CHANGES IN UNIT ACTIVITY OF MEDULLARY RESPIRATORY NEURONS AFTER INTRAVENOUS INJECTION OF ATP

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UDC 612.282.014.46:547.963.32

At the time of intravenous injection of adenosinetriphosphoric acid (ATP) into cats anesthetized with pentobarbital, the duration of the volleys in the medullary expiratory neurons, the number of spikes per volley, and their mean frequency were all reduced. After 15-150 sec the mean frequency of spikes in the volley from the inspiratory neurons was higher than initially. The response remained the same in the expiratory neurons as during injection of ATP. Comparison of these results with those of earlier investigations suggests that ATP weakens the action of pentobarbital and other drugs inhibiting respiration.

Adenosinetriphosphoric acid (ATP) is the chief source of energy of the muscles [8], the carotid sinus receptors [1], the sodium pump [7], and for changes in the excitability of the chemoreceptors of the skin [9] and for other physiological functions [5]. Little information is available on the role of ATP in the activity of the respiratory center [1].

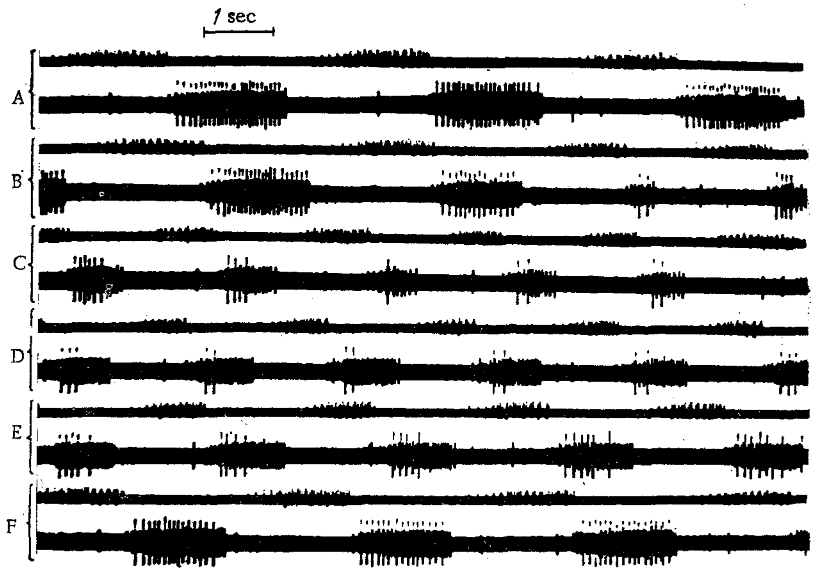

Fig. 1. Electrical activity of diaphragm (above) and of expiratory neuron (below) before (A) and after (B, C, D, E, F) intravenous injection of ATP.

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Group of Academy of Medical Sciences of the USSR, Kuibyshev Polytechnic Institute. Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 77, No. 3, pp. 3-6, March, 1974. Original article submitted January 3, 1973.

TABLE 1. Changes in Unit Activity of Medullary Respiratory Neurons During Intravenous Injection of ATP

Time of observation	Inspiratory neurons: no. of spikes per volley	duration of volley (in sec)	mean frequency (spikes/sec)	interval between volley (in sec)
Before injection of ATP	55,66±5,49	3,04±0,31	19,25±3,38	3,61±0,63
During injection of ATP	49,56±6,82	3,64±0,46	13,15±2,04	
P	>0,05	>0,05	>0,05	
15-150 sec after injection of ATP	39,27±1,82	1,83±0,46	20,24±3,64	1,48±0,72
P	<0,02	<0,05	>0,05	<0,05

Time of observation	Expiratory neurons: no. of spikes per volley	duration of volley (in sec)	mean frequency (spikes/sec)	interval between volley (in sec)
Before injection of ATP	73,41±15,65	2,24±0,40	33,01±5,34	3,55±0,39
During injection of ATP	38,54±5,05	1,21±0,26	20,01±3,15	
P	<0,001	<0,05	<0,05	
15-150 sec after injection of ATP	13,27±2,81	0,57±0,10	20,04±2,79	1,90±0,21
P	<0,01	<0,001	<0,05	<0,01

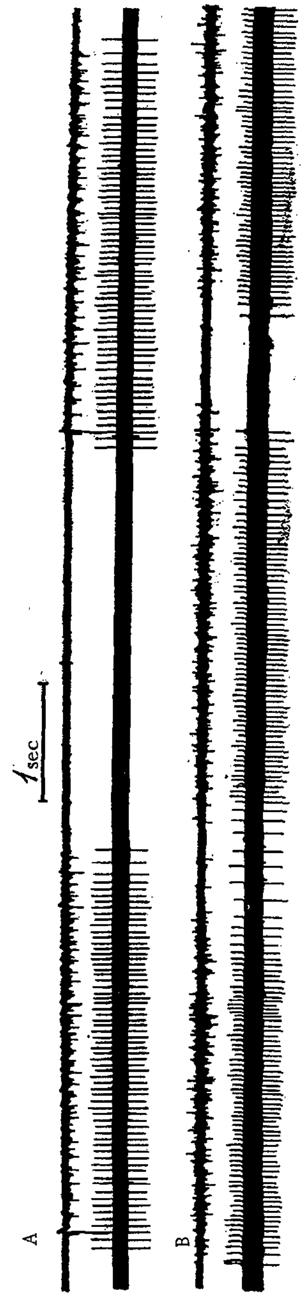

Fig. 2. Activity of diaphragm (above) and of inspiratory neuron (below) before (A) and after (B) intravenous injection of ATP.

It was accordingly decided to study the activity of the respiratory neurons after injection of ATP into the blood stream.

EXPERIMENTAL METHOD

Cats were anesthetized with pentobarbital (40-50 mg/kg). Unit activity in the respiratory center was recorded by extracellular glass microelectrodes. Activity of the diaphragm was recorded simultaneously with concentric electrodes. ATP (0.3-0.5 ml of the 1% solution) was injected into the femoral vein. The duration of the volleys, the number of spikes per volley, intervals between volleys, and the over-all distribution of spikes in the volley relative to the phases of the respiratory cycle were analyzed. Altogether, nine inspiratory and 12 expiratory neurons were tested.

EXPERIMENTAL RESULTS

The results in Table 1 show that during injection of ATP the number of spikes and their mean frequency in the expiratory neurons were reduced.

The duration of the volleys and the number of spikes in them began to decrease in the inspiratory neurons 15-150 sec after the injection of ATP. The mean spike frequency per volley of the inspiratory neuron, however, showed a tendency to increase. Meanwhile, the duration of the volleys and the number of spikes in the expiratory neurons continued to decrease while the mean frequency of spikes in the volleys remained almost the same as during the injection of ATP. These responses coincided with considerable shortening of the intervals between volleys. With the course of time the duration of the volleys and the number of spikes in them in the expiratory neurons became unequal, and gradually all the parameters returned to their initial values (Fig. 1).

In those inspiratory neurons whose volleys appeared before the beginning of the phase of inspiration and ended at the beginning of the phase of expiration a continuous discharge of spikes sometimes appeared under the influence of ATP (Fig. 2).

The over-all distribution of spikes relative to the phases of the respiratory cycle was unchanged by the injection of ATP, but sometimes the maximum of the discharges was shifted during the phase of the cycle – in the inspiratory neurons toward the end of inspiration and in the expiratory neurons toward the beginning of expiration.

The characteristics of unit activity of the respiratory neurons following injection of ATP into the blood stream are similar to those in unanesthetized cats [6]. ATP thus apparently weakens the narcotic action of pentobarbital and increases the excitability of the respiratory center. This conclusion is confirmed by earlier experiments in which injection of ATP into the fluid perfusing the cerebral ventricles of cats prevented the depression of respiration by subsequent injection of atropine [4], whereas injection of ATP after depression of respiration and the reflex excitability of the respiratory center by cocaine potentiated the restorative action of adrenalin [2]. This conclusion is also confirmed by disappearance of the reflex excitability of the respiratory center under the influence of anesthetics [3] disturbing oxidative phosphorylation and reducing the production of ATP.

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