PATHOLOGICAL PHYSIOLOGY AND GENERAL PATHOLOGY

THE ROLE OF THE TELENCEPHALON IN COMPENSATORY PROCESSES IN DUCKS

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The study of compensatory adapations of the nervous system in animals generally and in birds in particular is of certain theoretical and practical interest. Much work has been done on this by E. A. Asratyan and his collaborators (V. A. Dmitriev, A. I. Karamyan, B. D. Stefantsov and others); the experimental animals used were pigeons almost without exception. At present Asratyan's collaborators are studying these phenomena on birds (hens and ducks) in whom walking is more pronounced and which are therefore more suitable for these particular investigations.

The problem posed was to discover the role of the cerebral hemispheres in birds in compensatory phenomena developed following transection of the posterior half of the spinal cord.

It was necessary to establish concretely the following: 1) characteristic dynamic features of disruption and restoration of function in ducks following transection of the posterior half of the spinal cord, 2) the role of the higher sections of the central nervous system, in particular the cerebral hemispheres, in the compensatory phenomena accompanying such transection.

EXPERIMENTAL METHODS

Extensive experiments were staged. First the posterior half of the spinal cord was transected at the level of the 6th thoracic vertebra, then after complete compensation of disturbed functions both cerebral hemispheres were extirpated, successively. The operations were carried out under urethane-novocaine narcosis and under strictly aseptic conditions.

For more complete characterization of the disturbance and restoration of function all the ducks were subjected pre- and postoperatively to measurements of the flexor reflex threshold (induction stimulation), to careful visual observation of the course of recovery of motor and sensory function of the wings and legs and to measurements of the skin temperature of the feet.

EXPERIMENTAL RESULTS

Transection of the posterior half of the spinal cord as performed on 25 ducks led to profound disturbances of sensory-motor and trophic functions. During the first 4-5 days the ducks remained lying on the side or prone with extended legs and neck (Fig. 1). Reflexes from the wings and legs were sluggish; crossed reflexes were difficult to elicit and then only in rare cases. The threshold for flexor reflexes to induction current rose to 1.5-2 cm distance between the coils of the Du Bois-Reymond apparatus(the 5,000 turn coil was fed from a 2 v accumulator) (Table 1).

TABLE 1

Flexor Reflex Thresholds in Duck No. 11 on Section of the Posterior Half of the Spinal Cord (in cm of intercoil distance) Operation February 19, 1952.

Limb	Before operation			After operation								
	2/2	2/15	2/18	2/21	2/23	2/27	3/1	3/7	3/10	3/14	3/30	4/10
Right	16	16	16	14	14	14.5	14	13.5	13.5	14	15	15
Left	17	16	16	14.5	14	14.5	14.5	13.5	14	14	14.5	15

The skin temperature of the feet also showed a certain rise; diminution of tonus was noted in the limbs. The ducks ate and drank without assistance. In addition to the disturbances mentioned there were also trophic changes, namely dryness and coarsening of the skin on the plantar surfaces of the feet. In 6 ducks loss of voice was observed.

The disturbed functions began to be compensated gradually and rather slowly. Thus, from the 4-5th day the ducks began to hold up the head, and the reflexes from wings and legs became more brisk. On the 5-6th

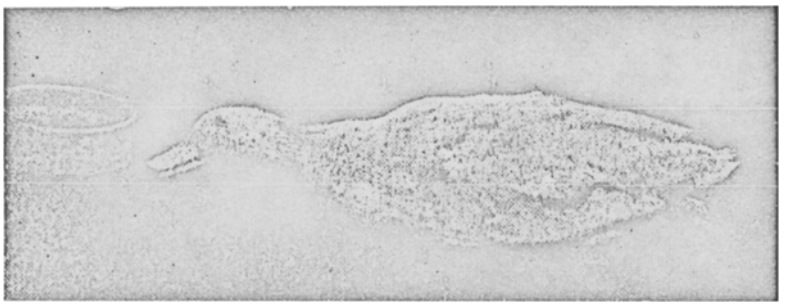

Fig. 1. Duck No. 9 on 2nd day after transection of the posterior half of the spinal cord.

day they were no longer prone, but sat up. The legs, however, remained more often extended. On the 7-8th day the ducks could raise themselves and stand at the side of the box on widely spread legs, on the 9-12-15th day they started making attempts at locomotion: at first they made 1-2-3 steps on semiflexed legs, then fell or stopped. It was interesting to note that on loss of equilibrium the ducks often made use of wings and tail for support. Towards the 15-20-25th day the ducks began to walk, at first slowly, then more quickly, but still limping and often stumbling. These disturbances became especially obvious on fast walking and running, as well as on negotiating obstacles which was a particularly difficult problem for the experimental birds,even two, and sometimes more, months postoperatively when superficially the compensation of function appeared to be complete.

After 2-3 months full recovery of the disturbed functions was seen and the operated ducks could not, usually, be distinguished from healthy ones. The very slow recovery of function, disrupted by transection of the posterior half of the cord, speaks for the important role played by acquisition of skills in these compensatory phenomena.

To elaborate this further, however, it was necessary to remove the cerebral hemispheres in these experimental birds.

With this aim in view 9 ducks with already well-compensated functions following transection of the posterior half of the spinal cord were subjected to right hemispherectomy. Two ducks died several days after this procedure. The 7 surviving ducks were subjected to left hemispherectomy, 2-3 and in some cases 4 months later.

The following results were obtained. Removal of one cerebral hemisphere led to decompensation of all those impairments of function observed after the spinal operation: profound disturbances of sensory, motor and trophic functions developed. In the first 4-6 days the ducks remained lying, most often prone, with extended legs (as was the case after the spinal operation). Contralateral hypotonia was noted in the muscles. Reflexes could be elicited from both legs and wings but they were sluggish on the side opposite to the removed cerebral hemisphere. The flexor reflex threshold on the contralateral side rose to 1.5-2.5 cm intercoil distance, and there was considerable increase in the skin temperature – by 4-6° on the average (Table 2).

TABLE 2

Flexor Reflex Threshold (Legs) in Duck No. 11 on Removal of Right Cerebral Hemisphere in cm Inter-Induction Coil Distance. Operation October 20, 1952.

Limb	Before operation			After operation						
	10/11	10/14	10/17	10/22	10/25	10/27	10/30	11/14	11/28	12/13
Right	15,5	15	16	14.5	15	15	16	16	16	15.5
Left	16	16	15.5	12.5	13.5	15	15	15.5	15.5	16

Following the first hemispherectomy (right) gradual restoration of the disturbed functions occurred in time. For instance the flexor reflex thresholds returned to normal on the 5-6th day in most cases.

In some ducks restoration of normal sensation in the limbs was delayed as long as 20-25 days. Restoration of skin temperature took, as a rule, longer and in isolated cases it failed to reach normal levels in the course

Fig. 2. Duck No. 9 on the 20th day following right hemispherectomy.

Fig. 3. Duck No. 9 on the 10th day after removal of second cerebral hemisphere (left).

of 2 months. Five ducks could stand on the 6-10th day, the other 2 – on the 18-22nd day postoperatively (Fig. 2). Normally coordinated walking was restored in 4 ducks on the 35-45th day, in 3 – on the 20-25th day.

Extirpation of the second (left) hemisphere was performed on 7 ducks in which right hemispherectomy had been followed by complete restoration of decompensated functions. It must be noted that this operation was much more grave. Only because of the specially developed nursing and feeding procedures could the operated ducks survive.

Five ducks were available for observation following the removal of the second hemisphere. In the first few days decompensatory phenomena were observed (as was the case after the first two surgical procedures). The ducks were lying prone with extended legs and neck unable to hold up the head. They did not eat or drink spontaneously and did not react to their surroundings or stimulation. Hypotonia of all muscles was seen. The flexor reflex threshold and skin temperature of the limb contralateral to the hemisphere removed last were raised.

Marked loss of weight was observed despite fully adequate diet. Lubrication of the feathers with coccygeal gland secretion ceased, resulting in a ruffled appearance.

In time the condition of the birds began to improve slowly. Beginning with the 9-12th day the ducks started to raise themselves on their feet and to stand (Fig. 3). The flexor reflex thresholds to induction current became normal on the 8-10th day. Differences in skin temperature were fairly slow to disappear, as was also noted after the first hemispherectomy. It must be remarked that once the ability to stand was recovered the ducks tended to exhibit "persistent" standing. They remained standing most of the time with their legs wide apart; they sat only rarely and almost never lay down, often sleeping in the standing position. Later on this inert state alternated with periods of increased automatic movements. The birds could not stand still at all, continuously cleaning themselves with the beak or feet, and twitching one or other wing all the time. After $1^1/_2$ months following removal of both cerebral hemispheres the ducks began slow locomotion on flexed and widely spread legs. In time the gait became more normal but there was no complete recovery of walking ability.

The data presented above permit the conclusion that the cerebral hemispheres in ducks participate in the compensation of derangements caused by section of the posterior half of the spinal cord. This participation is not, however, of such paramount importance as in mammals.

SUMMARY

Extensive experiments were carried out on ducks. It was noted that transection of the posterior half of the spinal cord in ducks caused profound sensory-motor and trophic disorders. Gradually the disturbed functions were restored, this time more quickly than after the operation on the spinal cord. Ablation of one hemisphere led to decompensation of all the recovered functions. In the course of time the disturbed functions were again restored, this time more quickly than after the operation on the spinal cord. Ablation of the second hemisphere in the same ducks was followed by profound recurrent disturbances which disappeared slowly and were not fully compensated.

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