DISTURBANCES AND RESTORATION OF FUNCTION IN THE HIND LEGS OF PUPPIES FOLLOWING DEAFFERENTATION

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Investigations of the disturbances and restoration of function following deafferentiation of the extremities in various animals have demonstrated that in frogs a sectioning of the posterior roots will not affect materially the motor functions [6]. Approximately the same picture is seen in birds with deafferentated extremities [5, 8]. The situation is quite different in mammals where deafferentation of the extremities leads to profound motor disturbances [1, 4, 6, 7].

E.A. Asratian [1] and his co-workers [2, 3] have shown that surgical damage to intracentral pathways of the nervous system in young animals produces a lesser disturbance which is more rapidly compensated than is the case with adult animals. An investigation of deafferentation from the aspect of evolutionary alterations coincidental with the age factor has not as yet been the object of an experimental study.

EXPERIMENTAL METHOD AND RESULTS

Twenty-two puppies ages two to four months were studied. In all of them the left rear limb was deafferentated. The surgical procedure consisted of severance of the posterior nerve roots and extirpation of the spinal nerve ganglia. Such an interference invariably led to disturbances of the standing and locomotor functions and sensations as well as some temperature alterations of the extremity. The depth and extent of the upset depended on the number of roots which were cut when the deafferentation was performed.

In the first group of nine puppies the trauma was relatively light as only 3-4 posterior roots were severed (from L_5 to L_7 or S_1). From the very first postoperative day all the animals exhibited hypotonus of the muscles in the deafferentated extremity as well as an absence of reflexes with mechanical, thermal and electrical stimulation.

However, the general condition of the puppies remained good. By the 3rd to 4th postoperative day they usually were able to rise and walk independently on three extremities. At times in walking they would use the deafferentated limb, although it would barely touch the ground, and they would most frequently lean on the rear surface of the foot. The entire weight of the body would be distributed among the three intact limbs.

By the 5th-12th day in seven of the puppies there was the presence of a pain response and an absence of movement upon mechanical and thermal stimulation of the altered extremity. The response to the stimulus was expersssed by the puppy's becoming upset, the limb was not moved but the animal became restless and whined.

The skin temperature of the deafferentatedlimb did not alter markedly. With time, the disturbed functions tended to become restored to normal. By the 8th-12th day the reflexes tended to reappear in the altered extremity. This group of animals seemed to maintain the general reaction to pain in the affected limb, no matter if the stimulus was mechanical, thermal or electric, even after reflexes had returned and the puppies be-

Fig. 1. Puppy Bolchok 3 days after deafferentation of the left rear extremity.

gan to move around. The most complete restoration of standing and walking with the use of the operated extremity occurred in the puppies after $1\frac{1}{2}$-2 months. By that time the muscle tone in the posterior extremities tended to rise and the animals moved about freely, resting their weight upon the affected limb and moving it about in almost complete coordination with the others.

In a second group of nine puppies in whom 5-6 posterior roots were severed (from L_4 down to S_1 or S_2) the functions of the affected limb showed much more damage than was seen in the first group. For the first 5-7 days the puppies were unable to tolerate sitting in the box, crawling on their fore-limbs, aided by their good rear extremity and dragging the deafferentated leg passively (Figure 1).

Hypotonia could be observed and an absence of reflexes in the affected extremity when either it or other parts of the body were stimulated. Also a slight rise in the skin temperature could be observed. In all the puppies of this and the preceding group, for the first 3-8 days postoperatively, there was seen the presence of a pain response and an absence of any movement when the deafferentated limb was stimulated mechanically, electrically or thermically, these stimuli being, at first, very strong and then of average strength (the puppies whined and were restless but did not move the limb). The same general response developed when the deafferentated limb was stimulated after the reflexes had returned.

By the 9th to 20th day the puppies began to stand and move around resting their weight on three limbs. The affected limb remained either bent or lowered and extended backward so that the puppy leaned slightly on its rear side. The body weight was distributed among the three intact limbs, this fact being registered electrically (Figure 2a and b). The restoration of standing and locomotion in the puppies of this group as well as sensation in the affected limb was a much slower and far more incomplete process than it was for the preceding group. Only by the 10th to 22nd day did reflex activity return to the deafferentated limb. By the 20th to 25th day the puppies began to stand and walk on all four extremities although even then the movements of the damaged extremity were of a swinging and uncoordinated nature (Figure 3a and b).

At times, while walking, the puppies would elevate the deafferentated limb and hold it up for 1-2 minutes after which they would lower it. This poor coordination in walking lasted for a long time. The locomotor function did not reach a stable level until $2\frac{1}{2}$-3 months following the operation.

By that time the awkward and ataxic movements had disappeared and the puppies walked briskly and freely, the affected extremity being used with almost complete restoration of coordination. However, even after 3-4 months there was still some residual ataxia in their gait.

In the third group of four puppies there were sectioned 7-8 posterior roots (from L_2 to S_1 or S_2), the disturbance in the function of the deafferentated limb being much as in the preceding group. Usually, up to the 4th to 10th days there would be observed a general reaction to mechanical, thermal or electrical stimulation of the affected limb. Thus, pinching, jabbing, thermal irritation (test tube with water at 80°C) and induction shock of varying intensity would stimulate the puppy so that it became irritable and whined but the paw was not withdrawn.

Up to the 7th-10th day the puppies would not rise but sat in their boxes. There was observed a hypotonia and an areflexia of the deafferentated extremity as well as a lowered response to mechanical, electric and thermal stimuli. On the 8th-10th day the puppies began to elevate themselves and stand on the three sound limbs, the deafferentated extremity being most often held elevated and fixed in the flexed position. Stimulation of the deafferentated limb at this time produced a local and a general response, the animal jerking its paw away and whining. This reaction continued even after the puppy was walking well. By the 15th-20th day the puppies could stand on all four extremities although they still limped when walking. The entire body weight was borne by the three sound limbs. Maximal motor restoration and return of sensitivity occurred in these animals after 3-4 months. By that time, even though the animals walked well and could run on all four extremities, there was some ataxial residue in the deafferentated extremity. This was most noticeable when the animal was running.

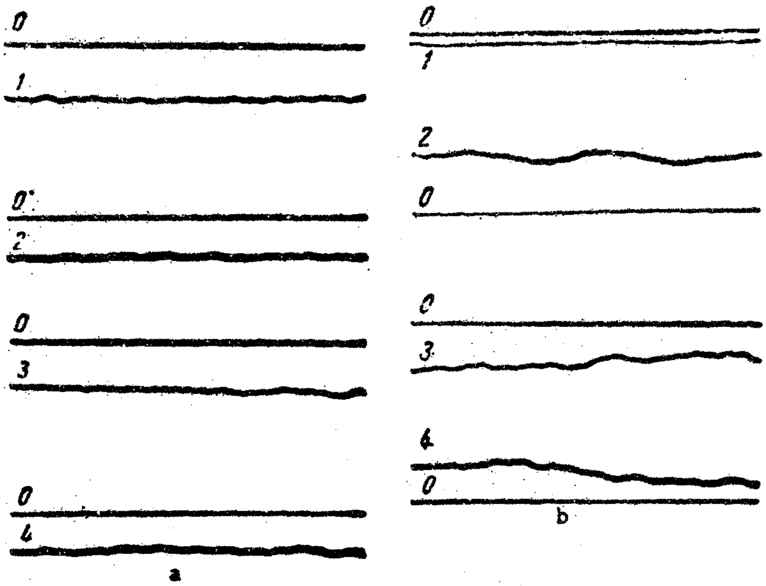

Fig. 2. Body weight distribution on each of the limbs of puppy Chernushka (a) before and (b) after partial deafferentation of the left rear extremity. 0) Base line; 1) left rear; 2) left fore; 3) right fore; 4) right rear extremity.

The data presented show that deafferentation of a rear extremity in a puppy just as in adult dogs produces profound motor and sensory disturbances in that limb; this being quite different from the effects produced by interference with the interocentral pathways [1, 4, 6].

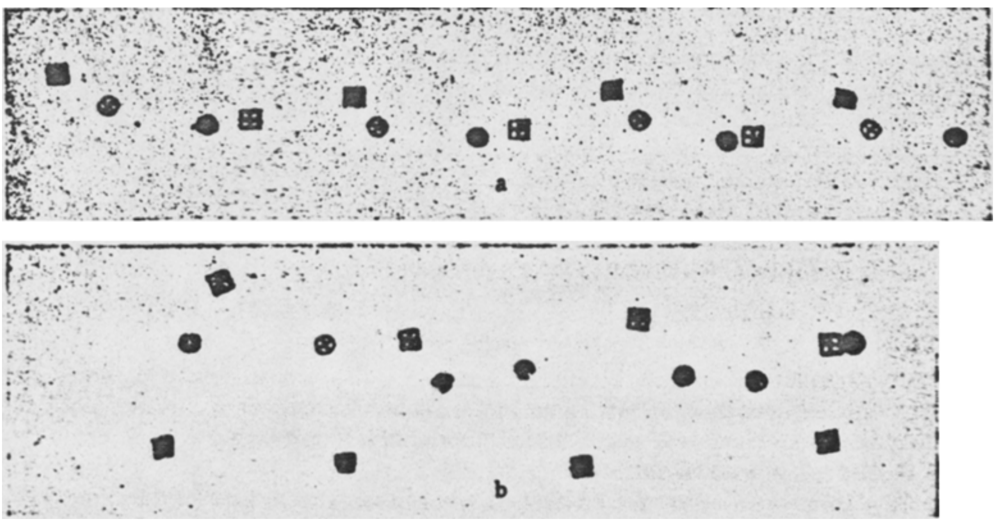

Fig. 3. Ichnogram of puppy Chernushka before deafferentation (a) and $1\frac{1}{2}$ months after deafferentation (b): ⊞) right fore; ●) right rear; ⊕) left fore; ■) left rear extremity.

As far as our interesting observation goes in regard to the presence of a pain reaction in the absence of a movement response, we are unable to advance a sensible explanation without doing some further special studies.

SUMMARY

Long-term experiments were performed on puppies, aged 2-4 months, in which the left hind leg was deafferentated.

This operation was performed by the section of the posterior roots and extirpation of the spinal ganglia. The number of roots which were divided varied from 3 to 8. It was established that deafferentation caused deep disturbances of the locomotor function and sensitivity of the deafferentated extremity both in puppies and in adult dogs. This differed from manifestations caused by affection of the interocentral paths.

LITERATURE CITED

[1] E.A. Asratian, Physiology of the Central Nervous System* (Moscow, 1953).

[2] S.N. Ivanova, Transactions of the Third Scientific Session on Problems of Growth Morphology, Physiology and Biochemistry* (Moscow, 1957), 70-72.

[3] L.S. Isaakian, ibid, 76-78.

[4] L.A. Orbeli and K.I. Kunstman, Izv. Lesgaft Inst. IX, 187-194 (1924).

[5] S. Baglioni, Arch. Anat. u. Physiol. 1907, suppl. 71-78.

[6] A. Bickel, Untersuchungen über den Mechanismus der nervösen Bewegungsregulation (Stuttgart, 1903).

[7] R. Magnus, Körperstellung (Berlin, 1924).

[8] N. Trendelenburg, Arch. Anat. u. Physiol. 1906, 1, 499-509; 1907, suppl. 201-208.

*In Russian.