

during hemorrhagic shock in dogs did not produce a significantly greater survival rate (Bergentz, S. E., and Brief, D. K.: *Surgery* 58: 412, 1965). However, the present studies do show a definite circulatory deterioration with metabolic acidosis, and it would seem advisable to continue to correct the acidosis occurring during any circulatory crisis. *Conclusion:* These studies suggest the necessity for re-evaluation of current concepts of the role of pH in cardiovascular function.

A Comparison of Respiratory Effort of Infants Anesthetized with Several Adult and Pediatric Systems. JACKSON VER STEEG, M.D., and WENDELL C. STEVENS, M.D., *Department of Anesthesia, College of Medicine, University of Iowa, Iowa City, Iowa.* Recent work demonstrated that the acid-base balance and ventilation of infants anesthetized with an adult circle system compared favorably with infants anesthetized with pediatric apparatus. (Graff, and others: *Anesth. Analg.* 43: 583, 1964). No comparison of the effort required to maintain this normal balance was made. We questioned if these normal values with the adult circle system were maintained at a significant additional cost to the infant. Therefore, we compared the respiratory effort expended by infants using several adult and pediatric anesthetic circuits. *Method:* Infants under one year of age who had been anesthetized and intubated using halothane-nitrous oxide-oxygen or halothane-oxygen were studied following the surgical procedure. An infant pneumotachograph was interposed between the endotracheal tube and the system being studied. Airway pressure was monitored from an outlet of the pneumotachograph. A continuous record of breath-to-breath air flow-pressure relation was obtained via pressure transducers and Grass recorder. Inspiratory volumes were determined from the pneumotachogram by planimeter readings and application of appropriate calibration factors. Inspiratory negative pressure required to move the inspiratory volume was indicated by deflection of the recorder stylus from the line of zero airway pressure. The area enclosed by this deflection was determined by planimetric readings and was used as an indication of effort required by the infant to move that inspiratory volume.

An index of inspiratory effort was calculated by dividing the inspiratory volume (ml.) by the area of the inspiratory pressure trace (sq. mm.). Systems compared included a 6.2 mm. inside diameter T-piece with reservoir tube, two infant circle absorber systems, adult circle systems with various unidirectional valve components including McKesson, Dräger, Ohio and Foregger dome valves and Ohio swivel and Sierra-Y headpiece valves. *Results:* Except in one instance, the adult systems were less efficient than pediatric systems. The T-piece and infant circle systems were notably more efficient than the system incorporating the Sierra valve and somewhat more efficient than the system incorporating the Ohio-swivel valve. A comparison of adult system demonstrated definite differences among systems. The McKesson circle system was uniformly highly efficient and the Sierra-Y valve uniformly less efficient when compared to other circuits. The other circle-valve systems ranged between these two extremes. It was noted that the volumes of inspiration were not compromised by the less efficient systems. In nearly every case, the least efficient system maintained the largest inspiratory volume. *Discussion:* This method of comparison of systems was chosen because it provides a simple method of studying results of varying resistance to passage of gas offered by anesthetic equipment. It offers a means of depicting, for comparative purposes, the effort an infant must expend to inspire whatever volume of gas inspired and takes into account varying gas flow rates and varying resistances during the respiratory cycle. The inspiratory index, described here, gives some indication of the return the infant receives for the effort expended. Since the volumes of inspiration were not compromised by the less efficient systems, acid-base changes due to respiratory causes alone would not be expected.

Studies on Latency and Duration of Action of Succinylcholine Chloride. LEONARD WALTERS, M.D., *Department of Surgery/Anesthesiology, University of California, Los Angeles, School of Medicine, Los Angeles, California.* Previous studies of the duration of action of succinylcholine were based on the onset and duration of apnea. In the study reported

here, muscle response to nerve stimulation was used as the criterion for relaxation. This criterion has the advantage of being little influenced by blood pH or P_{CO_2} , depth of anesthesia, or external stimulation. *Method:* One hundred adult patients receiving general anesthesia were included in this study. The majority of patients received nitrous oxide, oxygen and halothane anesthesia, but other kinds of nonflammable agents were used. Electrodes from a "Block-Aid" monitor were inserted subcutaneously over the ulnar nerve at the wrist. Supramaximal stimulation was applied at a rate of 34 per minute. A Grass force displacement transducer was secured in the hand, and the signal resulting from thumb adduction was recorded on a Sanborn recorder. The patients were divided into 7 groups in order to study varying doses and routes of administration of the drug. Commercially obtained succinylcholine was used. In most groups the concentration of drug was 20 mg./ml. In each case, the drug was administered as a single injection. The latent period was defined as the time from injection to the time of maximum twitch abolition. The duration of action was defined as onset of block until 50 per cent twitch recovery (T-50). After the twitch height reached a relative plateau, the patients were tested for post-tetanic facilitation. If this phenomenon was evident, it was assumed that some degree of dual block existed. Those patients exhibiting dual block were not used in the determinations of the duration of the block. *Results:* Four groups of 15 patients receiving intravenous succinylcholine, 0.5, 1.0, 2.0, and 4.0 mg./kg., had mean latent periods varying from 25 to 45 seconds. The mean durations of action (T-50) for the groups were, respectively, 5 minutes 50 seconds, 10 minutes, 13 minutes, and 17 minutes 10 seconds. Post-tetanic facilitation was seen in 2 patients receiving 2 mg./kg., and in 1 patient receiving 4 mg./kg. of the drug. Two groups of 15 patients receiving 1 and 2 mg./kg. of drug intramuscularly had mean latent periods of 4 minutes 25 seconds, and 4 minutes 10 seconds. Mean duration of action was 17 minutes 50 seconds and 27 minutes 10 seconds, respectively. Post-tetanic facilitation was seen in 6 patients receiving the higher dose. One group of 10 patients was given succinylcholine, 4 mg./kg., intra-

muscularly. The mean latent period was 1 minute 50 seconds. Seven of these patients developed post-tetanic facilitation. Because of the limited number of remaining cases, no assessment of duration was made. *Comment:* Partial paralysis from succinylcholine was determined to be of longer duration, when this technique was used, than when recovery from apnea was used as an end point. Although ventilation may commence early, the adequacy of early ventilation can be questioned. Certainly, respiratory reserve would be limited. The fact that the intramuscular route of administration caused a greater number of patients to develop dual block suggests that this is time dependent. This is further substantiated by other work showing that 3 mg./kg. of succinylcholine, when given by prolonged intravenous infusion, produces dual block in 100 per cent of patients. (Katz, R. L., Wolf, C. E., and Papper, E. M.: *ANESTHESIOLOGY* 24: 784, 1963).

Hyperventilation, Brain Damage and Flicker. J. G. WHITWAM, M.B., CH.B., M.R.C.P., F.F.A.R.C.S., ROBERT B. BOETTNER, M.D., ANITA P. GILGER, M.D., and ARTHUR S. LITTELL, Sc.D., *Anesthesia and Ophthalmology Services, Department of Surgery and Division of Biometry, Western Reserve University, Cleveland, Ohio.* Passive hyperventilation during operation has recently been condemned as an anesthetic technique because of alleged adverse neurological sequelae. Allen and Morris (*Brit. J. Anaesth.* 34: 296, 1962) detected latent cerebral damage by applying Berg's critical flicker fusion test (*Acta Psychiat. (KBH) Suppl.* 58, 1949) postoperatively to 24 patients who had been hyperventilated during operation. Because of the many variables present in measuring critical flicker fusion we undertook to study the effect of hyperventilation *per se* on critical flicker fusion in a carefully controlled environment. *Method:* Six health male volunteers between 22 and 26 years were passively hyperventilated by a Technician Huxley cuirass-type ventilator to 17-25 liters per minute for two hours. Critical flicker fusion was measured: (1) before hyperventilation, (2) after two hours of hyperventilation and (3) two and four minutes after one tenth of a hypnotic dose of hexobarbital. The same sub-