly blood pressure levels. In contrast to diethyl ether, methoxyflurane has a tendency to depress respiration. This observation led us to the present study. Seventeen unpremedicated mongrel dogs were anesthetized by to-and-fro absorption technique using only oxygen as a vehicle to vaporize the agent. No other anesthetic agents were used, so that any changes observed could be attributed to the agent itself. The dogs were allowed to breathe spontaneously and respirations were never assisted or controlled. Arterial blood samples were obtained at appropriate times, and the pH, P_{CO_2} and oxygen saturation were determined. Respiratory minute volume and tidal volume were measured with a respirometer and the rate was counted visually. In the dog the respiratory rate was decreased as the anesthetic depth was increased. Tidal volume was variable, but usually slightly decreased. The respiratory minute volume was invariably decreased from 5-8 liters per minute awake to as low as 0.175 liters per minute. The pH values of arterial blood samples taken during severe respiratory depression showed a sharp decline averaging 7.20 (range 7.05–7.34). In over one hundred clinical administrations of methoxyflurane we found it necessary to assist respiration. Measurement of respiration showed that in man deepening the level of anesthesia resulted in a decrease in tidal volume and respiratory minute volume. The respiratory rate was quite constant. In twelve instances respiration was not assisted or controlled and the anesthetic level was purposely deepened more than necessary for the operation. Analysis of arterial blood samples taken at this time revealed an average pH of 7.33 (range 7.29–7.37). During lighter levels of anesthesia, pH values of samples taken from the same patients had an average of 7.41 (range 7.38–7.59). This agent possesses a fortunate property which counterbalances this unfavorable respiratory effect. Clinically we have been able to provide satisfactory muscular relaxation for any operation without deep anesthesia. Abdominal relaxation is excellent in apparently very light anesthetic levels. As with diethyl ether, recovery time may be delayed if the agent is not discontinued about twenty minutes before the end of the procedure. This is no serious disadvantage since, as with diethyl ether, analgesia persists through very light levels of anesthesia. In summary, methoxyflurane is not the perfect anesthetic agent. It is potent and is non-explosive. The physiological and pathological effects are minimal compared to other halogenated hydrocarbons in clinical use. Respirations should be closely observed and usually assisted or controlled during methoxyflurane anesthesia.

Ventilator Techniques of Anesthesia for Neurosurgery. COL. HARVEY C. SLOCUM, MC, LT. COL. GEORGE W. HAYES, MC, AND CAPT. BERNARD L. LAEZMAN, MC, *Anesthesia and Neurosurgical Services, Walter Reed Hospital, Washington, D. C.* It is often difficult to attain and maintain adequate exposure for the neurosurgical approach to an intradural lesion. Required are the control of the neurophysiological factors responsible for cerebral blood flow, cerebrospinal fluid pressure balance, and to some extent the shift of tissue fluids within the brain. These controls are necessary to relieve the excess pressures which cause the bulging or tense brain when it is subjected to the effects of pathological lesions, anesthesia, and surgical manipulation. Techniques of anesthesia are presented which take into consideration the mechanical, vascular, and humoral aspects of cerebrovascular circulation. Changes in cerebrospinal fluid pressure vary in direct relationship to changes in central venous pressure in most instances. Thus variations in intrathoracic or thoracoabdominal pressures produce a direct cerebrospinal fluid pressure effect. Also, any mechanical inhibition of the venous outflow from the brain into the mediastinum will cause immediate venous vascular distention and bulging of the brain. The total amount of blood circulating through the brain at any given time is in direct relationship to the cross sectional area of the vascular bed. The variables in the vascular bed and the control of the flow of blood through it are regulated by the primary extrinsic factor of systemic pressure and the intrinsic factors of intracranial pressure, viscosity of the blood, and vascular tone. Although there is an extensive nerve distribution pattern to the cerebral vessels, the neurogenic factors seem to have no effect on cerebral vascular tone. Of the humoral factors which are primarily responsible for the regulation of vascular tone, carbon dioxide seems to be the dominant one. A threshold level of 1 per cent CO_2 in the inspired air is sufficient to influence cerebral blood flow while a concentration of 7 per cent CO_2 will double it. In contrast, hyperventilation (15 l./minute) may reduce cerebral blood flow by 30 per cent. The total body stores of 100 L or more of CO_2 maintain the plasma CO_2 in a steady state. Any mild respiratory alkalosis is rapidly compensated for; therefore with a moderate increase (20–30 per cent) of tidal exchange over normal, there should be no significant shift to the left of the O_2-CO_2 dissociation curve which would inhibit oxygen uptake by the brain tissue. Extremes of oxygen tension will vary cerebral blood flow. The critical level of hypoxia seems to be below 15 per cent. Inhalation of 10 per cent O_2 increases cerebral blood flow about 35 per cent. Inhalation of 100 per cent O_2 decreases the flow approximately 12 per cent. In hyperventilated dogs the reduction of cerebral oxygen as measured by an electrode technique is even greater. The arterio-venous oxygen difference as measured in man during hyperventilation varies with the changes in blood flow but does not seem to indicate any evidence of hypoxia. Even though moderate hyperventilation decreases cerebral blood flow 30 per cent there should be an adequate supply of oxygen available for the unconscious or anesthetized patient who has a 30 per cent decrease in metabolic demand for oxygen. In the anesthetic management of our patients for the neurosurgical approach to intradural lesions, pulmonary ventilators are used for both controlled and assisted respiration. The proper use of the ventilator assures the constant control of anesthesia and the ventilatory pattern. Of more significance is the decrease in total brain mass by the humoral control of cerebral blood flow and the decrease in fluid tension of the brain tissue. The shift in "brain water" is being studied in relation to variations in the electrolyte balance resulting from changes of P_{CO_2} and pH which occur within threshold limits of normal. Techniques of inhalation anesthesia using nitrous oxide and oxygen with ether or halothane are preferred. For patients having lesions of the posterior fossa the function of the respiratory center is preserved and supported at all times. In all other instances the control of respiration is advocated. By observation of the breathing pattern of the unanesthetized patient and by reference to the Radford Nomogram efforts are made to determine the "normal" minute volume exchange in each case. After the processes of anesthesia are stabilized, an apnea is produced by the use of minimal amounts of thiopental and curare. The ventilator is applied using a stroke volume and rate which will provide approximately a 20 per cent increase in ventilation over the predetermined minute volume requirements for the patient. A measured minute volume exceeding 10 L has rarely been used. A Cournand type III pressure breathing curve is desirable. Intermittent positive-negative pressures of approximately plus 15 and minus 5 are used. The flow of gases through the semiclosed system contains oxygen limited to 50 per cent. When the dura is opened the brain gives the appearance of fullness but does not tend to bulge unless there is a large space-occupying lesion present. The subarachnoid space appears to have an excessive amount of fluid in it which is easily drawn off when the subarachnoid membrane is opened. As the cerebrospinal fluid channels within the subarachnoid area function as the extracellular space of the brain, it appears that the intracellular tissue fluid shifts to the extracellular or cerebrospinal fluid space. As the fluid escapes through the opening in the subarachnoid, it becomes obvious that there is a decrease in total brain mass. The result is a neurosurgical field involving excellent exposure and a marked decrease in tissue tension. Clinical experiences with more than 250 intracranial procedures (3 failures) since February 1958 indicate that these techniques are equal or superior to the use of hypothermia, induced hypotension, and chemical dehydration in the attainment and maintenance of a "relaxed" brain, a facile surgical approach, and a minimum of neurophysiological morbidity.

Postoperative Distress in Children. ROBERT M. SMITH, M.D., JOHN B. STETSON, M.D., AND ANIBAL SANCHEZ-SALAZAR, M.D., *Department of Anesthesiology, Children's Hospital Medical Center, Boston.* The behavior of pediatric patients was observed during postoperative recovery to determine the incidence of pain or other forms of distress. This group, consisting of 355 infants and children from newborn to 12 years of age, was followed throughout the entire hospital stay. As might be expected in any study of pain, many problems of definition and interpretation complicated our attempts to draw specific conclusions, however, several interesting features did begin to take form. There appeared to be several different awakening patterns that a child might follow. It was at once evident that the majority of patients had little or no appreciable discomfort in the early recovery period. On the average day, out of twenty children who were observed in the Recovery Room, only one or two required medication for any form of distress. This low incidence suggests that much of the complex reaction to pain may be a type of behavior that must be learned. A few older children awoke promptly and indicated clearly the site and nature of their pain. This occurred more frequently following thiopental-nitrous oxide or cyclopropane anesthesia. The most interesting group consisted of children who would awaken and complain bitterly for approximately one minute, then fall sound asleep and not stir for another five or ten minutes. This performance would be repeated again and again. Many nonspecific signs of distress were observed, including crying, restlessness, excitement, rapid pulse, and irregular respiration or coughing. While these might be signs of physical pain, children sometimes were found to be equally upset by hunger, fatigue, thirst, unusual surroundings, or desire for their mother—factors that would not ordinarily be considered indication for analgesic agents. The signs of distress varied markedly with age. Except for a few infants who showed costal splinting after intrathoracic procedures, small babies rarely appeared to have appreciable pain. The type of operation showed definite relationship to postoperative distress. Following intrathoracic procedures all children over one year of age had sufficient pain from the wound or drainage tubes to require narcotics, and usually required 5 to 10 doses. Children recovering from orthopedic operations also showed considerable discomfort, 76 per cent requiring relief for pain of wound, cast or abnormal positioning. Other types of surgery caused surprisingly little distress. After upper abdominal procedures 56 per cent required narcotics, but on an average of only 2.2 doses each. Herniorrhaphy brought significant distress to only one in ten children. Extensive dental operations, plastic procedures, and neurosurgery rarely caused any appreciable discomfort. Before therapy was attempted, a definite effort was made to identify the cause and nature of each child's distress. To rule out abortive periods of excitement, no patients were allowed medication until distress had been evident for 10 minutes. Therapy in the nature of a narcotic, morphine, meperidine, or phenazocine, was administered intramuscularly or intravenously in doses of 0.05 to 0.1 mg./pound, 0.5 to 1.0, or 0.005 to .01 mg./pound, respectively. All three drugs proved effective not only in controlling true pain, but also in quieting children whose distress appeared to be emotional rather than physical in origin.

A Comparison of the Effects of Halothane, Cyclopropane, and Ether on the Ventricular Contractile Force of the Human and the Dog. J. HENRY SPROUSE, M.D., JOHN E. MAHAFFEY, M.D., T. D. DARBY, PH.D., AND JOHN A. HALL, M.D., *Departments of Anesthesiology and Pharmacology, Medical College of South Carolina, Charleston, South Carolina.* It is generally accepted that agents