ling is a long-lasting change in efficiency of synaptic pathways in the hippocampus, which is probably similar in nature to the long-term potentiation which has been widely discussed in the literature [3]. The results now obtained are evidence that changes in reactivity of neurons accompanying kindling may be found in a separate hippocampal segment, so that this phenomenon can be studied at synaptic and molecular levels. This model can be used to study the effects of various antiepileptic agents.

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EFFECT OF THE SYMPATHETIC NERVOUS SYSTEM ON CARDIAC RHYTHM CONTROL DURING BURST STIMULATION OF THE VAGUS NERVE

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The cardiac rhythm can be controlled with a fair degree of accuracy by burst stimulation of the vagus nerve (VN) [2, 3, 6, 7]. The control phenomenon is manifested as close agreement between heart rate and the frequency of volleys of impulses used to stimulate VN [2, 3]. With a change in following frequency of the bursts within a certain range, the heart rate changes correspondingly. For each characteristic of the burst, determined by the number of impulses, there is a corresponding range of control of the cardiac rhythm. With the aid of a successive series of ranges, the cardiac rhythm can be controlled within wide limits [3]. No data could be found in the accessible literature on the effect of activation of the sympathetic nervous system on this phenomenon of heart rate control.

In this investigation the effect of the sympathetic nervous system on heart rate control was studied by means of burst stimulation of the vagus nerve.

EXPERIMENTAL METHOD

Experiments were carried out on 40 adult noninbred cats of both sexes. The animals were anesthetized intraperitoneally with a 1% solution of chloralose–pentobarbital mixture (75 and 15 mg/kg respectively). The right inferior cardiac nerve (ICN) and the right VN were identified and dissected. The peripheral ends of divided nerves were placed on platinum

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TABLE 1. Ranges of Control of Heart Rate (number of beats per minute) during Burst Stimulation of Vagus Nerve Accompanied by Stimulation of Right Inferior Cardiac Nerve in Cats

Frequency of impulses in burst	Statistical parameter	Boundary of range during stimulation of right VN			right VN accompanied by stimulation of right ICN with frequency of 2 Hz			right VN accompanied by stimulation of right ICN with frequency of 4 Hz		
		upper	lower	width of range	upper	lower	width of range	upper	lower	width of range
1	$M \pm m$	123,5±2,80	115,8±2,82	7,7±0,93	150,1±6,63	142,6±6,42	7,5±1,12	167,8±8,49	160,5±9,43	7,3±1,17
	P	<0,001	<0,001	—	0,12	0,03	—	0,26	0,1	—
2	$M \pm m$	115,6±3,36	105,0±4,52	10,6±2,63	136,2±5,20	126,4±5,57	9,8±1,11	155,2±9,97	146,2±9,09	9,0±1,75
	P	<0,001	<0,001	—	0,016	0,001	—	0,20	0,03	—
4	$M \pm m$	110,5±3,34	92,1±3,72	18,4±1,32	122,7±3,92	109,0±5,23	13,7±2,15	141,6±6,65	131,6±6,46	10,0±1,41
	P	<0,001	<0,001	—	<0,001	<0,001	—	0,003	0,001	—
8	$M \pm m$	94,1±3,94	80,2±4,93	13,9±2,50	103,1±5,39	89,5±5,97	13,6±7,55	111,8±4,58	98,5±6,85	13,3±2,71
	P	<0,001	<0,001	—	<0,001	<0,001	—	<0,001	<0,001	—
16	$M \pm m$	71,2±2,60	59,6±4,46	11,6±2,50	78,8±2,60	62,8±4,86	16,0±3,26	84,0±1,50	66,0±5,51	18,0±4,00
		<0,001	<0,001	—	<0,001	<0,001	—	<0,001	<0,001	—

Legend. Significance of differences of P determined relative to original heart rate.

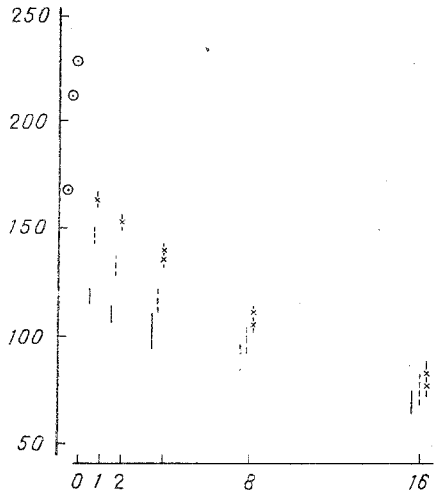

Fig. 1

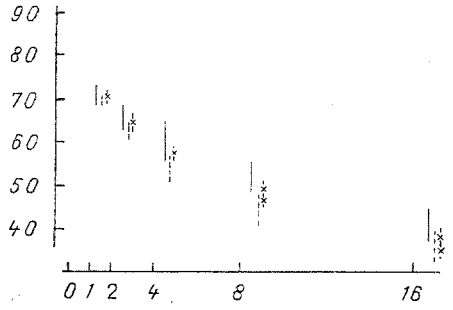

Fig. 2

Fig. 1. Ranges of control of heart rate during burst stimulation of right VN against the background of stimulation of the right ICN in cats. Abscissa, number of impulses in burst; ordinate, heart rate, beats/min, and frequency of bursts of impulses. Circled dot denotes heart rate: 1) initial; 2) against the background of stimulation of ICN with a frequency of 4 Hz. Here and in Fig. 3, continuous line represents range of control during isolated stimulation of VN; broken line, during combined stimulation of VN and ICN with a frequency of 2 Hz; crosses and dashes, during combined stimulation of VN and ICN with a frequency of 4 Hz.

Fig. 2. Effect of stimulation of right VN with bursts of four impulses against the background of stimulation of right ICN with frequencies of 2 and 4 Hz on heart rate. a) Initial ECG; b) isolated stimulation of VN; c) stimulation of VN against the background of stimulation of ICN with a frequency of 2 Hz; d) stimulation of VN against the background of stimulation of ICN with a frequency of 4 Hz. Top of fragment corresponds to upper limit of range of control, bottom part to lower limit. Times of arrival of burst and of periodic stimulation recorded as artefacts on ECG.

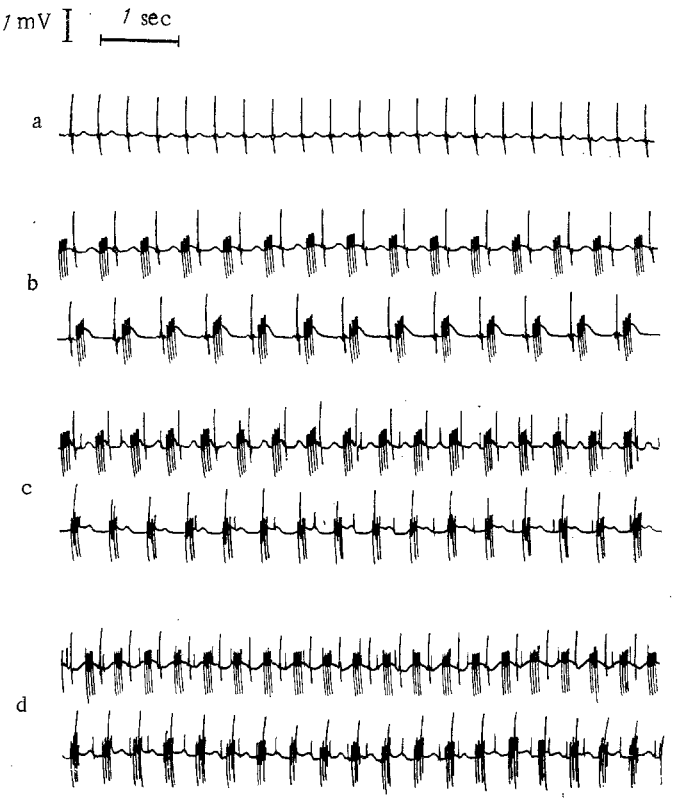

Fig. 3. Ranges of control of heart rate during burst stimulation of right VN against the background of stimulation of right ICN in cats. Abscissa, number of impulses in burst; ordinate, heart rate (in % of background frequency).

bipolar electrodes with interelectrode distance of 2 mm and embedded in a heated mixture of wax and mineral oil. The nerves were stimulated electrically by two ÉSU-2 stimulators. The right VN was stimulated by bursts of square pulses with following frequency of 0.9-2.1 Hz and amplitude of 1.9-6.0 V. Bursts of 1, 2, 4, 8, and 16 impulses were used. The duration of the impulse and frequency of impulse generation in the bursts were 2 msec and 40 Hz respectively. The right ICN was stimulated periodically by square pulses with a frequency of 2 and 4 Hz, and with an amplitude that varied from 7 to 16 V. In the course of the experiment the animals' ECG and blood pressure were recorded. After the original cardiac rhythm had been monitored, burst stimulation of the right VN was carried out. The limits of control were determined. Stimulation of the right ICN with a frequency of 2 Hz was applied. Against this background the limits of the ranges of control were again determined. Ranges of control during stimulation of the right ICN with a frequency of 4 Hz were determined similarly.

EXPERIMENTAL RESULTS

The stimulation of ICN led to an upward shift of the ranges of heart rate control along the frequency scale (Table 1; Figs. 1 and 2). During isolated stimulation of VN, the cardiac rhythm was controlled within limits of between 123.5 ± 2.8 and 59.6 ± 4.46 beats/min. During simultaneous stimulation of the right ICN with a frequency of 2 Hz and the right VN with bursts of impulses the ranges of control occupied the frequency band from 150.1 ± 6.83 to 62.8 ± 4.86 beats/min. The width of the individual ranges varied from 7.5 ± 1.12 to 16.0 ± 3.26 beats/min. In response to stimulation of ICN with a frequency of 4 Hz the following results were obtained: The ranges of control were between 167.8 ± 8.49 and 66.0 ± 5.51 beats/min, and the width of the ranges of control varied from 7.3 ± 1.17 to 18.0 ± 4.00 beats/min.

The upward shift of the limits of the ranges along the frequency scale depended mainly on the intensity of stimulation of the right ICN and the number of impulses in the burst stimulating VN. The largest upward shift of the range along the frequency scale was observed during stimulation of the right VN with a "burst" of one impulse, against the background of stimulation of the right ICN with a frequency of 4 Hz. The limits of the range

of control did not differ significantly from the original heart rate ($P = 0.26$), as a result of which control of the cardiac rhythm was achieved in a frequency band close to the original rhythm. With an increase in the number of impulses in the burst the degree of upward shift of the limits of the ranges of control along the frequency scale was reduced, and when there were 16 impulses in the burst the limits of the ranges did not differ significantly from those observed during isolated stimulation of VN.

The changes described above were compared with the original values observed before stimulation of ICN. Isolated stimulation of the right ICN with a frequency of 2 Hz led to an increase in heart rate from 161.7 ± 2.38 to 212.1 ± 2.93 beats/min. On stimulation of the right ICN with a frequency of 4 Hz the heart rate was increased from 171.5 ± 3.15 to 228.1 ± 4.18 beats/min. The ranges of control of the heart rate, as a percentage of the rate newly established under the influence of stimulation of ICN, are shown in Fig. 3. Expressed as percentages, the ranges of control did not differ significantly.

Control of the heart rate in warm-blooded animals has been achieved previously [1, 4] only within a frequency band below the original heart rate. The results now described are evidence that the degree of sympathetic activity has a significant influence on manifestation of the phenomenon of control of the heart rate, and that stimulation of ICN enables the heart rate to be controlled within the limits of the original rhythm. These data are in agreement with observations on frogs, in which sympathetic and parasympathetic fibers run to the heart in a common vagosympathetic trunk, During control of the heart rate in these animals, both sympathetic and parasympathetic structures are stimulated simultaneously. The possibility of control within a range close to the original rhythm, or even at a higher frequency, also was demonstrated in this case [5]. The sympathetic nervous system thus corrects reception by the heart of controlling impulses arriving along VN.

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