THE EFFECT OF THE STRESS REACTION ON HIGHER NERVOUS ACTIVITY

N. A. Nikolov

Department of Pathophysiology (Director, Dr. Med. Sci. Professor L. Telcharov),
I. P. Pavlov Higher Medical Institute, Plovdiv, Bulgaria
(Presented by Active Member AMN SSSR A. V. Lebedinskii)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 54, No. 10,
pp. 63-66, October, 1962
Original article submitted December 31, 1960

The effect of the stress reaction on the functions of the organism has been the subject of much research. So far as the nervous system is concerned, however, it remains inadequately studied. We do not know what functional and morphological changes take place in the brain during the stress reaction, and neither do we know how the nervous system regulates the individual stages of the general adaptation syndrome of Selye [2]. These problems are of fundamental theoretical and practical importance. In our previous investigations we have shown [1] that during the "shock" administration of cortisone, when a large dose of the hormone is given on the first day, and the dose is then progressively diminished, changes similar to the stages of shock and countershock of the general adaptation syndrome are observed in the higher nervous activity. We suggested at that time that the cerebral cortex probably also undergoes phase changes like those observed in other functional systems under the influence of the corticoid hormones secreted during the stress reaction.

The object of the present article is to demonstrate the changes in higher nervous activity during the stress reaction.

EXPERIMENTAL METHOD

Investigations were carried out on four dogs in a Pavlov sound-proof chamber. As stress-inducing agent we used a 10% formalin solution, which was injected into each dog's right fore-paw in a volume of 2 ml. Thorne's test was used to indicate the onset of the stressor effect. The dogs had a dynamic stereotype of conditioned reflexes to sounds and lights. The action of the conditioned stimuli along lasted 30 sec. The unconditioned stimulus consisted of 25 g of powdered meat and biscuit in proportions of 1 : 3. The unconditioned secretion of saliva was measured for a period of 60 sec.

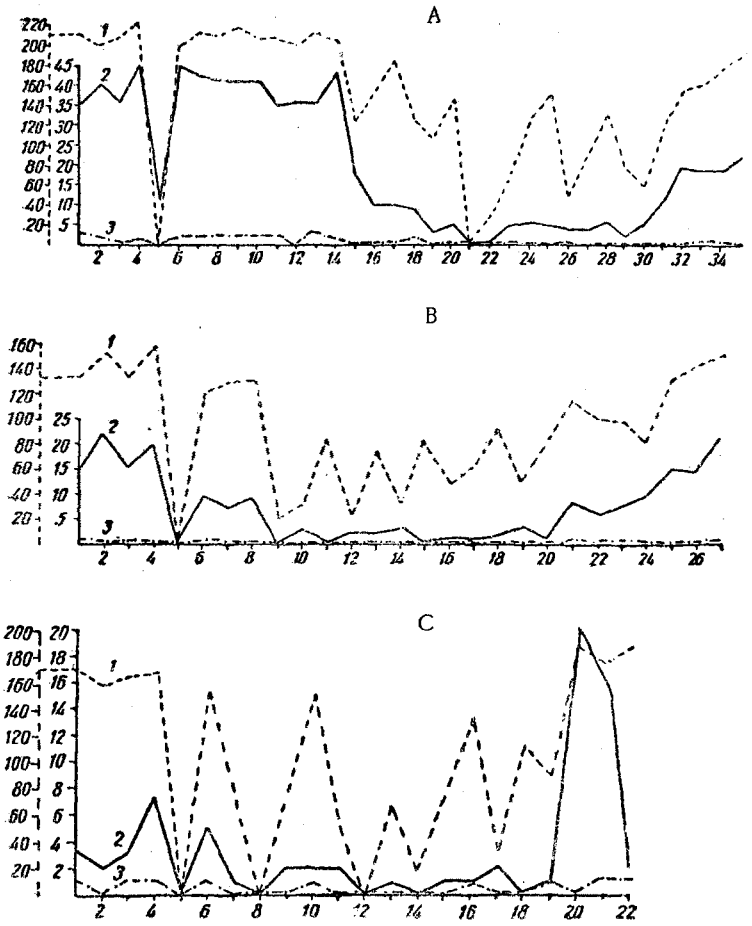
EXPERIMENTAL RESULTS

1. The dog Drebosak (male, mongrel, aged about 3 yr, weight 12 kg). Weak type of nervous system. The dog was being used for the first time in experimental research. The dynamic stereotype consisted of the following stimuli: buzzer, light, telephone bell, metronome with 120 beats per minute, metronome with 60 beats per minute (differential) and a rattle. The dog frequently fell into hypnotic inhibition of the 1st and 2nd degrees (according to I. P. Pavlov and L. N. Voskresenskii). Injection of formalin caused a strong waking reaction in the animal, which whined and yelped. When in the chamber, the dog refused to eat and secreted no saliva in response to both conditioned and unconditioned stimuli. Total inhibition lasted for 1 day. It may be considered that these phenomena were characteristic of the shock phase from the stage of the signal reaction; at this time the eosinophil count showed a decrease of 52% of the initial value. Restoration, though not complete, of the conditioned and unconditioned secretion of saliva corresponded to the phase of counter-shock from the signal reaction.

Next day, the higher nervous activity showed partial recovery: the dog secreted saliva in response to all the conditioned stimuli except the light. The unconditioned-reflex secretion of saliva was also restored to nearly the normal limits. This continued for 3 days, during which the dog lost 1.5 kg in weight. A complete inhibition of conditioned-reflex activity and a marked inhibition of the unconditioned-reflex secretion of saliva then returned. The inhibition of higher nervous activity continued for 18 days (stage of exhaustion), after which the unconditioned and conditioned-reflex secretion of saliva began to reappear. This could be called stage 4, or the stage of recovery. These fluctuations in higher nervous activity principally affected the process of excitation, and no particular changes were observed in internal inhibition (see figure).

Aseptic inflammation developed initially at the site of injection of the formalin, later becoming septic. The dog could not bear weight on its right forelimb. The inflammation subsided slowly and the animal regained the normal use of this limb.

2. The dog Vikhr' (male, mongrel, aged about 10 yr, weight 18 kg). The type of its nervous system was not determined. Injection of formalin caused a strong pain reaction with a sharp decrease in the conditioned secretion of saliva and the almost total suppression of the unconditioned secretion of saliva. On the same day, as a result of the stress reaction the eosinophil count fell by 51%. Here, too, the phase of shock lasted one day. Next day, the higher nervous activity was almost completely restored to the original level, at which it remained for 9 days (phase of countershock and stage of resistance). A decrease in the conditioned and unconditioned secretion of saliva then began. Hypnotic inhibition of the 1st and 2nd degree was present. After 8 days the animal fell into inhibition, last-



Effect of injection of formalin on the secretion of the salivary glands in dogs Drebosak (A), Vikhr' (B), and Balkan (C). Along the axis of ordinates: interrupted scale—unconditioned secretion of saliva, continuous scale—conditioned-reflex secretion of saliva in drops; along the axis of abscissas—days of the experiments. 1) Total unconditioned-reflex secretion of saliva during 1 day of the experiments; 2) total conditioned-reflex secretion of saliva in response to positive conditioned reflexes; 3) secretion of saliva in response to the differential stimulus (metronome 60). The arrow denotes the moment of injection of 2 ml of a 10% formalin solution into the right fore-paw.

ing 3 days (stage of exhaustion). A tendency towards recovery was then observed once more, lasting for about 8 days. The higher nervous activity was restored, although not with the same range as before the stress reaction. At this stage the dog had lost 2 kg in weight. At the site of injection of the formalin changes developed, similar to those observed in the experiments on the dog Drebosak.

3. The dog Balkan (male, mongrel, aged about 6 yr, weight 23 kg). The type of its nervous system was not determined. The animal was used twice in the investigation. The dynamic stereotype consisted of the following stimuli: buzzer, light, metronome (120/min), metronome (60/min, differential), bell, and light. The dog was frequently in a hypnotic or inhibited phase. The stress reaction caused inhibition of the conditioned and unconditioned secretion of saliva on the first day (phase of shock). On the same day the eosinophil count fell by 55% below normal. Next day the conditioned and unconditioned secretion of saliva was sometimes restored, sometimes inhibited. A separate phase of shock and stages of resistance and exhaustion were not distinguished. This state of affairs lasted 13 days, after which the stage of recovery of the higher nervous activity began. During this period the dog lost 1 kg in weight. At the site of injection of the formalin the same changes developed as in the experiments on the other dogs.

4. The dog Boyan (male, mongrel, aged about 5 yr, weight 20 kg). Weak type of nervous system. The animal had been used previously and in other investigations. The dynamic stereotype consisted of conditioned light and sound stimuli. A state of stabilized inhibition of the conditioned secretion of saliva was observed. The unconditioned secretion of saliva was stable. The stress reaction caused inhibition of the unconditioned secretion of saliva and a fall of 55% in the eosinophil count on the first day, after which the unconditioned secretion of saliva returned to its initial level. This state lasted 15 days, after which the secretion of saliva fell again. The remaining phenomena developed in this dog as in the others.

The experiments described above show that the stress reaction, caused by injection of 2 ml of 10% formalin solution into the paw of the right fore-limb of experimental dogs, causes typical phenomena characteristic of the general adaptation syndrome—a state of shock, during which a sharp decrease is observed in the conditioned- and unconditioned-reflex secretion of saliva. The eosinophil count fell by more than 50%. These results were explained by a marked overexcitation and inhibition of the cerebral cortex and subcortex. The phase of shock was replaced by a phase of countershock. At this period the conditioned and unconditioned secretion of saliva showed a tendency towards regaining its initial value. In some animals the stage of resistance was more prolonged, in others it was of short duration.

It follows from the experimental results that the stress reaction affects mainly the process of excitation, which is weakened, more so in the cortex than in the subcortex. In the stage of resistance the restoration of the strength of the process of excitation is more complete in the subcortex than in the cortex. When the stage of exhaustion develops, excitation is manifestly stronger in the subcortex. The same remarks apply to the stage of recovery, which starts first in the subcortex. This is due to the fact that the cerebral cortex is the most delicate nervous structure; the processes taking place in it are highly vulnerable, whereas the nervous ganglia in the subcortex are more primitive and more resistant to strong stimuli.

SUMMARY

Experiments with conditioned reflexes were carried out on 4 dogs. As established, stress reaction resulting from injection of formalin (2 ml of 10% solution) into the right fore-paw causes many changes in the higher nervous activity. During the first day they are manifested in a marked (up to a total) inhibition in the cortex and subcortex and eosinophil count reduction by more than 50% – the phase of shock. A phase of countershock develops within the next 3 days, merging with the stage of resistance. The nervous system becomes inhibited again at the stage of exhaustion. The 4th stage, or the restitution stage, is described as well. In stress reaction the excitatory process in the brain cortex suffers more than in subcortical nervous formations. This is explained by the greater resistance of the latter to strong stimuli formed during the phylogenesis.

LITERATURE CITED

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