ACTIVITY OF THE RESPIRATORY CENTER AS A PAIRED STRUCTURE DURING STIMULATION OF THE ANTERIOR GYRUS CINGULI IN RATS

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A very interesting aspect of the solution to the general theoretical and practical problems of paired brain activity is the analysis of such paired activity of the respiratory center (RC) in the medulla. Some particular features of the separate activity of halves of the respiratory center have been described, and the role of many suprabulbar structures in the genesis of asymmetry and asynchronism of respiration has been noted [6-8]. The question of the role of limbic structures in the activity of RC as a paired formation has not been adequately studied. Yet an important role in the mechanism of homeostasis [1, 3] and also in the central mechanisms of organization and control of the activity of visceral systems [2] has been ascribed to limbic structures.

The object of this investigation was to study the role of the anterior region of the gyrus cinguli, as one of the limbic structures, in the shared and separate activity of the right and left halves of RC.

EXPERIMENTAL METHOD

Electrical activity of the external intercostal muscles on the right and left sides of the thorax and unit activity of the right and left halves of RC in response to electrical stimulation (4-15 V, 60 Hz) of the anterior region of the right or left gyrus cinguli were studied in 65 acute experiments on rats of both sexes weighing 160-200 g, anesthetized with urethane (1.3 g/kg, intraperitoneally). Electrical activity of the respiratory muscles (RM) was recorded by bipolar needle electrodes, a UBP2-03 amplifier, S1-33 oscilloscope, and FOR-2 camera. Activity of respiratory neurons (RN) was derived extracellularly, on each side of the medulla alternately, by means of glass microelectrodes (tip 5-10 μ in diameter) from the region located 1.5 mm rostrally to the obex, at a depth of 0.5-1.5 mm, and 2 mm laterally to the midline. The results were subjected to statistical analysis [4].

EXPERIMENTAL RESULTS

The results showed that stimulation of the anterior regions of the right and the left gyrus cinguli caused various changes in the global electromyogram (EMG) of the external intercostal muscles on both sides of the chest and in activity of RN in both halves of RC: an increase or decrease in the amplitude and frequency of oscillations in the volley, lengthening or shortening of the volley and of the EMG interval between volleys (Table 1), a decrease in discharge frequency and lengthening of the interspike interval in RN activity. In the overwhelming majority of cases asymmetry of bioelectrical activity of RM and RN developed in response to stimulation of the gyrus cinguli. In some experiments asymmetry of electrical activity of RM was formed by an increase in amplitude of the oscillations of one side of the chest and a decrease on the other side, and also by an increase or decrease in amplitude of EMG oscillations on both sides of the chest, but to different degrees. Asynchronism was formed less frequently: a decrease in discharge frequency in the volley on the side of the chest contralateral to stimulation and an increase on the ipsilateral side, or an increase or decrease in discharge frequency in the volleys on both sides of the chest, but differing in intensity.

Asymmetrical and asynchronous changes in electrical activity of RM and RN were transient in character, and 1-9 sec after stimulation all parameters of EMG and unit activity were restored to their original values. The duration of the volley and of the interval between volleys of the EMG was restored first, followed by the discharge frequency in the volley, and last of all, the amplitude of oscillations of the EMG, The order of recovery of the parameters of the EMG and unit activity suggests that the anterior region of the gyrus cinguli, like the cortex [5], has a predominant effect on the intensity of discharges in RC and a less marked effect on its pacemaker function. On this basis, like other workers [9], we suggest that regulation of the depth and frequency of respiration rests on different mechanisms.

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TABLE 1. Changes in EMG Parameters of External Intercostal Muscles on Right (A) and Left (B) Sides of Chest During Stimulation of Anterior Region of Right (I) and Left (II) Gygnus Cinguli in Rats (M ± m)

Character of changes	State	Amplitude, μV		Discharge frequency in volley, spikes/sec		Duration of volley, sec		Interval between volleys, sec	
		A	B	A	B	A	B	A	B
Increase in test parameters	Initial	104,7±45,5	141,0±33,2	140,0±11,92	162,0±19,6	0,3±0,05	0,36±0,05	1,82±0,38	1,85±0,37
	I	130,7±53,3	165,4±33,6	176,0±14,8	190,0±22,6	0,38±0,07	0,44±0,15	2,28±0,30	2,18±0,30
	P	>0,76	>0,62	>0,06	>0,37	<0,001	>0,62	>0,37	>0,48
	II	158,0±20,2	203,0±19,9	159,4±21,28	192,6±18,2	0,55±0,04	0,50±0,05	1,66±0,73	2,22±0.66
	P	>0,48	>0,13	>0,19	>0,06	>0,55	>0,09	>0,37	>0,27
Decrease in test parameters	Initial	140,0±49,2	171,0±28,5	137,0±17,4	149,3±12,2	0,36±0,04	0,42±0,12	1,91±0,69	1,64±0,46
	I	116,0±64,4	117,1±19,5	99,0±9,8	111,1±10,4	0,27±0,04	0,36±0,01	1,56±0,6	1,37±0,40
	P	>0,76	>0,13	>0,06	<0,02	<0,001	>0,62	>0,76	>0,69
	II	86,2±22,4	135,5±32,0	133,3±10,8	141,2±12,7	0,29±0,11	0,42±0,03	1,53±0,20	1,43±0,41
	P	>0,76	>0,69	<0,03	>0,07	>0,19	>0,48	>0,42	>0,48

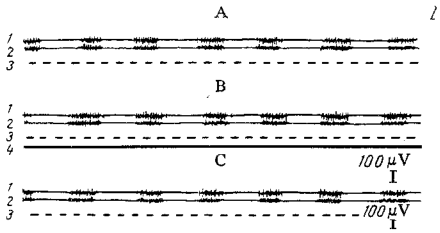

Fig. 1

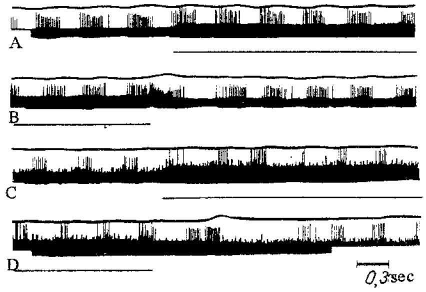

Fig. 2

Fig. 1. Activity of external intercostal muscles on left (1) and right (2) sides of chest before (A), during (B), and after (C) stimulation. 3) Time marker, 0.3 sec; 4) marker of stimulation.

Fig. 2. Activity of respiratory neurons on right (A, B) and left (C, D) sides of medulla during stimulation of anterior region of right gyrus cinguli in rats. In A, B, C, D, from top to bottom: external respiration, activity of RN, marker of stimulation. Time marker 0.3 sec.

Some particular features of the influence of the anterior regions of the left and right gyrus cinguli on electrical activity of RM and RN were discovered. During stimulation of the left gyrus cinguli on the side ipsilateral to stimulation mainly an increase in the amplitude, frequency, and duration of the EMG volley took place. On the side contralateral to stimulation the changes were less marked. Stimulation of the anterior region of the right gyrus cinguli in most cases caused a decrease in the amplitude and frequency of oscillations in the volleys on both sides and shortening of the volleys on the ipsilateral side. These findings suggest the presence of functional asymmetry of the anterior regions of the right and left gyrus cinguli, reflected in the predominantly stimulating effect of the left and the predominantly inhibitory effect of the right (Fig. 1) gyrus cinguli on activity of RC.

Comparative analysis of unit activity of the right and left halves of RC and electrical activity of RM on both sides of the chest showed that responses of the neurons to stimulation of the left or right gyrus cinguli were more uniform and were expressed mainly as a decrease in discharge frequency and an increase in the interspike interval (Fig. 2). In some observations the abundance of the changes in electrical activity of RM in response to stimulation of the gyrus cinguli differed in the right and left halves of RC.

These experiments thus showed that during stimulation of the gyrus cinguli, activity of the two halves of RC may be asynchronous. The anterior region of the gyrus cinguli, which exerts influences of various kinds on RC, induces the formation of different types of asymmetry and asynchronism of electrical activity of RM and RN. The character of the asymmetry of electrical activity of RM and RN thus revealed depends to a definite degree on the nature of the influence of the gyrus cinguli on RC: the predominantly inhibitory action of the anterior region of the right gyrus cinguli and the predominantly excitatory influence of the anterior region of the left gyrus cinguli, as well as the predominant influence of the gyrus cinguli on the intensity of discharges in RC.

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