THE ACTION OF NARCOTICS ON THE MONOSYNAPTIC REFLEXES OF THE CERVICAL AND LUMBAR REGIONS OF THE SPINAL CORD

O. B. Il'inskii

From the Laboratory of Pathophysiology (Head — the late Prof. V. S. Galkin) and the Laboratory of the Physiology of the Circulation of the Blood and Respiration (Head — Prof. G. P. Konradi) of the I. P. Pavlov Institute of Physiology (Director — the late Academician K. M. Bykov) of the AN SSSR, Leningrad

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Research by a number of workers has shown that the polysynaptic reflex arcs of the lumbar division of the spinal cord are more sensitive to the action of narcotics than the corresponding reflex arcs of the cervical division [2, 3, 6, 7, 13]. The monosynaptic reflexes have received only little study in this direction. On this subject, some authors [13] consider that narcotics depress different monosynaptic reflexes to different degrees, and others [5] point out that bineuronal reflex arcs in different regions of the spinal cord are successively excluded.

The present work was carried out in order to elucidate the action of narcotics on the monosynaptic reflexes of different regions of the spinal cord.

EXPERIMENTAL METHOD

Experiments were carried out on spinal cats. Under deep ether anesthesia the spinal cord was divided at the level of the 1st cervical vertebra, after which the animal was transferred to artificial respiration and was kept warm, and the anesthesia was terminated. Recordings were made of the ipsilateral and contralateral reflexes of the extensors of the elbow (triceps) and knee, which have similar functions and can be classed as monosynaptic reflexes [8-12, 15]. For this purpose steel drills were passed through the humerus and femur, and firmly fixed to a stand. By means of electromagnetic coils with iron cores, rhythmic and synchronous blows of equal strength were applied through the skin to the tendons of the triceps brachii and quadriceps femoris muscles. At the moment of closure of the circuit (once in 3 seconds) the cores were drawn into the coils, thereby striking the tendons, and when the circuit was broken the cores were brought back to their original position by the pull of a rubber band. The isotonic contractions of the muscles were recorded on a kymograph. The initial amplitude of the knee jerk in all the experiments was 2-3 times greater than that of the triceps jerk, so that its recording was reduced in size by the appropriate degree by means of pneumatic transmission.

In some experiments the spinal cord was divided in addition at the level of T9-10 and all the limb muscles were denervated (except the triceps brachii and quadriceps femoris muscles), and the blood pressure in the common carotid artery was recorded.

We investigated the action of sodium amytal, evipan, penthothal, ether, chloralose, ethyl alcohol, chloral hydrate and urethane. Ether was administered by inhalation, using an artificial respiration apparatus, and all the other drugs were injected into the femoral (sometimes the jugular) vein, in solutions preparared ex tempore. The anesthetic drug was administered several times in each experiment. The last injections showed no essential difference from the first in their action.

The results of the more detailed study of the action of pentothal and urethane were treated statistically. They are given in the table, in which each figure is the mean value of several observations, and the limits of

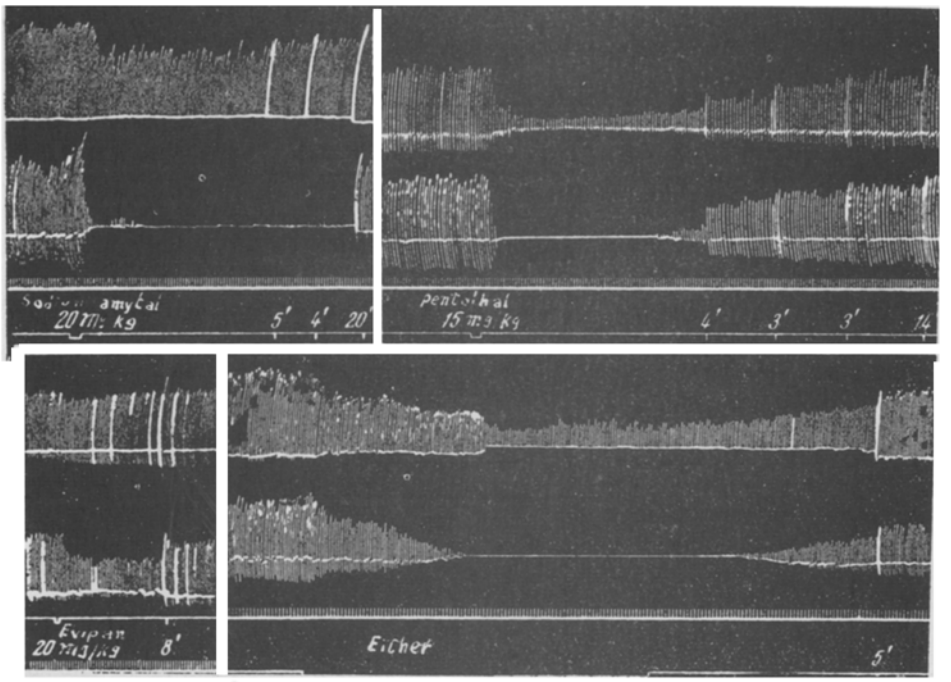

Fig. 1. The action of sodium amytal, evipan, pentothal and ether on the tendon reflexes. Significance of the curves (from above down): extensor reflex of the elbow, knee jerk, time marker (5 seconds), stimulation marker. It is clearly seen that sodium amytal, evipan, pentothal and ether cause, mainly, depression of the knee jerk.

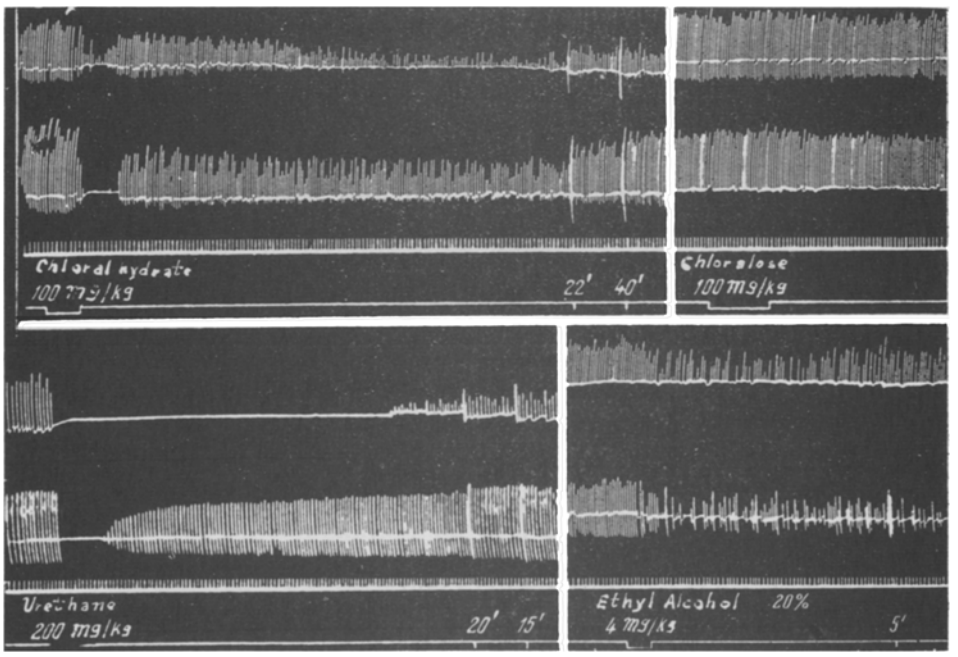

Fig. 2. The action of chloral hydrate, chloralose, urethane and ethyl alcohol on the tendon reflexes. Significance of the curves as in Fig. 1. It will be seen that chloral hydrate and urethane depress, mainly, the extensor reflex of the elbow. Chloralose produces no essential changes, but ethyl alcohol gives a characteristic picture of equal inhibition of the two reflexes under examination.

Changes in the Tendon Reflexes by the Action of Anesthetics

Dose, in mg/kg body weight	Degree of inhibition of reflexes, as % of original amplitude															
	triceps jerk	knee jerk	triceps jerk	knee jerk	triceps jerk	knee jerk	triceps jerk	knee jerk	triceps jerk	knee jerk	triceps jerk	knee jerk	triceps jerk	knee jerk	triceps jerk	knee jerk
	time in minutes (from moment of injection)															
	1/2	1/2	1	1	2	2	3	3	5	5	10	10	15	15	20	20
	Pentothal															
20	76. 7	82,1	82.6	83,1	84,5	89.6	83.5	87.6	81.5	77.9	56.8	59.1	46.3	43.3	39.4	39.9
15	44.8	75.7	56.9	81.6	56.6	83.7	53.6	79.4	45.9	68.6	32,5	52.9	21.3	37.2	15,5	26.9
10	12,8	46.7	33.0	61.6	34.7	61.0	32.9	54.5	26,1	53,9	16.4	38.3	12.3	37,9	10.2	27.9
5	0	19.0	5.0	28.0	8.8	28.8	11.3	28.2	7.3	24.6	3.7	16.0	2.6	14.4	2.2	14.1
	Urethane															
500	83.2	62.7	54.1	65.8	83.6	83.1	90.3	67 7	84.0	55.2	73.4	37.0	53.6	20.6	40.6	15.1
400	91.8	73.0	95.6	72.3	85.7	64.3	75.9	49.4	57.8	34.8	39.5	20.1	27.5	14.5	20.4	12.6
300	73.1	56.6	74.5	53.6	78.6	46.1	62.1	33.8	45.9	23.8	33.2	16.1	26.6	13.2	24.4	13.4
200	84.5	60.1	82.5	53.7	73.3	38.6	61.1	30.3	52.3	22.6	34.6	16.3	27.5	10.7	19.1	4.3
100	38.2	27.6	38,1	24,2	36.5	21.4	30.5	16,5	25.9	11.9	18.2	9,1	14,9	5.4	11.6	3,2

statistically significant variations in the degree of change of the reflexes are indicated by the bold line. The difference in the degree of inhibition of the reflexes was regarded as significant when $P < 0.05$ [1]. Altogether 246 observations were made on 82 animals.

EXPERIMENTAL RESULTS

The action of the various barbituric acid derivatives – sodium amytal (10-40 mg/kg), evipan (20-40 mg/kg), pentothal (5-20 mg/kg) – on the tendon reflexes investigated was the same. All these drugs produced, mainly, depression of the knee jerk (Fig. 1). The maximum inhibition of the reflexes was observed 2 minutes after injection (see table). In some cases immediately after injection of the barbiturate the reflexes increased slightly (especially the knee jerk), and then became depressed. Recovery of the triceps jerk took place more rapidly than that of the knee jerk.

The action of ether was identical with that of the barbiturates (see Fig. 1), i.e., it selectively depressed the knee jerk. Chloral hydrate and urethane had the opposite action to ether and the barbiturates. Both chloral hydrate (50-100 mg/kg) and urethane (100-500 mg/kg) mainly inhibited the extensor reflex of the elbow (Fig. 2, see table). Under these circumstances certain peculiarities were observed in the action of chloral hydrate. At the moment of injection both reflexes were depressed for a short time; later they recovered rapidly, and only after this did a slowly developing depression appear, which was greater in the triceps jerk. Restoration of both reflexes (especially the triceps jerk) took place much more slowly than in the case of action of the other anesthetics.

Even in quite large doses (50-150 mg/kg), chloralose had practically no action on either reflex (see Fig. 2) or else it gradually depressed both reflexes to an insignificant degree. Ethyl alcohol also altered the essential character of the contractions (see Fig. 2), or depressed the knee jerk to a greater extent. Often when alcohol was given, a considerable increase was observed in the reflexes at the moment of injection.

Experiments were carried out on spinal animals, and therefore the difference in the degree of inhibition of the reflexes examined did not depend on the direct effects of higher divisions of the central nervous system. The character of the reaction was unchanged by the use of the ipsilateral or contralateral limbs, by division of the spinal cord at a level below the thoracic vertebrae and division of all the nerves of the limb apart from those supplying the triceps brachii and quadriceps femoris muscles. No causal connection could be established between the changes in the tendon reflexes and the blood pressure changes and the site of injection of the drug (femoral or jugular vein).

In view of the fact that, other things being equal, the pentothal group and the urethane group had opposite actions, the degree of vascularization of the cervical and lumbar regions of the spinal cord played no essential part in this phenomenon.

It may thus be considered that the differing depth of inhibition of the reflexes which we examined, by anesthetics, depends on certain features of the structure of these reflexes which have not yet been studied.

The subdivision of the anesthetics into groups, which occurred in our experiments, was mainly in agreement with the existing classifications in the literature [4, 14]. An analysis of this subdivision of the anesthetics into groups forms the subject of our later investigations.

SUMMARY

Experiments were performed on spinal cats. The author studied the effect of sodium amytal, evipan, pentothal, ether, chloralose, ethyl alcohol, chloral hydrate and of urethane on the monosynaptic (tendon-elbow extensor and knee) reflexes of the cervical and lumbar sections of the spinal cord.

Sodium amytal, evipan, pentothal and ether inhibit mainly the knee jerk while chloral hydrate and urethane, the elbow extensor reflex. In the doses employed chloralose did not materially change any of the reflexes, while ethyl alcohol either inhibited both reflexes to the same degree, or had a greater inhibitory effect on the knee jerk. Changes in the tendon reflexes under the effect of narcotics were not directly influenced by the higher divisions of the central nervous system, interaction of different areas of the spinal cord, reciprocal relationships, blood pressure variations, the site of administration of the above preparations or by the different degree of vascularization of the cervical and lumbar sections of the spinal cord, but depend on the, as yet uninvestigated, peculiarities in the pattern of the above-mentioned reflexes.

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