Despite changes in volume of respiration, physiologic dead space to tidal volume ratios remained constant (Nunn, J. F., and Hill, D. W.: J. Appl. Physiol. *15:* 383, 1960). From the results, it does not seem to matter whether the volume of gases is given by ventilator or spontaneously inhaled: the efficiency of carbon dioxide elimination is not altered. *Conclusion:* The results confirm the need for an increased oxygen concentration in the inspired mixture during weaning from controlled breathing but fail to show the constant increase in oxygen consumption previously reported (Supported by Grants HE-09337-03 and HE-10248-02 from the USPHS.)

Detection of Venous Air Embolism by Carbon Dioxide Monitoring. R. W. M. BETHUNE, M.D., and VERNE L. BRECHNER, M.D., *UCLA School of Medicine, Los Angeles, Calif.* The purpose of this project was to examine the value of carbon dioxide monitoring for the detection of venous air embolism. Experimental work was performed on dogs and the method was applied in the operating room. *Method:* For dogs instrumentation was similar to that previously reported (Brechner, V. L., Bethune, R. W. M., and Soldo, N. J: ANESTHESIOLOGY *28:* 240, 1967) with the addition of continuous montitoring of alveolar nitrogen and arterial blood gas analysis before and after embolism. Ventilation was controlled mechanically in all animals. For patients instrumentation included continuous ECG and alveolar carbon dioxide monitoring. EEG and central venous pressure were recorded for some patients. Ventilation was controlled mechanically in all patients. *Results:* In dogs the standard embolus (1.5 ml./Kg.) caused immediate marked increase in right ventricular pressure, abrupt marked decrease in concentration of exhaled carbon dioxide, no change or slight transient fall in systemic arterial pressure, and an increase in concentration of exhaled nitrogen. The increase in concentration of alveolar nitrogen was immediate, returning to pre-embolism level in one to two minutes. The RV pressure and alveolar CO_2 returned to pre-embolism levels in 5 to 20 minutes. Arterial blood gas analysis immediately before and after embolism showed an increase in partial pressure of CO_2 after embolism In 16 patients undergoing neurosurgical procedures in the sitting position the alveolar CO_2 was recorded continuously. Two patients had frank air embolism with extreme hypotension, necessitating repositioning and external cardiac massage. In both patients a fall in alveolar CO_2 was noted before catastrophic hypotension occurred. In a third patient rapid fall in CO_2 from a previously constant 2.6 to 1 per cent was not accompanied by any significant change in systemic pressure, but a minor transient cardiac murmur was probably heard. This fall in CO_2 was assumed to indicate early air embolism. The neurosurgeon concurred that air entry was probable; with application of wet packs no progression occurred. The alveolar CO_2 gradually returned to the level before embolism over 30 minutes. *Summary:* In dogs a venous air embolus of 1.5 ml./Kg. caused an increase in RV pressure, no change or slight transient decrease in systemic pressure, immediate abrupt fall in alveolar CO_2 and an immediate definite increase in alveolar nitrogen. Blood gas analysis immediately before and after a standard embolus showed an increase in partial pressure of CO_2 after the embolus. In patients an abrupt fall in alveolar CO_2 may be the only sign of early or small-volume venous air embolus. The fall in alveolar CO_2 may precede the onset of systemic hypotension by a period sufficient to permit local corrective measures and thus prevent massive embolism

The Protective Effects of Succinylcholine Administration in Severe Hemorrhage in the Dog. WILLIAM A. BOYD, M.D., PH.D., and DENNIS B. HILL, B.S., *The University of Texas M. D. Anderson Hospital and Tumor Institute at Houston, Houston, Texas.* It is believed that hypothermia induced prior to hemorrhage protects animals subjected to controlled hemorrhage because of the decrease in cellular metabolism which results at the reduced temperatures. Johnson *et al.* (Johnson, R. H., Smith, A. D., and Spalding, J. M. K.: Physiol. *169:* 584, 1963) reported that muscular relaxation depresses metabolic rate. This study was done to determine whether succinylcholine administered prior to bleeding would protect

dogs subjected to controlled hemorrhage. *Method:* A modification of the method reported by Schleuter *et al.* (Schleuter, J. N., Kelly, T. R., and Motlagh, F. H.: Arch. Surg. *90:* 893, 1965) was used for the study of hemorrhage in dogs. Fourteen days after splenectomy the blood volume of the dogs was determined by the RISA hemodilution technique. Animals were lightly anesthetized with sodium pentothal, their tracheas were intubated, and they were mechanically ventilated with room air. Forty-five per cent of measured blood volume was removed through a cannula in the femoral artery at a rate of approximately 100 ml./min. Ten minutes later, an additional 10 per cent of the prehemorrhage blood volume was removed at a comparable rate. Immediately after completion of the second hemorrhagic procedure, a volume of saline solution equal to the volume of blood removed during the second bleeding period was rapidly administered intra-arterially. The animals were observed for 24-hour survival. Animals studied included control animals and animals receiving succinylcholine 2.0 mg./Kg. immediately before the first bleeding procedure. *Results:* Of 12 control animals studied, none survived for 24 hours. Of 15 animals given succinylcholine before hemorrhage, seven survived for 24 hours. *Conclusion:* Succinylcholine administration before controlled hemorrhage significantly reduced the mortality rate in dogs. Possible mechanisms to account for this protection are being studied currently.

The Sympathomimetic Effect of Gallamine on the Heart. BURNELL R. BROWN, JR., M.D., and J. RICHARD CROUT, M.D., *The University of Texas, Departments of Pharmacology and Anesthesiology, Southwestern Medical School, Dallas, Texas.* We have observed that gallamine triethiodide (Flaxedil®) has a positive inotropic effect on mammalian cardiac muscle *in vitro.* Gallamine is also reported to increase stroke volume in humans anesthetized with halothane (Smith, N. T., and Whitcher, C. E.: J.A.M.A. *199:* 704, 1967) and, when initially administered, to produce a 54 per cent incidence of ventricular arrhythmias in patients anesthetized with cyclopropane (Walts, L. F., and Prescott, F. S.: Anesth. Analg. *44:* 265, 1965). Because it is difficult to account for these effects on the basis of the well-known atropine-like action of the drug, animal experiments were done *in vitro* and *in vivo* to determine whether gallamine has previously unrecognized sympathomimetic properties *Methods: In vitro* experiments were done on isometrically contracting left atria from guinea pigs and cats, and on papillary muscles from cats. Preparations were driven electrically at 60 tests/minute in a modified Krebs-Henseleit solution at *p*H 7.4 and 37° C. *In vivo* studies were done in anesthetized cats (pentobarbital 30 mg./Kg. i.p.) ventilated with oxygen through an endotracheal tube. Contractile force was measured with a Walton-Brodie strain gauge sutured to the right ventricle. *Results:* Gallamine (5×10^{-7} M to 5×10^{-4} M) increased the contractile force of isolated preparations up to 70 per cent. This effect was abolished by propranolol (2×10^{-6} M) a β-adrenergic receptor antagonist. Atria taken from guinea pigs pretreated with reserpine (2.5 mg./kg. i.p. 24 hours previously) failed to respond to gallamine, indicating that an intact norepinephrine store is required for this response. Tachyphylaxis to the positive inotropic effect of gallamine developed rapidly; however, exposure of tachyphylactic atria to 1×10^{-7} M *l*-norepinephrine for ten minutes restored the response to gallamine. Responses to gallamine were not blocked by atropine (1×10^{-8} M) or hexamethonium (1×10^{-4} M). Gallamine also antagonized the negative inotropic effect of acetylcholine on atria (*i.e.*, gallamine had an atropine-like action), but its potency in this regard was only 1/2,000 that of atropine. *In vivo* studies in cats treated with atropine (1 mg./kg. i.v.) showed that gallamine in a dose of 3 mg./kg. i.v. increased cardiac contractile force 50 per cent. This response was abolished by prior administration of propranolol (0.7 mg./kg. i.v.). *Conclusions:* Gallamine triethiodide exerts a positive inotropic effect on hearts of guinea pigs and cats *in vivo* and *in vitro.* This sympathomimetic action is mediated via the release of norepinephrine from cardiac adrenergic nerve endings—a mode of action similar to that of tyramine. The increase in contractility is