REGIONAL NEUROVASOMOTOR RESPONSES OF THE PULMONARY CIRCULATION

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The blood volume and blood flow in the lungs with the body in the horizontal and vertical position and during stimulation of sympathetic and vagus nerves were studied by the method of regional electroplethysmography in experiments on anesthetized cats with an intact thorax. The hydrostatically more heavily loaded regions of the lungs were found to be more labile toward the action of a neurogenic stimulus, as was manifested by an increase in the parasympathetic vasomotor response of the basal regions and a decrease in the response of the apical regions with the body in a vertical position. The results suggest the existence of regionally differentiated mechanisms of vasomotor control in the pulmonary circulation, aimed at compensating for postural changes in the pulmonary hemodynamics.

KEY WORDS: Lungs; circulation; regional differentiation; neurogenic vasomotor responses.

It has recently become clear that many aspects of the physiology and pathology of the lungs cannot be adequately understood without making allowance for regional differences in the pulmonary hemodynamics [1, 9, 10, 12].

We showed previously [4-7] that the direct vasomotor action of the vagus nerves on the pulmonary circulation consists of an increase in the blood volume in the lungs, whereas the action of the sympathetic nerves is to reduce it. The magnitude of these effects differs in different parts of the lungs. The possibility cannot be ruled out that regional inequality of neurovasomotor reponses of the pulmonary circulation may depend on the state of the regional pulmonary hemodynamics.

The investigation described below was undertaken to study this problem.

METHODS

Experiments were carried out on 43 cats with an intact thorax, anesthetized with pentobarbital (40-50 mg/kg, intraperitoneally), and artificially ventilated after administration of listhenon. During preparatory operations the sympathetic and vagus nerves were isolated in the neck and tracheotomy performed. The animal was fixed on a tilting table, the angle

TABLE 1. Some Indices of the Regional Pulmonary Hemodynamics in Different Positions of the Body in Space and during Stimulation of Autonomic Nerves

Position of animals	Regions	CO	V	CO	V	Delta V, ml/100 cm³	
		ml/100 cm³		DI		VN	SN
Horizontal	Apical	280±22	12,4±0,4	0,95	0,98	0,41±0,04	0,21±0,02
	Ventrobasal	258±17	10,8±0,3	0,88	0,85	0,45±0,03	0,23±0,01
	Dorsobasal	335±18	14,6±0,5	1,15	1,13	0,48±0,03	0,25±0,03
Vertical	Apical	88±7	4,8±0,3	0,37	0,48	0,33±0,03	0,20±0,02
	Ventrobasal	306±16	12,2±0,4	1,28	1,23	0,62±0,04	0,24±0,02
	Dorsobasal	320±17	12,8±0,4	1,34	1,29	0,51±0,04	0,29±0,04

Legend. CO) cardiac output; V) blood volume; VN) vagus nerve; SN) sympathetic nerves; DI) distributive index; Delta V) change in blood volume.

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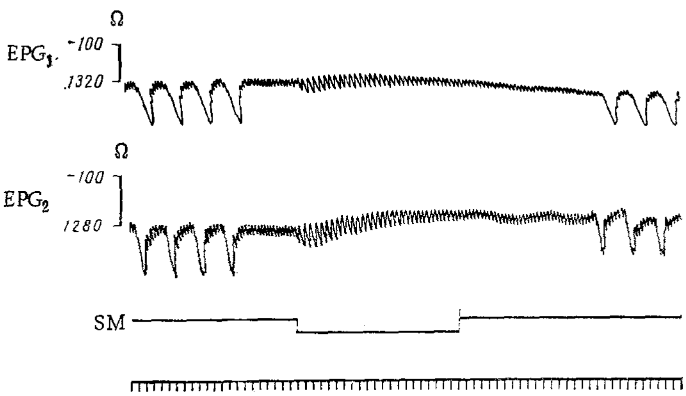

Fig. 1. Simultaneous recording of electroplethysmograms from dorsobasal (EPG_1) and ventrobasal (EPG_2) regions of right lung during stimulation of ipsilateral vagus nerve with animal in horizontal position. From top to bottom: electroplethysmograms, stimulation marker (SM), time marker (1 sec). Basic resistance and calibration values given in ohms.

of tilt of which could be varied smoothly from 0 to 90°. The nerves were stimulated by a current of supply system frequency and with a voltage of 3 V until the maximal effect was achieved. Artificial respiration was stopped during stimulation of the nerve. The blood volume and blood flow in different parts of the lungs were studied by the method of regional electroplethysmography [2, 3], by means of which these parameters can be evaluated quantitatively and repeatedly [3, 8]. The electroplethysmograms were recorded from the following regions of the lungs: apical, medial, and basal, for each of which dorsal and ventral were distinguished. The location of the electroplethysmographic transducers, introduced along the air passages, was verified by fluoroscopy in frontal and lateral projections of the lungs.

RESULTS

The results of investigation of the blood flow and blood volume of different regions of the lungs in animals in the horizontal (lying supine) and vertical (head uppermost) positions are given in Table 1. As they show, the blood flow and blood volume of the lungs vary and have a positive gradient in the direction of the force of gravity, irrespective of the position of the body in space. When the position of the body was changed, a redistribution of the blood flow and blood volume in the lungs took place. In the vertical position, there was greater regional inequality of the pulmonary hemodynamics than in the horizontal position. These results are in good agreement with the concept of regional variation in functions of the lungs and also with results obtained by other workers [1, 11, 12].

Investigation of regional neurogenic vasomotor responses depending on the position of the body revealed differences between the values of the parasympathetic effects of an increase in blood volume for the dorsobasal regions of the lungs in the horizontal and vertical positions in cases when a change to the vertical position was accompanied by a decrease in their relative blood volume (in 15 of 26 cases). The vasomotor effect recorded from the dorsobasal regions of the lungs was significantly greater ($P < 0.01$) in most cases (11 of 15) in the vertical position than in the horizontal.

A simultaneous tracing of the electroplethysmograms from the dorsobasal and ventrobasal regions of the right lung, obtained during stimulation of the ipsilateral vagus nerves with the animal in the horizontal position is given in Fig. 1. A similar tracing for the animal in a vertical position is given in Fig. 2. As Fig. 2 shows, the parasympathetic effect of an increase in the blood volume in the dorsobasal region of the lung increased significantly when the animal was in the vertical position. The increase in the parasympathetic effect for the ventrobasal regions was not significant, but for the apical regions, on the other hand, there was a tendency for the parasympathetic effect to decrease in the vertical position (the

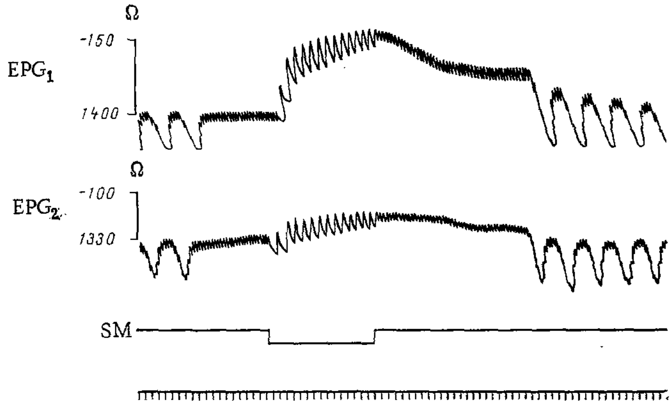

Fig. 2. Changes in blood volume of dorsobasal and ventrobasal regions of lungs during stimulation of vagus nerve with animal in vertical position. Legend as in Fig. 1.

differences are not statistically significant). However, if the values of the regional effects are compared for different positions of the body, a significant difference ($P < 0.01$) is found between them for the apical and basal regions of the lungs in the vertical position, whereas in the horizontal position they are approximately identical (Table 1). No such differences could be found when regional sympathetic effects on changes in blood volumes of the lungs were investigated, possibly because of the generally insignificant character of sympathetic vasomotor responses in general (about 2% of the initial blood volume) [6, 7].

Comparison of these data with results obtained during the study of postural hemodynamic responses shows that the regional vasomotor effect of a change in blood volume of the lungs depends on the original state of the regional pulmonary hemodynamics. Regions of the lungs with a heavier hydrostatic load are also more labile toward the action of the neurogenic stimulus; this is probably evidence of the existence of regionally differentiated neurovasomotor mechanisms in the pulmonary circulation, the action of which can to some degree compensate for disturbances of the pulmonary hemodynamics due to the effect of the force of gravity.

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