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ROLE OF THE CORPUS CALLOSUM IN PAIRED ACTIVITY OF THE RESPIRATORY CENTER

N. A. Merkulova and O. A. Vedyasova UDC 612.282-06:612.826.1

KEY WORDS: respiratory center; respiratory muscles; callosotomy; asymmetry.

An interesting aspect of the study of the structural and functional organization and regulation of activity of the respiratory center (RC) is the study of its behavior as a paired formation. Close axon-dendritic interaction has been demonstrated between respiratory neurons (RN) of the ventral and dorsal respiratory groups of the right and left halves of the medulla [12-15] and connections have been found between the nuclei of the medial zone and respiratory nuclei of the lateral zone [9], which must play a definite role in the functional unification of the two halves of RC as a single mechanism. At the same time it has been shown that an essential role in paired activity of RC is played by suprabulbar structures [4, 5, 10], including the cerebral commissures [4, 6].

The aim of the present investigation was to study the role of the corpus callosum in the mechanisms of integration of activity of the two halves of RC.

EXPERIMENTAL METHOD

In acute experiments on 63 cats weighing 2.3-3.5 kg anesthetized with pentobarbital (40 mg/kg, intraperitoneally) responses of RN of symmetrical nuclei of the right and left halves of RC and changes in the electromyograms (EMG) of the external intercostal muscles on both sides of the chest induced by successive stimulation of the right and left posterior sigmoid and marginal gyri, were studied before and after callosotomy. Unit activity of RN was derived extracellularly by glass microelectrodes (diameter of tip 3-10 μ), filled with 3 M KCl solution, in the region of the nuclei of the tractus solitarius, nucleus ambiguus, and nucleus retroambigualis, alternately on the right and left sides, and was recorded by means of a UBP1-02 amplifier and S1-18 oscilloscope with FOR-2 photo-optical recorder. EMG of the right and left respiratory muscles (RM) was recorded simultaneously by needle bipolar electrodes, using a UBP2-02 amplifier, S1-33 oscilloscope, and FOR-2 recorder. The cerebral cortex was stimulated through silver bipolar electrodes with interelectrode distance of 1.5 mm by a pulsed current (10-20 V, 50-100 Hz). The corpus callosum was divided with a scalpel and completeness of division was verified morphologically. Activity of RN was analyzed by the method in [8]. During analysis of the EMG the duration of the volleys and intervolley intervals and the frequency and amplitude of oscillations in the volley were determined. The results were subjected to statistical analysis by the direct difference method [7].

EXPERIMENTAL RESULTS

Stimulation of the posterior sigmoid and marginal gyri both before and after callosotomy induced responses in the overwhelming majority of RN tested in both halves of RC, which were manifested mainly as inhibition of activity, and also as various changes in components of the EMG of RM on the right and left sides of the chest.

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TABLE 1. Mean Discharge Frequency (in percent of initial value) in Volleys of Activity of Inspiratory Neurons of Right (A) and Left (B) Nuclei of Tractus Solitarius during Stimulation of Right and Left Posterior Sigmoid (T.1 and T.2) and Marginal (T.3 and T.4) Gyri before and after Callosotomy

Site of stimulation	Statistical parameter	Before callosotomy		After callosotomy	
		A	B	A	B
T. 1	%	20,1	27,1	29,1	20,7
	D $\pm m$ (D)	4,9±0,7106	7,0±1,7110	7,3±1,2663	4,0±1,7424
	P	<0,001	<0,001	<0,01	0,05
T. 2	%	19,8	22,7	29,4	37,0
	D $\pm m$ (D)	5,7±0,7230	7,7±2,7135	8,0±3,8621	6,4±2,1199
	P	<0,0001	<0,05	<0,05	0,05
T. 3	%	24,4	36,1	21,8	14,8
	D $\pm m$ (D)	5,1±0,8616	9,0±2,4700	6,3±2,1200	8,2±3,5613
	P	<0,01	<0,01	<0,05	0,05
T. 4	%	21,4	16,7	36,4	29,1
	D $\pm m$ (D)	4,7±0,7459	4,6±1,2800	9,7±1,9210	13,4±5,0237
	P	<0,001	<0,01	<0,01	0,05

Legend. D) Mean difference between values of mean discharge frequency before and during stimulation; m(D) denotes error of mean of difference; P) probability.

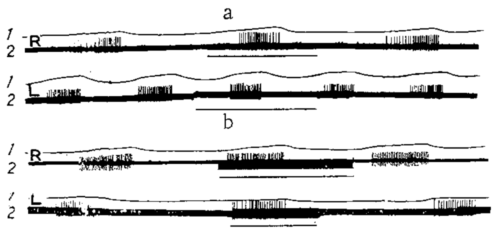

Fig. 1. Responses of inspiratory neurons of right (R) and left (L) nuclei of tractus solitarius to stimulation of posterior sigmoid gyrus of left hemisphere before (a) and after (b) division of corpus callosum. 1) Pneumogram, 2) unit activity. Horizontal line is marker of stimulation.

Before callosotomy, in response to unilateral cortical stimulation RN of the contralateral half of RC responded more often (77.7%) than RN of the ipsilateral half (69.0%). After callosotomy the number of RN responding to stimulation of the cortex of the ipsilateral hemisphere increased (79.3%) and the number of RN responding to contralateral stimulation decreased (67.3%).

The effects of unilateral stimulation of any of the above-mentioned cortical zones on activity of symmetrical RN before and after callosotomy thus depended on the position of the stimulated region in the cerebral hemisphere ipsilateral or contralateral relative to the side of the recorded RN. Not only quantitative but also qualitative differences were observed in the response of right- and left-sided RN. Both before and after callosotomy responses of RN of the symmetrical respiratory nuclei induced by cortical stimulation were mainly asymmetrical. In most cases the effects of stimulation of identical areas of the cortex on RN activity in each half of RC were in the same direction, most frequently inhibitory, largely due to the specific character of corticofugal influences on different groups of RN [11], and asymmetry was manifested as differences in the abundance of the neuronal responses (Table 1). Before callosotomy asymmetry in RC activity was formed as a rule on account of the more abundant responses of RN located in the half of RC contralateral relative to stimulation, but after division of the corpus callosum, on account of predominance of responses of RN on the ipsilateral side (Fig. 1).

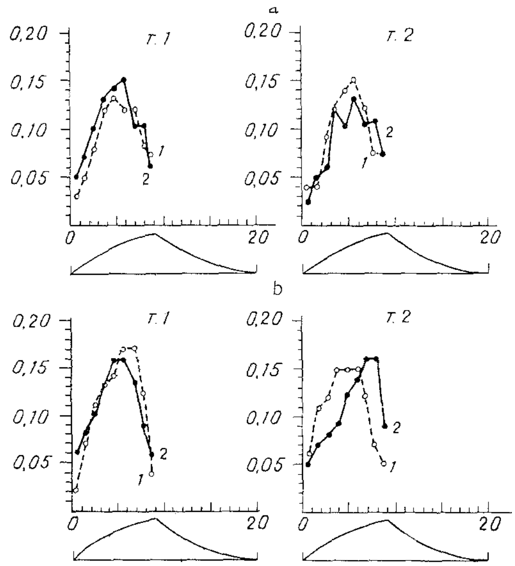

Fig. 2. Distribution of spike density in discharges of inspiratory neurons of left nucleus ambiguus before and during stimulation of right (T.1) and left (T.2) posterior sigmoid gyri before (a) and after (b) callosotomy. 1) Distribution of spike density before, 2) after stimulation.

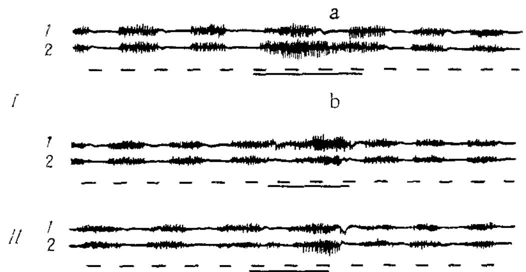

Fig. 3. Changes in EMG of external intercostal muscles on right (1) and left (2) sides of chest during stimulation of right (I) and left (II) posterior sigmoid gyri before (a) and after (b) callosotomy. Continuous line — time marker 0.3 sec; horizontal line — marker of stimulation.

This rule was found to extend to changes in all parameters of activity of the different types of RN, and particularly clearly in the redistribution of interspike intervals. Before callosotomy the character of distribution of spikes in volleys of activity of RN on the contralateral side of RC was found to be least resistant to cortical stimulation. After callosotomy, the form of distribution of interspike intervals changed more conspicuously in RN of the ipsilateral half of RC (Fig. 2).

Asymmetry of activity of RN, which developed in most cases of stimulation of the posterior sigmoid and marginal gyri, was more varied than asymmetry of the responses of RN, and unlike the latter, it was usually manifested as differences in the direction of changes in the frequency-temporal and amplitude characteristics of EMG on the right and left sides of the chest (Fig. 3). The diversity of asymmetry of the electrical activity of RN was perhaps associated with the complexity and variety of the pathways transmitting central and peripheral influences to the efferent component of the respiratory system [1-3]. Comparison of the intensity of the changes in EMG of RN to ipsilateral and contralateral cortical stimulation showed that the character of and relationship between asymmetry of RM activity before and after callosotomy were the same as for RN (reflecting to some degree the processes taking place in RC).

The corpus callosum, which maintains functional relations between each hemisphere and the ipsilateral and, more especially, the contralateral halves of RC, thus participates in the mechanisms of paired activity of RC. This participation is manifested by the fact that the corpus callosum determines the number of responding RN of the right and left halves of RC, and also the character of their responses to cortical stimulation.

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PROTHROMBIN — THE SUBSTRATE FOR BLOOD PLASMA KALLIKREIN AND FACTOR XIIa

I. P. Baskova, A. Tuero,
Yu. V. Krizhevskaya, G. A. Yarovaya,
and É. G. Mirkamalova

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The blood clotting system is a cascade of successive reactions of activation of proenzymes (inactive clotting factors) into the corresponding enzymes (active clotting factors) and it is postulated that each enzyme can activate only one, strictly definite, specific precursor protein [9]. However, many recent investigations have shown that this principle is infringed. Limited proteolysis of the same proenzymes can take place by various enzymes, not only of the blood clotting system, but also of the fibrinolytic, kallikrein-kinin, and complement systems which are functionally closely connected with it [15].

It is accordingly important to study the action of the various blood plasma proteolytic enzymes on prothrombin, the precursor of the enzymes thrombin, and to assess the possibility of generation of thrombin activity under these circumstances. We know that factor Xa is a

Laboratory of Physiology and Biochemistry of Blood Clotting, Moscow State University. Department of Biochemistry, Postgraduate Medical Institute, Moscow.

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