patients, with no known pulmonary disease, have been studied. Pentobarbital and atropine were given as premedication, anesthesia was induced with thiopental, and succinylcholine was used to facilitate intubation. Anesthesia was maintained with halothane 1 per cent in oxygen, or with nitrous oxide and oxygen in ratios of 3 : 1 or 2 : 1. All patients received *d*-tubocurarine for profound relaxation. Ventilation was by mechanical respirators, always at a frequency of 20 to 25 per minute.

Total compliance was measured by the Super Syringe (Janney, C. D.: ANESTHESIOLOGY *20:* 709, 1959), *p*H by glass electrode, and tension of carbon dioxide and of oxygen by our modifications of the Severinghaus and the Clark electrodes. Amplification and recording was by a Sanborn no. 350–3600 system. Thorough inflation of the lungs was carried out just before the period of study, which lasted an average of 83 minutes. Following the initial inflation, arterial blood samples were drawn and compliance measured. During the study period the patient's position was unchanged and ventilation was with constant volumes and pressures, and was adequate (X arterial *p*H 7.48 units, $\bar{X}$ arterial tension of carbon dioxide 36.9 mm. of mercury). A progressive fall in total compliance ($\bar{X}$ 12 per cent) and in arterial oxygen tension (X 22 per cent) was demonstrated during the period of constant ventilation. *Results:* At the end of the study period successive passive hyperinflations were administered, and before and after each inflation arterial blood samples were drawn and total compliance measured. The first (20 cm. of water pressure sustained for 10 seconds) caused a 17 per cent rise in compliance and a 13 per cent rise in oxygen tension. With subsequent hyperinflations (30 cm. of water for 15 seconds; and 40 cm. of water for 15 seconds), there was no further increase in compliance, but mean oxygen tension rose 27 per cent and 41 per cent in relation to the value before inflations. The arterial oxygen tension was consistently lowest at the end of the period of constant ventilation; highest following hyperinflation. In nine patients breathing halothane 1 per cent in oxygen the lowest oxygen tension was $\bar{X}$ 312 mm. of mercury; the highest, after hyperinflation, was $\bar{X}$ 482 mm. of mercury. This difference was significant ($P < 0.01$). *Discussion:* The reported findings suggest that increased physiologic shunting may occur during anesthesia, but is reversible, at least in part. The magnitude of the gradients between inspired and arterial oxygen tension suggests that a mixture of nitrous oxide and oxygen, in a ratio of 3 : 1 (or higher), may cause hypoxemia. This assumption is supported by values found in our cases breathing this mixture. Following a period of constant ventilation, the arterial oxygen tension was $\bar{X}$ 75.6 mm., and after hyperinflation $\bar{X}$ 102.3 mm. of mercury. Comparing the effect of hyperinflation on compliance and on arterial oxygen tension, leads to the suggestion that an increase in compliance, following inflation, may in great part reflect changes in surface tension of already open alveoli, and re-opening of airspaces cannot be assumed to occur in parallel with an increasing compliance.

Effect of Hemorrhage on Rate of Fall of Plasma Thiopental Concentration. NORMAN A. BERGMAN, M.D., *Division of Anesthesiology, University of Utah College of Medicine, and Veterans Administration Hospital, Salt Lake City, Utah.* Diminished peripheral blood flow following hemorrhage has been postulated as the cause of the delay in redistribution of thiopental resulting in prolonged high levels of the drug in the central blood pool and in rapidly perfused vital tissues. This report describes attempts to verify this prediction experimentally by comparing the rate of disappearance of thiopental from plasma during normovolemia and following hemorrhage in dogs. *Method:* Endotracheal intubation and cannulation of femoral artery and vena cava via femoral vein were performed on dogs anesthetized with diethyl ether or halothane. Six control dogs were permitted to awaken without further manipulation. Four dogs had 25–30 ml./kg. blood withdrawn before being permitted to awaken. Four other dogs were subjected to identical initial hemorrhagic episodes but were maintained at a predetermined hypotensive level throughout the experiment by repeated withdrawals of blood. Upon recovery from inhalation anesthesia each animal received thiopental, 25 mg./kg. over a two-minute period. Mechanical assistance was

provided during periods of respiratory depression. Simultaneous arterial and venous blood samples were withdrawn at predetermined intervals following thiopental administration. *p*H was determined on arterial samples. Plasma thiopental levels were determined on venous samples using the technique of Brodie and associates. In two additional dogs effects of variations in blood *p*H on plasma thiopental levels were studied by simultaneous measurement of these variables during progressive respiratory acidosis induced by rebreathing. *Results:* In the two dogs studied during respiratory acidosis average decrease of plasma thiopental below expected values was 1.5 mg./liter per 0.1 unit decrease in blood *p*H. Plasma thiopental levels obtained from samples withdrawn during significant acidosis in all other animals were corrected to a *p*H in the normal range using this value. *Discussion:* The observed decline of plasma thiopental levels following administration of 25 mg./kg. is best defined by a two-component exponential function. The equation for control animals is: $y = 20.3 \times 10^{-.0373\,t} + 29.0 \times 10^{-.00152\,t}$ (y is concentration of thiopental in mg./liter and t is time in minutes). For dogs subjected to hemorrhage the equation is: $y = 23.9 \times 10^{-.0426\,t} + 19.3 \times 10^{-.00228\,t}$. Although the exponent defining the rapid component of the equations is larger for bled dogs, this difference is not significant. The difference between exponents defining the slow component of the equations is statistically significant ($P < .05$). Thus, under conditions of this experiment, plasma thiopental levels declined more rapidly in dogs subjected to hemorrhage than in control dogs. This is contrary to what is predicted on the basis of a dynamic concept of the distribution of thiopental in the body (Price, H.; ANESTHESIOLOGY *21:* 40, 1960). It is concluded that following hemorrhage other factors which determine plasma thiopental levels in addition to peripheral blood flow are altered. These factors might include increased ability of tissues to take up thiopental from blood and sequestration of thiopental in poorly perfused peripheral vascular beds.

Problems in Resuscitation from Cold Exposure. ANTONIO BOBA, M.D., and HIROKUNI SAKAI, M.D., *Department of Anesthesiology, the Albany Medical Center Hospital and the Albany Medical College of Union University, Albany, New York.* Death from cold exposure is due to the peripheral circulatory failure (Lynch, H. F., and Adolph, E. F.: J. Appl. Physiol. *11:* 192, 1957) at a time when no measurable oxygen deficit has been accumulated (Adolph, E. F.: Publ. 451 Nat. Acad. Sci. 1956, p. 44). On this basis it was predicated that if adequate means were made available for support of the circulation and ventilation and heat transferred from an external source, successful resuscitation could be accomplished even after circulatory and respiratory arrest. *Method:* A modification of the machine proposed by Gollan (Science *111:* 85, 1950) was employed for the purpose of resuscitating 45 splenectomized dogs immersed in ice water and allowed to breathe room air without mechanical assistance. The animals were divided into three groups. The first group of animals were removed when the heart rate had fallen to one half of control rate, the animals still breathing and the blood pressure still present. The second group of animals was removed from immersion at the time of acute circulatory failure. The third group of animals was removed from the tub at the time of "death" as manifested by ventricular fibrillation or arrest. From each group some animals were used as controls (removed from exposure and left in room air), some animals were rewarmed by the external application of heat, and some were resuscitated by means of the pump-oxygenator-heat-exchanger. *Results:* All animals removed from exposure at the time the heart rate had fallen to one-half of the control rate survived. Of the group of animals removed from exposure at the time of acute circulatory failure, the controls and all those rewarmed by external means died. All animals in whom the pump-oxygenator-heat-exchanger was employed were resuscitated and lived from 4 to 24 hours, the cause of death being atelectasis or hemorrhage. Of the group of animals removed from exposure at the time of "death," all controls and all rewarmed by external means died. All animals in whom the pump-oxygenator-heat-exchanger was employed could be resuscitated although survival was limited