EFFECT OF STIMULATION OF LATERAL HYPOTHALAMIC NUCLEI ON BLOOD SUPPLY TO THE HEART, RESISTANCE OF THE CORONARY VESSELS, AND BEHAVIOR OF UNANESTHETIZED CATS

S. P. Nogina

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In response to stimulation of the lateral hypothalamic nuclei by currents of different frequency and amplitude in unanesthetized cats, responses increasing the blood supply to the myocardium are predominant. Responses reducing the coronary blood flow, which arise in response to stimulation by a current of any intensity and in conjunction with various behavioral responses, are augmented parallel with enhancement of the behavioral responses. A marked decrease in the blood supply to the myocardium during convulsions or violent behavioral responses was always due to an increase in the resistance of the coronary vessels.

The view is widely held among clinicians that emotions and cardiovascular diseases are closely linked [5]. The development of lethal coronary insufficiency has been described in cases of midbrain pathology [9]. However, in experiments on anesthetized animals it has not yet proved possible to obtain even a weak and transient decrease in the blood supply to the heart in response to stimulation of the sympathetic nerves of hypothalamus [1, 4, 6, 7, 8, 11, 13]. At the same time it is known that general anesthetics can significantly modify vascular responses [10].

It was therefore decided to study the changes in the blood supply to the heart in response to hypothalamic stimulation in chronic experiments on unanesthetized animals able to move freely around the cage.

By such experiments it will be possible to compare vascular responses with changes in behavior. Since the severest ischemic changes in the myocardium in anesthetized cats, as the ECG showed, were obtained in response to stimulation of the lateral hypothalamic nuclei [13], these structures were chosen for stimulation.

EXPERIMENTAL METHOD

Chronic experiments were carried out on male cats. Under pentobarbital anesthesia bipolar nichrome electrodes were inserted into both lateral hypothalamic nuclei. A flat thermoelectrode of the Noyens – Marshak [3] type was sutured 10-14 days later to the epicardium of the left ventricle of the same animals in order to record changes in the volume velocity of the coronary blood flow (CF). During this operation a polyethylene catheter was introduced into the aorta through the right carotid artery by Turanski's method [2] to measure the arterial pressure (AP). The experiments began 10-14 days after the second operation. Synchronous bilateral stimulation of the lateral hypothalamic nuclei was carried out by square pulses 1 or 3 msec in duration, from 1 to 8 V in amplitude, and at frequencies of 1, 5, 10, 20, 25, 50, 100, and 150 Hz. The duration of stimulation was 90 sec and the intervals between periods of stimulation 2-30 min. In one experiment up to 10 stimuli were applied to the animal. Results obtained from six animals with a total number of 226 periods of stimulation were analyzed. The animals were fed before the experiments. Values of AP, CF, and heart and respiration rates were recorded and the character of the behavioral responses was noted. The thermoelectric method enables only qualitative changes in CF to be assessed. However, if

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TABLE 1. Character of Changes in Coronary Blood Flow and Arterial Pressure (in %) Associated with Various Types of Response to Stimulation of Lateral Hypothalamic Nuclei

	Type I	Type II	Type III	Type IV	Type V
Coronary blood flow					
Increase	18	38	36	57	75
Decrease	22	27	23	16	21
Phasic responses	3	7	21	20	—
No change	57	28	20	7	4
Arterial pressure					
Increase	37	16	49	77	96
Decrease	52	59	10	4	—
Phasic responses	6	7	36	17	4
No change	5	18	5	2	—

the same electrode was used during the experiments and the conditions of its operation remained constant, it was possible to compare the responses of CF quantitatively also. In cases in which changes in CF and AP were opposite in direction, changes in the resistance of the coronary vessels (RCV) could be detected.

EXPERIMENTAL RESULTS AND DISCUSSION

A distinguishing feature of these experiments was that both autonomic and behavioral responses to stimulation of the lateral hypothalamic nuclei were very varied. Five types of responses arising consecutively as the amplitude or frequency of the stimulating current was increased were distinguished conventionally. The division into types was based on the behavioral responses, which could be differentiated more precisely than the autonomic responses.

In type I there were no visible changes in behavior; in type II slight changes in behavior were observed, the animals were slightly restless and changed their posture; in type III elements of searching, orienting, and food-getting responses were observed; the animals licked and made swallowing movements, sniffed at the floor, looked around, and sometimes ate; in type IV the behavioral responses were well marked and had the character of negative emotions: the animals made rapid movements, rushed about, mewed, climbed up the cage, chewed at the lead, and defecated and urinated frequently; in type V paroxysmal responses developed: the animals fell to the floor, gave a characteristic cry, struggled, and frothed at the mouth.

The character of the changes in CF and AP associated with each type of response is shown in Table 1. Clearly the number of cases of an increase in CF in response to stimulation increased successively from responses of types I to V, i.e., with an increase in the intensity of stimulation and an increase in the severity of the behavioral responses. The number of responses with no accompanying change in CF diminished progressively. It is particularly important to note that the responses with a decrease in CF were observed in each type, and their number varied only very slightly.

Comparison of the direction of the changes in CF and AP for responses of each type showed that in 47% of cases the changes in these indices differed in direction. In these responses there was evidently a change in RCV. A decrease in RCV was found in 11% of responses and an increase in 36%. The increase in RCV was found to produce all the cases of a decrease in CF in the responses of type V. In responses of types IV and III an increase in RCV brought about the overwhelming majority of cases of a decrease in the blood supply to the myocardium, while in type II it caused half of them, and in type I only one-quarter. The first three types of responses appeared more often in response to stimulation of the hypothalamus by a current of up to 6 V at a frequency of 10 Hz or by a current of up to 3 V at a frequency of 100 Hz. Responses of types IV and V were usually produced by stronger stimulation. The boundaries of the parameters of stimulation causing the appearance of a particular type can be shown only very approximately, for they differed not only in different animals, but even in the course of the same experiment. Although cases of an increase and decrease in CF were observed in all types of responses, they were by no means equal in magnitude, but increased considerably from type I to type V. The character and magnitude of the changes in AP in the responses of different types are illustrated in Fig. 1.

A marked decrease in the blood supply to the myocardium observed in responses of types III, IV, and V at the time of a sharp rise of AP could evidently be produced only by a successively rising RCV. Changes in AP and CF during pressor responses accompanied by a decrease in the blood supply to the myocardium are compared in Fig. 2 (the comparison was made using measurements obtained by the same thermoelectrode on the animal). Clearly, whereas the degree of decrease in CF showed an approximately twelvefold increase from type I to type V of the responses (from 5 to 60 scale divisions), the degree of increase in AP rose fivefold. Parallel with the intensification of the behavorial responses as the intensity of stimulation of the lateral hypothalamic nuclei increased, in many cases a successive increase in RCV was observed.

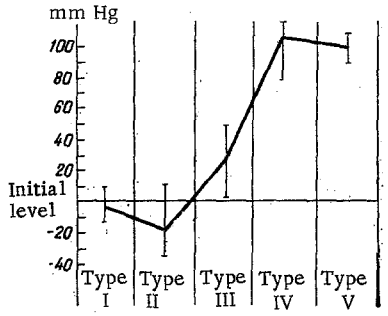

Fig. 1

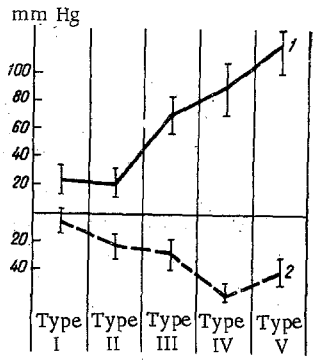

Fig. 2.

Fig. 1. Change in arterial pressure during stimulation of lateral hypothalamic nuclei.

Fig. 2. Comparison of changes in arterial pressure (1) in mm Hg and in coronary blood flow, (2) in scale divisions during responses accompanied by constriction of the coronary vessels, to stimulation of the lateral hypothalamic nuclei: 1) change in AP; 2) changes in CF.

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