EFFECT OF EXTIRPATION OF THE CERVICAL SYMPATHETIC GANGLIA ON FORMATION OF THE SCRATCH REFLEX DURING POSTNATAL DEVELOPMENT IN RATS

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Extirpation of the cervical sympathetic ganglia in newborn rats causes delay in the formation of the rhythmic phase of the scratch reflex and the operation at the age of 5 days weakens inhibitory effects during the period of inhibition of this reflex so that the animal continues to exhibit many "spontaneous" scratching movements. The results demonstrate the importance of the cervical portion of the sympathetic nervous system to the normal development of the scratch reflex in newborn rats.

The development of specialized reflexes in the newborn animal, like the formation of all new forms of movement, is based on inhibition and extinction of old coordination patterns in the central nervous system and the formation of new patterns [14]. An essential role in the suppression of the old and formation of the new coordination patterns is played by the adaptive and regulatory influences of the sympathetic nervous system [8, 15]. The effect of sympathectomy is most marked in animals at the lower levels of development [5, 16, 17].

Investigations in ontogenesis have shown that extirpation of the superior cervical sympathetic ganglion gives rise only to temporary changes in the formation of the defensive shaking conditioned reflex [7, 13]. Work in the author's laboratory has shown that removal of the cervical sympathetic ganglia affects the development of alternating limb movements [4] and the relationships between specialized cleansing reflexes during postnatal development of rabbits [12].

In the investigation described below the effect of extripation of the cervical sympathetic ganglia on development of the scratch reflex during postnatal development of rats was studied. The scratch reflex passes through 3 stages in its development: tonic, rhythmic, and gradual inhibition of the reflex [2, 19].

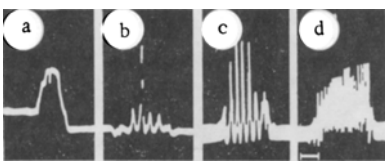

Fig. 1. Scratching movements by intact newborn (a) rats and by rats on the 1st (b), 3rd (c), and 11th (d) days of life (time marker 1 sec).

EXPERIMENTAL METHOD

The dynamics of the scratch reflex under normal conditions and after extirpation of the cervical sympathetic ganglia was studied in Wistar albino rats from the first day after birth until the acquisition of vision (on the 14th day). The scratch reflex was recorded graphically by the method of Voino-Yasenetskii and Moskalenko [3]. The reflex was evoked by a series of light tactile stimuli applied to the area of skin on the lateral surface of the trunk which the rat touches during the spontaneous scratch reflex at this period. Altogether 5 stimuli at intervals of 5 min were applied during the experiment.

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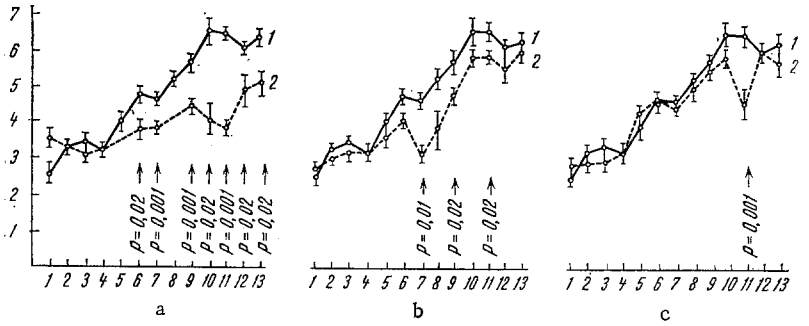

Fig. 2. Rhythm of scratching movements: 1) intact rats, 2) rats undergoing operation on 1st (a), 3rd (b), and 5th (c) days after birth. Abscissa, age (in days); ordinate, number of scratching movements per second.

The cervical sympathetic ganglia (superior and middle simultaneously) were removed on the right side under ether anesthesia. The rats underwent the operation immediately after birth and at the ages of 3 and 5 days. In some experiments removal of the ganglia was verified histologically. After all the sympathectomized rats had acquired vision, constriction of the palpebral fissure was observed on the side of the operation. In addition, the rats undergoing the operation on the day after birth were considerably retarded in size and weight [10]. Altogether 102 control experiments were carried out on 15 intact rats and 88 experiments on 19 sympathectomized rats. To study the effect of the operation itself on the course of the scratch reflex a mock operation without actual removal of the cervical sympathetic ganglia was performed on 6 rats.

EXPERIMENTAL RESULTS

Only the tonic phase of the reflex was observed in the newborn rats, i.e., in response to tactile stimulation the rat merely drew its paw toward the trunk without performing rhythmic movements with the limb (first stage of development of the reflex; Fig. 1a). In some of the rats on the first day of life (28%) the second stage of development of the reflex was well marked (Fig. 1b). During this period the reflex quickly disappeared, especially if the repeated stimuli was applied at intervals of less than 3 min. Scratch movements are most clearly evoked from the 3rd to the 8th day, but after the 7th day the 3rd stage – gradual inhibition of the reflex – can already be seen (Table 1).

The speed of the rhythmic scratching movements of the limb increased with age (Fig. 1 and 2). In the day-old rats the limb performed 2.6 ± 0.3 movements per second. By the age of 9 days the rhythm of the scratching movements were 2.5 times faster, namely 6.7 ± 0.4 times per second (Fig. 2). This is the characteristic speed of movements of the adult rat (1, 12].

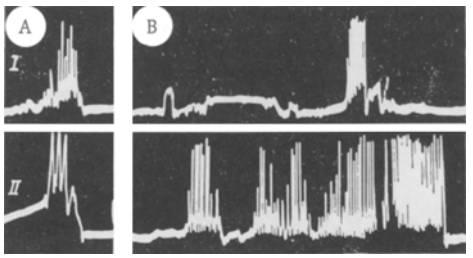

Fig. 3. Scratching movements in intact and sympathectomized rats: A) reflex movements on the 11th day of life in intact (I) rats and rats undergoing sympathectomy on the first day of life (II); B) spontaneous movements on 11th day of life in intact rats (I) and rats undergoing operation on 5th day of life (II). Time marker 1 sec.

Extirpation of the cervical sympathetic ganglia in rats caused delay in the formation of the scratch reflex. Depending on the age at which the operation was performed, this delay affected predominantly either the period of formation of the rhythmic phase of the reflex or the phase of its inhibition.

Changes in the formation of the rhythmic phase of the scratch reflex were seen most clearly in the rats undergoing operation on the first day after birth. By the 6th day (on the average) after the operation the rate of increase in the frequency of the scratching movements in the rats of this group was appreciably slower. By the 11th day the speed of the scratching movements in the sympathectomized rats was 4.0 ± 0.1 per second, compared with 6.6 ± 0.1 in the controls. These differences persisted until the end of the period investigated (Figs. 2a and 3A).

TABLE 1. Percentage of PositiveResponses to Tactile Stimulation in Intact and Sympathectomized Rats

Group of animals	Age (in days)												
	1	2	3	5	6	7	8	9	10	11	12	13	14
Intact (15 rats)	28	20	58	56	72	45	40	18	17	20	3	13	4
Undergoing operation at age of 5 days (7 rats)	—	—	—	—	43	20	—	46	—	49	49	26	23

In the rats undergoing operation at the age of 3 days, delay in the acceleration of the scratching movements was less marked and by the age of 12 days the differences had disappeared (Fig. 2b). Even less marked changes were observed in the group of rats undergoing operation at the age of 5 days. On the 6th day after the operation (11th day of life) the speed of the scratching movements was reduced, but on the following days the differences disappeared in this case also (Fig. 2c). Other investigators also have observed that the age at which the operation is performed affects the results [4, 7, 12, 13].

In the rats undergoing the mock operation without extirpation of the cervical sympathetic ganglia on the first day after birth no significant changes were observed in the speed of the scratching movements. In the control rats, for example, the speed of the scratching movements at the age of 11 days was 6.6 ± 0.1 per second while in the rats after the mock operation it was 6.3 ± 0.1 per second ($P > 0.5$).

After the 9th day of life the stage of inhibition of the scratch reflex was clearly evident in the intact rats: the percentage of positive responses to stimulation gradually decreased. After the operations at the ages of 1 and 3 days no definite changes were found in this process of inhibition. However, in rats undergoing the operation at the age of 5 days inhibition of the reflex was greatly weakened (Table 1). The rats of this group also exhibited numerous "spontaneous" scratching movements. Whereas the intact rats on the 11th day sometimes gave 1 or 2 brief series of scratching movements, the sympathectomized rats at this age gave successive series of these movements, forming clearlydefined rhythmic groups (Fig. 3B). Grouped activity of this type, subdivided into series of scratching movements, was observed in the intact rats at the age of 6 days, i.e., at an earlier stage of development, and this is also evidence of weakening of inhibitory influences on the course of the scratching reflex in the sympathectomized rats.

The results of these experiments show that the cervical sympathetic ganglia influence the process of formation of the scratch reflex in postnatal development. In the period of formation of the rhythmic phase of the reflex these influences facilitate the establishment of a rhythmic pattern, while during the period of inhibition of the reflex they contribute to its disappearance of "concealment." According to Sherrington the scratch reflex is a spinal reflex [18], but higher levels of the central nervous system participate in its formation as well as the spinal cord [2, 20]. For example, the functional maturation of the diencephalon plays an important role in the formation of the rhythmic phase of the reflex, and functional maturation of the cortex is equally concerned in the formation of the period of its inhibition. Extirpation of the cerebral cortex in the period of "concealment" of the scratch reflex can bring about its reappearance [2, 20]. De-inhibition of the scratch reflex is also observed after extirpation of the cerebellum [6, 11]. The delay in the development of the scratch reflex after extirpation of the cervical sympathetic ganglia observed in the present experiments were evidently the result of weakening of the adaptive and regulatory influences of the sympathetic nrevous system on the coordination patterns in the central nervous system which are laid down at each stage of development of this reflex.

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