

with 5  $\mu\text{g}/\text{kg}$  of naloxone, were given to each of ten healthy volunteers in a randomized, double-blind, complete crossover design. Gas exchange, lung volumes and ventilatory response to rebreathing  $\text{CO}_2$  were determined. *Results:* Naloxone antagonism of depression was clearly evidenced by the  $\text{CO}_2$  response curves. The larger the dose of oxymorphone (in the presence of a constant dose of oxymorphone) the less the respiratory depression. Complete reversal was not attained. Further studies suggest 14  $\mu\text{g}/\text{kg}$  of naloxone are required to reverse 14  $\mu\text{g}/\text{kg}$  of oxymorphone. Naloxone produced a dose-related decrease in subjective sedation after narcotics, contrasting with the sedative effects of increasing doses of levallorphan with opiates. No significant dose-related changes were observed in  $\text{O}_2$  consumption,  $\text{CO}_2$  excretion, R.Q., vital capacity and its components, respiratory rate, tidal volume, anatomic deadspace, minute ventilation, or end-tidal  $\text{CO}_2$  tension. *Summary:* Since naloxone reverses even mild respiratory depression and does not itself cause depression, it should be preferable in cases of undiagnosed narcosis, postoperative depression after narcotic-supplemented anesthesia, the depressed newborn, and other clinical circumstances where the agonistic properties of nalorphine and levallorphan might be hazardous.

#### Thiobarbiturate-Succinylcholine-Oxygen for Uncomplicated Cesarean Section.

Y. KOSAKA, M.D., L. C. MARK, M.D., and R. RAKAHASHI, M.D., *Departments of Anesthesiology, Hiroshima Prefectural Hospital and Sapporo Medical College, Japan, and Columbia University, New York, N. Y.* The apparent paradox of the wakeful baby newly delivered from a mother anesthetized with thiopental 400 mg and nitrous oxide 50 per cent was previously verified in vaginal deliveries but not in cesarean sections, in which five of six infants were depressed at birth, (*Amer. J. Obstet. Gynec.* 95: 621, 1966). In an ongoing study of cesarean sections in Japan, however, using thiamylal at a dose of 4 mg/kg, depression of the newborn was uncommon (Kosaka *et al.*, *Hiroshima Igaku* 19: 848, 1966). *Methods:* Thiopental or thiamylal, 8 mg/kg,

was administered intravenously in 45 seconds to each of 35 patients undergoing elective cesarean section. All received succinylcholine, 1 mg/kg, for tracheal intubation, followed by hyperventilation with oxygen 100 per cent until ligation of the umbilical cord, 45 seconds to 13 minutes later. Time from uterine section to delivery was 20 to 68 seconds in 33 cases, and 2½ and 2¾ minutes in the others. (Because of the short time requirements in some of the studies planned, 15 patients received nitrous oxide and halothane for less than four minutes, followed by three minutes of lung washout with oxygen 100 per cent, prior to thiopental.) Subsequent uterine and wound closures were accomplished with inhalation anesthesia. Blood samples for thiopental measurement were obtained at birth from the maternal antecubital vein and the umbilical artery and vein. Apgar scores were determined one minute after birth. *Results:* Apgar scores of 7 or less were obtained in 16 of the 35 cases in which the mother received 8 mg/kg; 13 of these 16 were delivered within three to seven minutes after thiobarbiturate injection. These results compare unfavorably with those after the lower dosage of 4 mg/kg, when only four of 36 babies scored 7 or less. Finster and Poppers recently reported relative safety of thiopental, 250 mg, for the induction of general anesthesia for cesarean section, using nitrous oxide 70 per cent and succinylcholine 0.2 per cent intravenously (*ANESTHESIOLOGY* 29: 190, 1968). They related Apgar scores of 6 or less to prolonged anesthesia (mean: 22.7 minutes) and surgery, with increased fetal acidosis. In the corresponding (4 mg/kg) series of Kosaka *et al.*, with a shorter duration of anesthesia and operation (maximum: seven minutes), poor results were attributed to asphyxia from surgical difficulty or aspiration of amniotic fluid. Noteworthy in both of these series was the stringent limitation of total dosage of thiopental (4 mg/kg would seem adequate in most instances). *Summary:* A strictly controlled thiobarbiturate-succinylcholine-oxygen sequence seems safe for cesarean section in the absence of complications such as eclampsia, polyhydramnios and hemorrhage. Essential to success are an expert anesthesiologist and an

expert obstetrician, working closely together as a team. (Supported in part by a China Medical Board Visiting Professorship at Sapporo Medical College.)

**Quantitative Programmed Closed-circuit Methoxyflurane Anesthesia.** H. T. KYE, M.D., and H. J. LOWE, M.D., *University of Chicago, Pritzker School of Medicine, Chicago, Ill.* The rates of uptake of methoxyflurane at constant inspired and alveolar concentrations have been reported by Eger (*ANESTHESIOLOGY* 25: 94, 1964). In the present investigation, the rates of whole-body methoxyflurane uptake at constant arterial concentration (12 mg/100 ml or 2 ml vapor/100 ml blood) were calculated in twelve unselected patients from the individual organ volumes, blood flows, and anesthetic solubilities. *Methods:* Following induction with thiopental and intubation, liquid methoxyflurane was injected into the closed system by means of a Harvard infusion pump. The uptake curve for a 100-kg patient was plotted on a potentiometer curve follower (Data-Trak) and connected to the infusion pump by means of a rheostat which permitted reduction of the infusion rate in proportion to reduction in the weight of the patient. *Results:* At the programmed rates, the blood methoxyflurane concentrations gradually fell from maximum values (12–15 mg/100 ml) observed 15–20 minutes after induction to 9–12 mg/100 ml during the remaining 90–120 minutes of anesthesia. Since fat is the only tissue compartment with a sufficiently long time constant to contribute significantly to uptake after two hours of anesthesia, it was concluded that the blood flow to fat was 200 to 300 ml greater than that used in the model compartment system. *Summary:* In all cases, the program was satisfactory for surgical anesthesia. Blood methoxyflurane concentrations in the recovery room were all less than 3.5 mg/100 ml.

**Effects of Volatile Anesthetics on Non-excitable Tissue.** T. N. MacKRELL, M.D., and M. SCHWARTZ, Ph.D., *Departments of Anesthesiology and Engineering Physics, University of Louisville, Louisville, Ky.* To deter-

mine the fundamental effects of volatile anesthetics on nonexcitable living tissue, the gastric mucosa of the frog, *Rana pipiens*, was studied. *Methods:* An *in vitro* technique in which the frog gastric mucosa was mounted between cylindrical chambers was used. The secretory and nutrient solutions were aerated with a gas mixture containing a concentration of anesthetic, 5 per cent CO<sub>2</sub> and the remainder O<sub>2</sub>. The effects of methoxyflurane, halothane, fluorene, chloroform, and trichloroethylene upon the H<sup>+</sup> secretory rate were determined. *Results:* All agents of sufficient potency showed a marked increase in resistance as the H<sup>+</sup> rate decreased to zero. A striking effect was the correlation of the H<sup>+</sup> rate decrease with the relative potencies of the anesthetics. The mean concentrations of the first three agents necessary to produce a 40 per cent decrease in H<sup>+</sup> rate (methoxyflurane 0.5 per cent, halothane 2.4 per cent, fluorene 3.3 per cent) were each approximately three times the mean alveolar concentration (MAC) (*ANESTHESIOLOGY* 28: 994, 1967). From this study we predict the MAC for chloroform to be about 0.6 per cent. Preliminary estimates suggest that the MAC for trichloroethylene is about the same as that for chloroform.

**Pulmonary Venous Admixture before and after Halothane-Oxygen Anesthesia with Spontaneous Respiration.** B. E. MARSHALL, M.D., P. J. COHEN, M.D., S. AUKBERG, M.D., and C. H. KLINGENMAIER, M.D., *Department of Anesthesia, University of Pennsylvania, Philadelphia, Penna.* *Methods:* Pulmonary venous admixture ( $Q_v/Q_t$ ) was measured in ten patients premedicated with morphine and atropine before, during and after halothane-oxygen anesthesia with spontaneous respiration. *Results:* The preanesthetic  $Q_v/Q_t$  (mean  $4.4 \pm 0.6$  per cent) was positively correlated with age. After 40 minutes of anesthesia the  $Q_v/Q_t$  had increased threefold (mean  $12.1 \pm 2.1$  per cent) but only a minor further increase (mean  $14.8 \pm 2.8$  per cent) occurred after three hours. When anesthesia was discontinued,  $Q_v/Q_t$  returned to normal (mean  $5.2 \pm 0.9$  per cent) after three hours and to intermediate values at 40 minutes (6.5

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