PHARMACOLOGY

THE DIFFERENCE IN THE VELOCITY OF ACTION OF SODIUM AMYTAL ON THE REFLEX ARCS OF THE CERVICAL AND LUMBAR AREAS OF THE SPINAL CORD

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When hypnotic or narcotic substances are administered to an animal the hind limbs become "ataxic" and "paretic" sooner than the fore limbs [4, 7, 8, 11, 12, 13, 14].

This phenomenon was not, however, analyzed before the experiments of Bernhard and collaborators [5, 6, 9, 10]. These experiments established that on stimulation of the cerebral cortex, the pyramidal pathways (at the level of the medulla) or of nerves, following administration of narcotics, earlier depression of biocurrents was noted in the nerves and muscles of the hind limbs than in those of the forelimbs. This differential sensitivity to narcotics did not depend on the influence of supraspinal centers, cervical reflexes, fluctuations of blood pressure or inflow of afferent impulses, but was connected with the magnitude of the central delay of the reflex which proved to be greater by 1-1.8 milliseconds for the multisynaptic reflexes of the hind limbs.

However, explanation of paresis and ataxia of the hind limbs by the functional organization of the spinal reflex arcs exclusively, proved to be improbable. We therefore undertook to investigate the role of the higher portions of the central nervous system in the phenomenon of differential sensitivity of reflex arcs at different levels of the spinal cord to narcotics.

EXPERIMENTAL METHODS

Observations were made on intact animals and on animals subjected to transection of the cord at various levels, extirpation of the lumbar part of the sympathetic nervous system and decerebration.

Decerebration was performed at the intercollicular level; transection of the cord was made at the level C_1. In a number of experiments the cord was also transected at the level T_{7-8} and the lumbar sympathetic chains were removed. Transections were carried out in short-term experiments or one to three days prior to the experiments. Experiments on normal animals were performed not sooner than 60 minutes after administration of the narcotic in the dose of 40-60 mg/kg. Under long-term conditions changes in behavior and character of motor activity were investigated after administration of 5-50 mg/kg body weight of narcotic. Stimulation was effected by threshold (or slightly greater than threshold) single square-wave stimuli of 0.5 millisecond duration acting on sensory and mixed nerves (n. cutaneus medialis, superficialis radialis, ulnaris in the forelimbs and n. saphenus, suralis, tibialis in the hind limbs). Bipotentials were led off by needle electrodes from the muscles (m. quadriceps femoris, semitendinosus, semimembranosus, gracilis, gastrocnemius, tibialis anterior, and sartorius in the hind limbs, and m. biceps brachii, triceps brachii, palmaris longus, flexor digitorum profundus, extensor carpi ulnaris in the forelimbs). The potentials were recorded with the help of a symmetrical two-channel

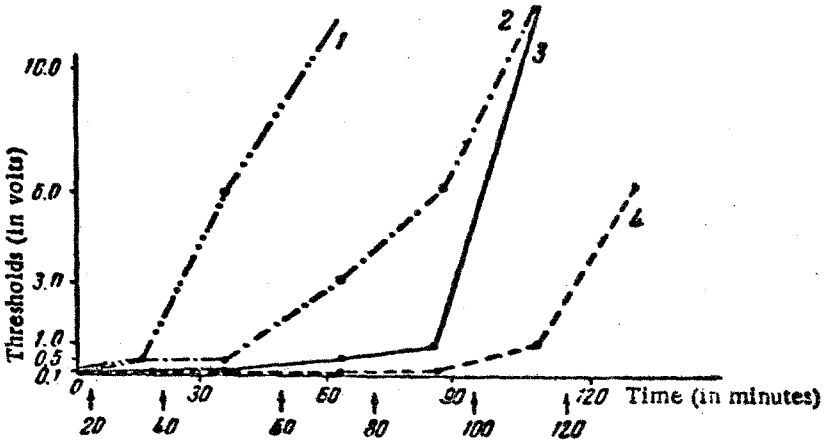
*Deceased.

amplifier and oscillograph. The thresholds were determined in terms of stimulus voltage. 1% solution of sodium amytal was used as narcotic; it was injected intravenously (sometimes intraperitoneally) in single or divided doses.

A total of 47 experiments was performed. 11 on decerebrate, 10 on spinal and 26 on intact cats.

EXPERIMENTAL RESULTS

Experiments on intact, spinal and decerebrate animals showed that the reflex arcs of the lumbar part of the spinal cord were more sensitive to narcotics than the corresponding arcs of the cervical region. With increasing doses of amytal there was first a rise in the threshold of the reflexes in the hind limbs (biopotentials were recorded from the m.tibialis anterior and semitendinosus on stimulation of n. tibialis) and only later a rise in the fore limbs (records of biopotentials were made from m. biceps brachii and palmaris longus on stimulation of n. tibialis) (see figure). When the narcotic was given to an intact animal visual observation revealed ataxia of the hind limbs with no change in the motor activity of the forelimbs.



Changes in reflexes under the influence of sodium amytal. Earlier depression of reflexes in hind limb muscles shown definitely. Arrows indicate moment of narcotic administration. Figures above arrows show total amount of substance injected. 1) m. tibialis anterior; 2) semitendinosus; 3) biceps brachii; 4) palmaris longus.

Our findings thus agree completely with the data of the authors cited above.

It is known that there is a possibility of transmission of inhibitory influences from suprasegmental structures to the spinal cord by way of the sympathetic nervous system [1, 2, 3].

In order to elucidate the participation of the sympathetic nervous system in the phenomenon under consideration, experiments were performed on animals with lumbar sympathetic chains removed: with spinal transection at T_{7-8} and lumbar sympathectomy (performed several days prior to the experiment). Control experiments were performed on animals with spinal transection at T_{7-8} but without sympathectomy. In all the experiments there was first a depression of reflexes of the lumbar part of the spinal cord, i.e., the results proved to be identical with the data of the preceding series.

Whereas the successive depression of the various reflex arcs depending on the experimental conditions did not change, the rate of restoration of reflex activity was different in experiments with decerebrate and spinal animals.

Following a single injection of a small dose of amytal (10-20 mg/kg) to a spinal animal complete restoration of reflexes occurred in the course of 45-75 minutes, while in decerebrate cats the time interval was 1½ hours and longer. When the same doses of the narcotic were given to intact animals (under long-term experimental

conditions) noticeable changes were observed in the motor function, expressed in greater discoordination of the hind limb movements. Although comparison of the results of short-term experiments with visual observations presents considerable difficulties, the similarity of the data from this series of experiments permits, it would seem, drawing of a parallel between these results (see table).

Duration of Change of Reflexes and Motor Function After a Single Injection of Sodium Amytal

Spinal animals			Decerebrate animals			Intact animals (data of visual observations)		
dose (in mg) per 1 kg of body wt.	method of administration	duration of changes in reflexes (in min)	dose (in mg) per 1 kg of body wt.	method of administration	duration of changes in reflexes (in min)	dose (in mg) per 1 kg of body wt.	method of administration	duration of changes in reflexes (in min)
10	Intravenous	60	10	Intravenous	95	10	Intravenous	>300
10	"	70	10	"	240	10	Intraperitoneal	>240
10	"	45	20	"	>180	10	Intravenous	>180
15	"	74	20	"	95	20	"	>300
15	Intraperitoneal	67				20	Intraperitoneal	>240
20	Intravenous	40						

Restoration of reflex activity in spinal animals following administration of sodium amytal occurred more rapidly than in decerebrate animals, and more rapidly in the latter than the restoration of motor functions in intact animals. These data suggest that the phenomenon of differential sensitivity of spinal reflex arcs to the narcotic is determined not only by different functional organization of these arcs in the spinal cord but also by the influence of higher sections of the nervous system. What these structures are and what the nature of their influence may be remain so far unclear.

SUMMARY

The effect of sodium amytal on various reflex arcs of the spinal cord was studied in experiments on decerebrated spinal and intact cats.

It was established that the reflex arcs of the lumbar area of the spinal cord were more sensitive to the action of sodium amytal than those of the cervical area. The effect of this substance does not change when the lumbar portion of the sympathetic nervous system is removed as well as after section of the spinal cord at the level T_{7-8}.

It was also demonstrated that different time is required for reestablishment of normal reflex activity in decerebrated, spinal and intact animals following administration of the same doses of sodium amytal.

On the basis of these experiments it is assumed that suprasegmental structures take part in this phenomenon.

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