THE INFLUENCE OF DYNAMIC STEREOTYPE CONDITIONED FOOD REFLEXES AND NEUROTIC CONDITION ON THE CARDIAC RHYTHM AGAINST A BACKGROUND OF NORMAL AND DISTURBED CARDIAC ACTIVITY

B. M. Fedorov

Laboratory of Infectious Pathology (Dir. – Corr. Member AMS USSR A. Y. Alymov) of the Institute of Normal and Pathological Physiology (Dir. – Active Member AMS USSR V. V. Parin) AMS USSR, Moscow
(Presented by Active Member AMS USSR V. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 51, No. 3, pp. 37-42, March 1961
Original article submitted May 14, 1960

Recently, the cardiac components of conditioned food reflexes have begun to attract considerable interest among investigators as sensitive indicators of conditioned reflex activity.

Study of this question is connected with methodological difficulties and is a topic of individual investigations conducted on animals with normal hearts [1, 4, 5, 6, 11, 12]. Of particular interest is the question of the influence of the functional condition of higher nervous system centers on the cardiac activity of a diseased organism.

In order to produce disturbances of cardiac activity, we have repeatedly used intravenous and intramuscular injections of strophanthin. This causes a more consistent derangement in atrioventricular conductivity than experimental myocardial infarcts or diphtherial intoxication.

The primary difficulties encountered in work with conditioned food reflexes on strophanthin-poisoned animals were the danger of intoxication to the animal's life, a sharp decline of food excitability, and the occurrence of vomiting reactions.

It is known from clinical observations that the cardiac glycosides exhibit a favorable, tranquilizing effect on the nervous system. V. M. Bekhterev [3] considered them to be one of the basic, active components of a mixture proposed by him. However, in an attempt to trace the active fraction of strophanthin (aglucone of strophanthidin) on the higher nervous activity of white rats, S. N. Asratian [2] observed a decrease in reflexes, disturbances in orientation reaction, and refusal to take food even when the dose used was, in his opinion, not toxic for the heart.

We were confronted with a difficult task: to preserve previously developed conditioned food reflexes against a background of heavy poisoning with strophanthin. Considering the results of our previous investigations [7, 8], we deemed it impossible to work with conditioned food reflexes against the background of increased vomiting excitability. However, we also realized that in a number of cases with intravenous injection of strophanthin it is possible to modify the illness so that disturbances in cardiac rhythm will persist for over four days, while the vomiting reactions persist only during the first two days following repeated injections.

EXPERIMENTAL METHODS

The experiments were conducted on three dogs. The food reflexes were developed first, then the animals were poisoned with strophanthin. In order to avoid an environmental conditioned reflex with vomiting reaction, strophanthin was injected outside the conditioned reflex chamber.

In the course of experiments with conditioned food reflexes in the chamber, electrocardiogram, respiration, and saliva flow were recorded at practically all times.

EXPERIMENTAL RESULTS

The following positive conditioned reflexes were obtained with dog Greta, with a strong type nervous system (weight 18 kg): tone of 400 db, buzzer and light, differentiation from the tone 800 db (tone +, buzzer, light, tone −, tone +). Usually short reflexes (up to 15-18 seconds) were used because prolongation of the isolated action of the conditioned stimulus markedly decreases the cardiac components of conditioned food reflexes.

The positive conditioned motion reaction was well expressed. (When the light was turned on, the dog bent its head to the food pan. When tone + or buzzer were switched on, it licked the food pan.) Conditioned reflex salivation reached 4-5 drops in 15 seconds. During the isolated action of conditioned stimuli, the cardiac rhythm increased 30 to 40 beats per minute (from 80-90 to 100-120). When the light was turned on, it increased 10 to 20 beats per minute. The most striking increase in cardiac rhythm (up to 120-140 beats per minute) occurred during the first 6-10 seconds following reinforcement.* Differentiation according to secretory indicators was absolute. Motion reaction was expressed by a turn of the head to the direction of the door. Differentiation caused only a slight change in the cardiac rhythm, in most cases in the direction of slowing. After a dynamic stereotype was obtained, the animal was subjected to a disturbance of the cardiac function.

During a period of 26 days strophanthin was injected 5 times in dosages from 1.4 to 2.2 ml of 0.05% solution.

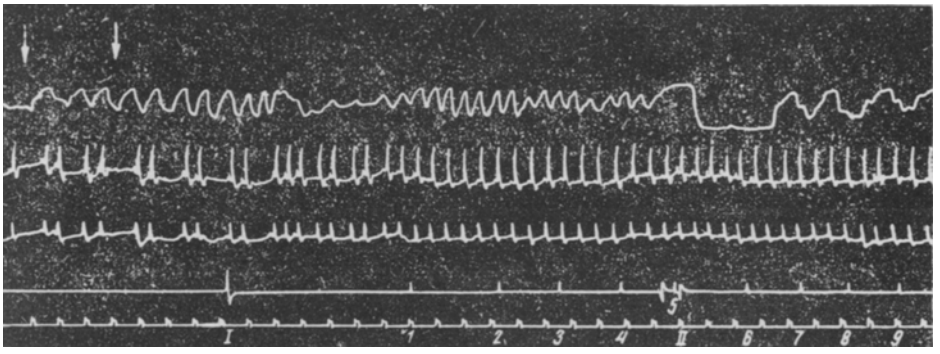

Fig. 1. Changes in cardiac activity and respiration in the process of conditioned food reflex in dog Greta four days after fourth injection of strophanthin. Significance of curves (from top to bottom): Respiration, electrocardiogram leads II and III; marks of application of conditioned and unconditioned stimuli and salivation in drops; time marks (one second). Prior to application of conditioned stimulus, sinus arrhythmia and second-degree atrioventricular block is marked with arrows. Following application of conditioned stimulus (I), increase in sinus rhythm and normalization of atrioventricular conduction. Conditioned reflex salivation − 5 drops (1, 2, 3, 4, 5). Following reinforcement (II), further increase in sinus rhythm. Unconditioned salivation (6, 7, 8, etc.).

Persistent disturbance in the cardiac rhythm were manifested as incomplete second-degree atrioventricular block; this stage was observed after the fourth injection of strophanthin. The experiments with conditioned reflexes were continued during the intervals between the injections (starting with the third day after an injection).

* The rhythm is indicated in beats per minute.

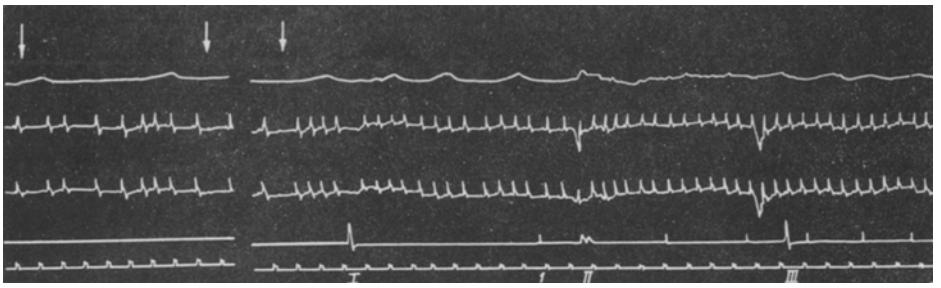

Fig. 2. Changes of cardiac activity and respiration during the process of conditioned food reflex in dog Serzh four days after sixth administration of strophanthin. Atrioventricular block of second degree with periodic omission of ventricular contractions prior to application of conditioned stimulus. Improvements in atrioventricular conduction after application of conditioned reflex. Legends are the same as in Fig. 1. I) Application of conditioned stimulus; II) reinforcement; III) termination of conditioned stimulus.

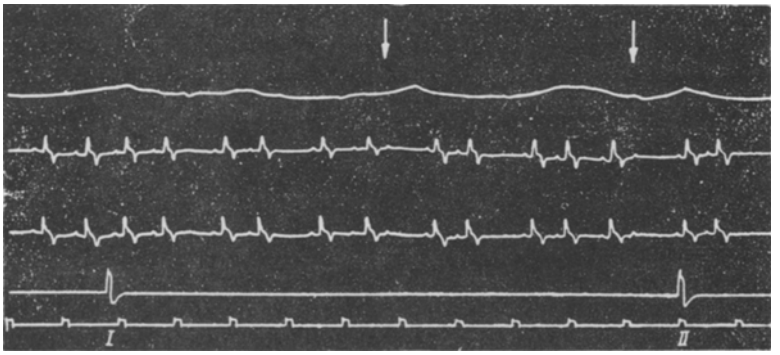

Fig. 3. Changes in cardiac activity and respiration under the influence of differentiating stimulus in dog Serzh in the same experiment. During the action of differentiating stimulus, atrioventricular second-degree block persists. I) Application of differentiating tone; II) termination.

With this background, under the influence of positive conditioned stimuli, an increase in the cardiac rhythm and improvement in the atrioventricular conductions were observed. Increase in the rhythm and normalization of the atrioventricular conduction were practicularly well expressed, beginning with the fourth day after injection, at the time of conditioned stimulus (tone) which followed differentiation (Fig. 1). Differentiation of the background of strophanthin poisoning aroused more energetic motor reactions in this dog, then before poisoning. However, it was not accompanied by changes in cardiac activity that are characteristic for positive reflexes – increase in rhythm and improvement of conductivity.

The second dog with a strong type nervous system, Serzh (weight 17 kg), responded to the action of positive conditioned stimuli only by a turn of his head toward the food pan. Conditioned reflex salivation was at the rate of one drop per 10 seconds, 2-3 drops per 15 seconds. During the isolated action of the positive conditioned reflex, the heart rate increased from 70-80 to 90-100 per minute, respiration from 10-12 to 15-18 per minute.

According to secretory indicators, the differentiation was absolute. During the process of its achievement, a difficult condition was observed when the dog whined and tried to tear down the balloon. In a number of instances this caused a more definite increase in heart rate than positive conditioned reflexes. After the 53rd application of the differentiating stimulus, the reaction attained a more stable character; the dog turned away from the food pan and the heart rate did not change in most cases. Following achievement of conditioned reflexes, an attempt was made to reproduce arrhythmia.

The same dog made it possible to observe the influence of dynamic stereotype on the disturbed rhythm of cardiac function against the background of strophanthin poisoning. During a 38-day period, strophanthin was injected seven times in a dose of 1.1 to 1.8 ml (0.05% solution). Constant disturbances in the rhythm occurred as an incomplete second degree heart block after the sixth injection of strophanthin. The experiments with conditioned reflexes between injections were performed only after vomiting had subsided, not sooner than the third day after injection.

Following the sixth and seventh injections, against the background of an incomplete atrioventricular second degree block, the positive conditioned stimuli (tone, buzzer, and light) caused conditioned reflex salivation, a slight increase in the rate of respiration, increase in the heart rate, and normalization of conduction (Fig. 2). Differentiation, which was absolute prior to poisoning, was not disturbed during poisoning. The motion reaction to the action of the differential stimulus was maintained negative (turn away from the food pan). Concommitantly, the respiration rate increased slightly, and atrioventricular conduction did not change, a periodic omission of ventricular contractions being maintained (Fig. 3).

The third dog, Irma, a true neurotic, developed a strong biologically negative reaction which obscured the previously developed conditioned reflexes. A development of the neurotic condition was observed while differentiation was applied. In individual experiments, the dog would stop eating the mixture of meat and biscuits. An attempt to place food into the dog's mouth initiated an active defense reaction. However, the minute a collar was put on the dog, providing a relative stimulus signifying termination of the experiment, the dog's behavior would change markedly and the animal would immediately consume large quantities of food. This neurotic condition was accompanied by attacks of marked increase in respiration rate (up to 360 per minute) in a majority of cases without or with only a slight increase in cardiac rate. A true tachycardia produced by strong positive stimuli was observed only at the height of the neurotic condition. Later, differentiation was discontinued from the stereotype. However, even after this the animal maintained signs of the neurotic condition expressed by attacks of tachypnea, principally at the beginning of an experiment and during the action of strong stimuli. Small doses of bromine provided no therapeutic effect.

Of particular interest are the results observed in a 24 hour starvation experiment, performed before administration of strophanthin. Increase in gastric irritability augmented the difficult condition of the animal during the experiment. This was accompanied by severe disturbances in the heart rhythm characterized by attacks of paroxysmal ventricular tachycardia.

Some time later, dog Irma was poisoned with strophanthin. Following poisoning it was impossible to correlate disturbances in the cardiac rhythm with the essential level of gastric irritability. However, as result of administration of strophanthin (during three months, a total of 25 injections in dosages from 1.4 to 2.25 ml was given) after a desired level of gastric irritability had been achieved, clear normalization of the respiratory components of conditioned food reflexes was demonstrable.

The experiments permit one to conclude that a neurotic condition alone, without any other interference, is capable of causing severe disturbances in cardiac function, expressed as paroxysmal ventricular tachycardia. At the basis of this arrhythmia lie adrinergic neural mechanisms [9, 10], which permit differentiation of disturbances in cardiac rhythm based on a neurotic reaction from alterations in cardiac rhythm connected with food reflexes. It was possible to maintain unaltered dynamic stereotype conditioned food reflexes in dogs with strong type nervous systems when they were poisoned with strophanthin.

Positive conditioned reflexes exert a normalizing influence on atrioventricular conduction against a background of disturbed cardiac function. This influence is weaker than the previously described influence of vomiting reflexes. However, it could be of interest in appraising the importance of dynamic stereotype physiological reflexes as a factor providing a tone for a diseased organism and its cardiac function.

SUMMARY

Neurotic condition of the animal provokes changes of respiration and cardiac activity rhythm with the appearance of severe disturbances in the latter in the form of paroxysms of tachycardia. Against the background of strophanthin poisoning and marked derangement of the cardiac activity it is possible to preserve intact the dynamic stererotype of conditioned food reflexes in dogs with a strong type of the nervous system. Positive conditioned reflexes produce a normalizing effect on the atrioventricular conductivity. This is of interest for evaluation of the significance of dynamic stereotype as a factor normalizing the sick organism and its cardiac activity.

LITERATURE CITED

1. P. K. Anokhin, Internal Inhibition as a Problem of Physiology [in Russian] (Moscow, 1958).
2. S. N. Asratian, Selective Action of Drugs on the Central Nervous System [in Russian] (Leningrad, 1958) p. 51.
3. V. M. Bekhterev and G. A. Pevzner, Clinical Medicine 6, 172 (1925).
4. V. P. Lekishvili, Zhur. Vyssh. Nervn. Deyat. 6, 6, 822 (1956).
5. E. F. Melikhov, Trudy Inst. Physiologii im. I. P. Pavlova (Leningrad, 1953) Vol. 2, p. 165.
6. B. V. Pavlov and N. A. Shustin, Physiol. Zhur. USSR 34, 3, 305 (1948).
7. B. M. Fedorov, Byull. Éksp. Biol. i Med. 37, 2, 17 (1954).
8. B. M. Fedorov, Problems of Reactivity in Pathology [in Russian] (Moscow, 1954) p. 235.
9. B. M. Fedorov, Byull. Éksp. Biol. i Med. (Suppl.) 1, 21 (1957).
10. B. M. Fedorov, Modern Questions of Neurism in Physiology and Pathology [in Russian] (Moscow, 1958) p. 315.
11. V. A. Shidlovskii, Materials of The First Scientific Conference on Problems of Reticular Formation in the Cerebrum (Moscow, 1960) p. 126.
12. W. H. Gantt, W. C. Hoffmann, and S. Dworkin, 17th International Physiological Congress (Oxford, 1947) p. 15.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
