

administration. [Work supported by USPHS Grant H-4859 and B-2842.]

**A Wakefulness-Associated Factor in the Central Control of Respiration.** B. RAYMOND FINK, M.D., *Department of Anesthesiology, College of Physicians and Surgeons, Columbia University, and Service of Anesthesiology, The Presbyterian Hospital, New York.* It is generally believed that in man at rest the volume of ventilation depends mainly on the stimulating effect of  $\text{CO}_2$  (or of H ions) on the respiratory center, and that apnea results if the  $\text{P}_{\text{CO}_2}$  falls below a critical threshold value. Acapnic apnea is indeed a common event in overventilated anesthetized patients, and the threshold  $\text{P}_{\text{CO}_2}$  under these circumstances has been measured quite accurately. As regards the waking state, however, information concerning the acapnic threshold is curiously uncertain. Accordingly, the effects of active and passive overventilation were reinvestigated in a study on 13 volunteers. Minute volume was measured with an anemometer. end-expiration  $\text{CO}_2$  tension ( $\text{P}_{\text{eCO}_2}$ ) observed with an infrared analyzer. Overventilation reduced the  $\text{P}_{\text{eCO}_2}$  to a mean value of 22 mm. Hg ( $\pm 4$ ). On discontinuing overventilation rhythmic spontaneous respiration immediately resumed in every experiment. No instance of apnea or of periodic breathing was encountered. The absence of apnea is contrary to other reports and may be attributed to the fact that only subjects with unprepared minds were studied. In the first ten minutes of recovery, the minute volume was consistently about two-thirds of the control volume. It is concluded that during awake recovery from acute hypopnea a rather constant respiratory stimulus is at work which is independent of the  $\text{CO}_2$  tension. Since no such stimulus can be detected in anesthetized subjects, the hypothesis is suggested that the unknown stimulus depends largely on the presence of a state of wakefulness. A wakefulness-associated stimulus of respiration can explain why the onset of rhythmic respiration often coincides with the first signs of wakefulness, both at the end of controlled overventilation anesthesia and at the beginning of a baby's life. Depression of the same stimulus with the onset of sleep may account for the sudden apparent loss in

sensitivity to carbon dioxide which occurs at this time. The influence of a powerful wakefulness-associated stimulus may be discernible in the respiratory effects of two successive equal doses of a rapid sleep-inducing drug. In observations on 20 patients, the initial dose (150 or 200 mg. of thiopental sodium), if it suppressed wakefulness, always produced a deep depression of respiration, and sometimes apnea. After recovery of respiration but before recovery of wakefulness a second injection paradoxically caused less depression than the first, and never apnea. Apparently at the time of the second injection respiration was maintained without the wakefulness stimulus and was therefore no longer vulnerable to its removal. [This study was supported by Grant No. RG 4717 from the National Institutes of Health, United States Public Service.]

**Humidification of Inspired Air.** YONG HYON HAN, M.D., AND HARRY J. LOWE, M.D., *Department of Anesthesiology, Roswell Park Memorial Institute, Buffalo, New York.* The need for tracheostomies has increased during the last decade. The proper warming and humidification of inspired air serves to reduce postoperative pulmonary complications by preventing crust formation and inspissation of mucus. Conventional methods for humidifying inspired air such as nebulization and oxygen tents are not entirely satisfactory. Wally and Allander have designed metal rebreathing chambers which serve as heat and moisture exchangers. The higher heat capacity of the metal relative to air results in a transfer of heat and moisture from expired air to inspired air. The comparative effectiveness of these means of humidifying inspired air has not been reported. *Methods:* Normal volunteer subjects breathed for half-hour periods through a nonbreathing system in which all expired moisture was condensed by freezing to  $-70^\circ\text{C}$ . and determined gravimetrically. With the exception of minor modifications, the details of this method were described by Burch. In each experiment the oral inspired and expired air temperatures, humidity of inspired air, and number of respirations were determined. All expired gas was collected and measured in a spirometer. The water loss from the respira-

tory tract was calculated subtracting the absolute humidity of inspired air from expired air, and expressed as milligrams per liter of respiration. The normal water loss of each subject was determined prior to testing the water conserving efficiency of the humidifying devices. **Results:** The normal water loss during oral breathing in 26 determinations on three subjects was 27.7 mg./l. (per cent relative humidity (R.H.) equals 75 at 32 C.) and was directly proportional to the minute volumes between 3 to 19 liters per minute. The net water loss from the respiratory tract decreased as the absolute humidity of the inspired air increased. In nine determinations on anesthetized patients the expired absolute humidity was 23.4 mg./l. (R.H. equals 60 at 32 C.). This represents approximately 12 cc. of water loss per hour. Four normal subjects receiving 0.6 to 1.4 mg. of atropine expired 28.6 mg./l. (R.H. 80 at 32 C.). Rebreathing through an external dead space of 100 and 200 ml. reduces normal water loss from the respiratory tract by 3.0 and 8.0 mg./l. respectively. In sixteen determinations the heat and moisture exchangers reduced the water loss by one-half (14.0 mg./l.). When the absolute humidity of inspired air was 14.0 mg./l., the subjects were in respiratory water balance, and at higher absolute humidity of the inspired air a positive water balance was obtained. Under the usual conditions employed with oxygen tents or nebulizers, subjects expired more water than they inhaled and remain in negative respiratory water balance. In conclusion, heat and moisture exchangers were found to be as or more efficient than nebulizers. In addition, they do not produce droplet formation. In order to obtain respiratory water balance, heat and moisture exchangers thus far tested required that the inspired air at room temperature be at least 60 per cent saturated. We are continuing the investigation of various designs and conditions which might improve the efficiency of heat and moisture exchangers.

**A Clinical Method for Estimation of Blood Volume with the Use of Total Sympathetic Blockade.** JEAN HENLEY, M.D., and MARYLYN M. KRITCHMAN, M.D., *Francis Delafield Hospital and Columbia University, New York, New York.* Paralysis of the sympathetic nerv-

ous system eliminates cardiovascular compensatory reflexes. Once hemostatic mechanisms are obtunded, two of the variables which normally determine blood pressure, that is, vasoconstriction and changes in heart rate, are stabilized. Generalized vasodilatation occurs except in areas where control is not under sympathetic nervous system regulation and the heart slows to about sixty beats per minute. Cardiac function remains good since it is favored by a slow rate and reduced peripheral resistance. Practically speaking, the only factor which can now vary is the blood volume. Under total sympathetic blockade, in relatively healthy patients, presumably with an adequate blood volume, the systolic pressure falls to a plateau between 70 and 90 mm. of mercury, with a diastolic pressure 15 to 20 mm. of mercury lower. In patients who have been compensating for a blood volume deficiency, the pressure will fall below 70 mm. of mercury but can be raised to this level by transfusion of blood or plasma expanders. Once a plateau of blood pressure has been established, the pressure will decrease only with hemorrhage or with enlargement of the vascular tree, loss of visceral vessel tone during abdominal exploration. The blood pressure can be restored to the plateau by transfusion after hemorrhage and will return spontaneously to the previous level shortly after exploration ceases. If sympathetic blockade is maintained, there will be changes in pulse volume during hemorrhage, but not in pulse rate. At the Delafield Hospital over 150 patients have undergone major cancer surgery under total sympathetic blockade using total epidural or very high spinal analgesia combined with two to three nitrous oxide and oxygen via an endotracheal tube. Fifty consecutive cases in this series were reviewed revealing prompt return to preoperative blood pressures after surgery even in hypertensives. Normal hemoglobin and hematocrit determinations were found in the immediate postoperative period, except in one patient who was not given a transfusion according to these criteria and went into shock when the blockade wore off. No cardiovascular accidents occurred and no patient was overtransfused even though in several instances massive blood replacement had been necessary. No operation was less than three hours