

THE EFFECT OF THE RESISTANCE TO RESPIRATION
ON THE FUNCTIONAL STATE OF THE RESPIRATORY CENTER
IN DOGS IN CHRONIC EXPERIMENTAL CONDITIONS

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During respiration, the functional state of the respiratory center undergoes considerable changes through resistance, and these are reflected in the slowing of the rate and increase in the depth of respiration [1, 2, 6-10].

Acute experiments on dogs, conducted in this laboratory [4], have shown that the slowing of the rate and increase in the depth of respiration may be observed not only during respiration against resistance, but also after changing to free respiration. In some cases this action took the form of adoption of the rhythm established during respiration against resistance.

This paper describes an investigation of the influence of the resistance to respiration on the functional state of the respiratory center in dogs in chronic experimental conditions.

EXPERIMENTAL METHOD

The investigation was conducted on 3 adult dogs: altogether 97 chronic experiments were conducted, varying in duration from 1 h 30 min to 1 h. The observations began 30 min after the dog had been placed in the experimental harness.

The resistance to respiration was created by application of the mask of a respirator for 5, 10, or 30 min (resistance to respiration 5-10 mm water). In the course of one experiment the mask was worn from 3-5 times, with intervals of 30 min between applications. The respiratory movements were recorded by means of a pneumograph on a kymograph. The ECG was recorded in standard lead II on a type EKP-S-2 electrocardiograph. In some experiments the dogs received a subcutaneous injection of morphine in a dose of 0.01-0.02 g.

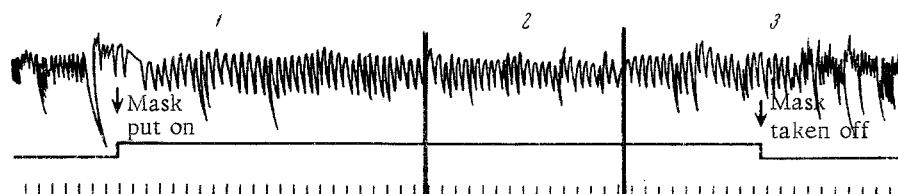
EXPERIMENTAL RESULTS

During respiration against resistance, a slowing of the rate and a considerable deepening of the respiratory movements were observed in all the dogs.

At the same time as the changes affecting respiration, in all the dogs the heart rate was slowed (by 10-25 beats/min), and in the individual animal the most marked slowing of the heart was recorded in experiments in which the initial rate was high.

For control purposes, a small series of experiments was carried out in which the mask was worn but without incorporating resistance. These experiments showed no changes in the respiration and pulse. The results of the investigations carried out during respiration against resistance were in agreement with data in the literature cited above.

The changes in the ECG during respiration against resistance demonstrated the development of respiratory arrhythmia or an increase in its severity under the influence of the resistance to respiration; no regular changes were observed in the pattern of the waves and intervals of the ECG in these circumstances.



Changes in the amplitude and frequency of respiration during respiration against resistance and immediately after removal of the resistance to respiration. Experiment No. 28 on October 6, 1961, on the dog Vagus. 1) Initial pneumogram during the first 2 min after inclusion of resistance to respiration (respiration rate fell from 42 to 20/min; amplitude rose from 9 to 19 mm); 2) pneumogram at 5th min of respiration in mask (respiration rate 24/min; amplitude 15 mm); 3) pneumogram at 10th min of respiration in mask and in after-period; the frequency and amplitude established during respiration in the mask were maintained for 15 sec; respiration rate 24/min, amplitude 15 mm.

After removal of the mask, in most (68 of 97) experiments characteristic changes in respiration were observed for a considerable length of time: the rhythm and amplitude established during respiration against resistance were maintained, or alternatively the respiration rate was slightly faster than during respiration in the mask, although slower than initially; the amplitude of the respiratory movements was lowered, but it was nevertheless higher than in the initial state (before the mask was applied).

Effect of Small Doses of Morphine on Amplitude and Frequency of Respiratory Movements during Respiration against Resistance and in Period of After-Effect

Date and no. of expt.	Amp. of respiratory movements (in mm)						Respiration rate (per min)					
	before injection of morphine			after injection of morphine			before injection of morphine			after injection of morphine		
	initial back- ground	resp. in mask	after- effect	initial back- ground	resp. in mask	after- effect	initial bkgrd.	resp. in mask	after- effect	initial bkgrd.	resp. in mask	after- effect
The dog Rex												
21 17/VIII 1962	5	11	9	7	10	7	26	18	24	10	10—14	14—18
22 22/VIII 1962	7	12—13	12	9	11	9	20	14	19	14	14	16
24 29/VIII 1962	6	9	8	7	8	8	18	16	17	13	16—12	18

The dog Roza

23 15/IX 1962	1,5—3	4—6	2—3	2—4	2—4	2	26	14	40	12	10	10
24 19/IX 1962	1,5—3	3—6	2—3	2—3	3—4	2—3	26	12—16	19	9	10	12
33 2/I 1962	2	4	2	2	2	2	28	16	28	14	14	14

The duration of the period of the after-effect varied from 10 sec to 1 min 20 sec (see figure). In 29 experiments, when the resistance to respiration was removed, a reversion to the initial rate and depth of the respiratory movements was observed immediately.

During the period of the after-effect the changes in the rhythm and amplitude of the respiratory movements were by no means parallel: the driving of the rhythm of the respiratory movements developed after the change in the depth of the respiratory excursions.

When the experimental results were analyzed, a gradual slowing of the respiration rate from 1 experiment to the next was observed throughout the period of the investigation. These changes in the level of activity of the respiratory center were associated with the long period spent by the dog in the harness and with the dog's becoming accustomed to breathing through the mask.

Similar changes in the activity of the respiratory center were observed in this laboratory during experiments by V. S. Raevskii and A. I. Kruglyi [3] on two dogs to investigate their gas exchange. Long and frequent training of the animals in the harness for 6 months led to a considerable slowing of the respiration rate.

The administration of a small dose of morphine, by excluding the influence of the cerebral cortex on the subcortical centers, is known [5] to increase the depth and to slow the rate of respiration and also to slow the heart rate. In the present experiments the stimulant action of the resistance to respiration was less marked in character against this background (see table).

The injection of morphine depressed the manifestation of the reaction of the respiratory center during the after-period also. The changes in the heart rate in the form of its slowing during respiration against resistance were also diminished by the action of morphine.

It is concluded from these findings that the dissociation of the cerebral cortex from the subcortical centers depresses the reactivity of the respiratory center to adequate stimulation.

SUMMARY

Three adult dogs were used in 97 chronic experiments to study the influence of resistance to respiration on the functional state of the respiratory center. Resistance to respiration was produced by using a respiratory mask for 5-10-30 min. In a number of experiments, the animals were given morphine in 0.01 g doses. The pneumogram and electrocardiogram were registered in the second standard lead.

Respiration with resistance was accompanied by a slow-down in the rhythm of respiratory movements and an increase in the amplitude; in 68 experiments out of 97, these changes were noted also in the period of after-effect. At the same time, in the process of training of the animals changes in the amplitude of respiratory movements arrived first, and duplication in their rhythm came on later. Morphine reduced the reaction of the respiratory center under the influence of increased resistance to respiration.

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