

contraction, the electrodes must be kept close together (within a few cm) to eliminate the possibility of picking up potentials from distant muscles. In addition, attitudinal and myotatic or stretch reflexes from improper positioning must be avoided when resting muscle is being sampled for contraction. This often requires that the subject recline with the

face in the midline and with the knees and arms slightly flexed, in a position of absolute comfort.

On the basis of these observations, it is evident that reports dealing with electromyograms should describe the type and placement of electrodes and the positioning of the subject.

14893

Effects of Morphine, Nembutal, Ether, and Eserine on Two-Neuron and Multineuron Reflexes in the Cat.

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In the spinal cat, small doses of morphine (5 mg per kg) cause diminution in the amplitude of the flexor reflex, but leave stretch reflexes unaffected or slightly enhanced.¹ This differential action has now been investigated by a study of effects on transmission through two-neuron and multineuron reflex arcs in the spinal cat, since it is known that stretch reflexes traverse the former,² while reflexes of cutaneous origin traverse the latter³ pathway. The effects of morphine have been compared with those of nembutal (sodium ethyl, 1-methyl-butyl barbiturate), ether, and eserine (physostigmine salicylate).

Methods. The experiments were performed on adult cats that had been made spinal at the first cervical segment under ether anesthesia. Respiration was maintained artificially and full recovery from the anesthesia was attained before making the study. The lumbosacral spinal cord was exposed by laminectomy and monophasic leads were taken with chlorided silver electrodes from ventral roots L₇ and S₁

severed from their peripheral connections. The nerves to the gastrocnemius muscle, the sural, and one or both branches of the common peroneal nerve were exposed in the ipsilateral hindleg, crushed distally and placed on chlorided silver wire electrodes for stimulation. All exposed nerve tissue was covered with paraffin oil at a temperature of 38°C. Heat was applied to the animal externally. In some experiments, stimulating electrodes were placed on ipsilateral dorsal roots; in others, reflex responses were recorded from a peripheral nerve. Stimulation was effected by single condenser shocks supramaximal for A fibers. Action potentials were recorded photographically by means of an amplifier and cathode ray oscillograph. Ether was administered through the artificial respiration airline by means of a bottle with a regulating valve. The other drugs were freshly prepared (aqueous solutions) and injected intravenously.

Results. *A. Morphine.* Small doses (5 mg per kg) of morphine sulfate regularly enhanced reflex discharges through two-neuron arcs and depressed those through multineuron arcs (Fig. 1). These effects appeared in from 2-15 minutes and persisted for several hours. Larger doses of morphine (15 mg per kg) depressed also the two-neuron arc discharges in experiments in which the reflex was from peripheral nerve to ventral root. The most note-

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¹ Wikler, A., *J. Pharmacol.*, 1944, **2**, 176.

² Lloyd, D. P. C., *J. Neurophysiol.*, 1943, **6**, 317.

³ Lloyd, D. P. C., *J. Neurophysiol.*, 1943, **6**, 293.

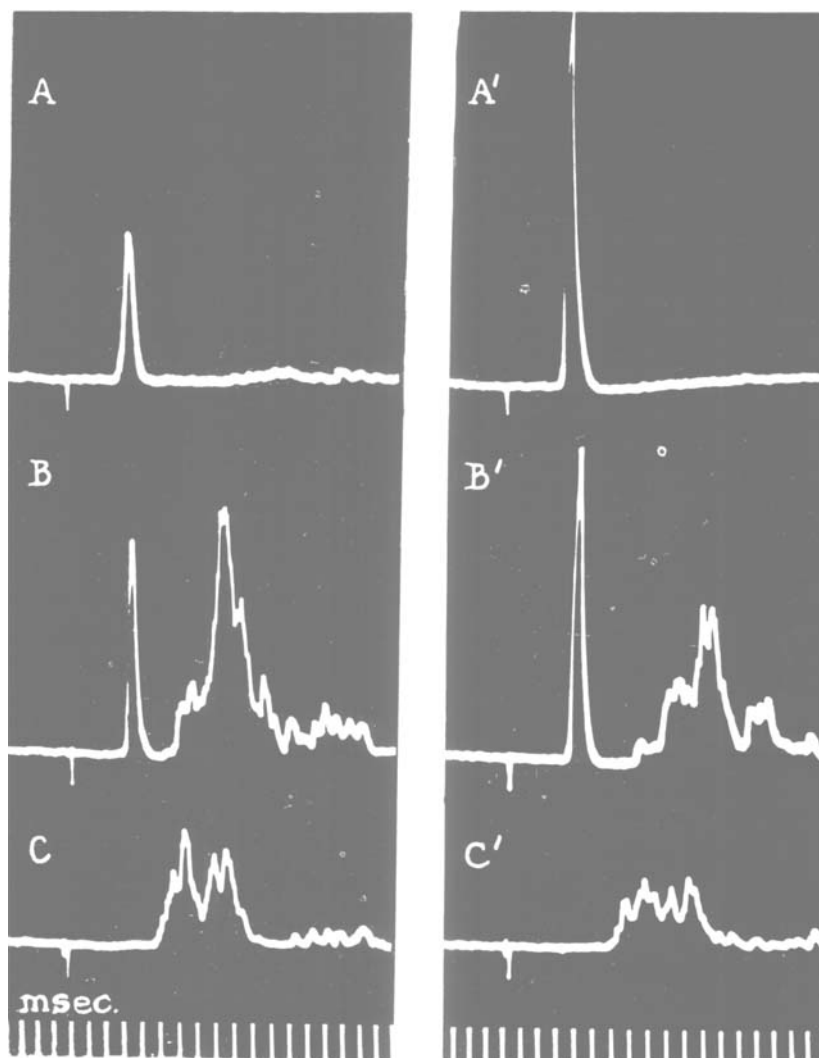


FIG. 1.
Effects of morphine (5 mg per kg i v) on reflex discharges into ventral root L_7 in spinal cat, on stimulation of peripheral nerves by single condenser shocks. A. Two-neuron are reflex from gastrocnemius nerve. B. Two-neuron and multi-neuron are reflex from deep peroneal nerve. C. Multineuron are reflex from sural nerve. A', B', C', corresponding reflex discharges 24 minutes after injection of morphine. Note enhancement of two-neuron and depression of multineuron reflex are discharges.

worthy effect of the large doses, however, was on the multineuron arcs. Following the initial depression of the reflexes over these arcs there regularly followed, after 1.5-2 hours, an enhancement of the discharge.

B. Nembutal. Following the injection of nembutal, depression of reflex discharges over both two-neuron and multineuron arcs was

observed, regardless of dose. Previous injection of eserine or morphine plus eserine did not alter the relationship of the depression with respect to the two forms of reflex discharges.

C. Ether. During induction of ether anesthesia, both two-neuron and multineuron reflex arc discharges were progressively de-

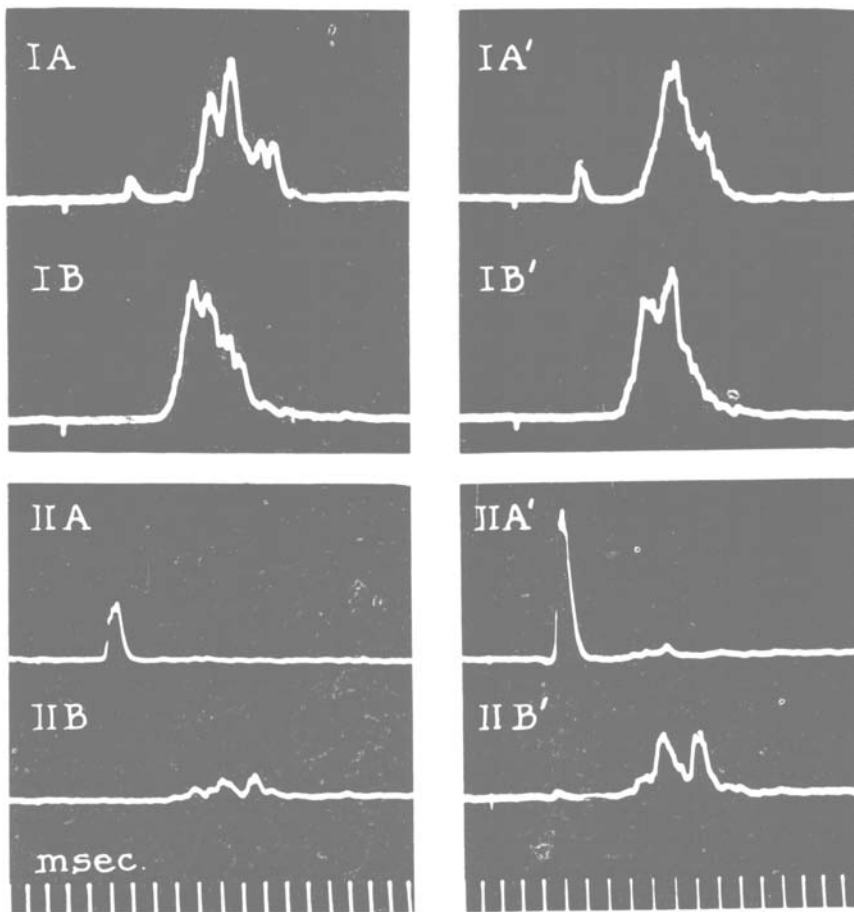


FIG. 2.

I. Eserine as the first agent. A. Two-neuron and multineuron reflexes from deep peroneal nerve. B. Multineuron arc reflex from sural nerve. A', B', corresponding reflex arc discharges 22 minutes after injection of eserine (0.25 mg per kg).

II. Eserine, after morphine (5 mg per kg) had enhanced the two-neuron reflex and further depressed the multineuron reflex in a spinal cat in which both reflexes had previously been depressed by nembutal (0.24 mg per kg). A. Two-neuron reflex from gastrocnemius nerve. B. Multineuron reflex from sural nerve. A', B', corresponding reflex discharges 7 minutes after injection of eserine (0.25 mg per kg). Note enhancement of both two-neuron and multineuron reflex arc discharges.

pressed, the latter somewhat more rapidly than the former.

D. *Eserine*. Following the injection of eserine (0.25 mg per kg), two-neuron arc reflex discharges were regularly enhanced, while the multineuron arc discharges were little affected. If, however, eserine was injected after morphine, or nembutal plus morphine, both two-neuron and multineuron arc discharges were enhanced simultaneously. (Fig. 2.).

Discussion. Although morphine, ether, and

nembutal alike have the power, in the cat, to depress spinal reflexes traversing multineuron arcs, gradation of dose serves clearly to differentiate morphine from the other two agents. Large doses of morphine augment the discharges over multineuron arcs, while large doses of ether and nembutal produce further depression. Additional differentiation appears in the action on two-neuron arc discharges. Morphine, in small doses that depress the multineuron arc discharges, regularly increases the two-neuron arc discharge. An increase of

⁸ Schroeder, H. A., and Adams, N. H., *J. Clin. Invest.*, 1941, **20**, 442.