CUTANEOUS RESPIRATION IN MAN: *VI. The Effect of Drugs on the Rate of Carbon Dioxide Elimination and Oxygen Absorption*

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CUTANEOUS RESPIRATION IN MAN

VI. The Effect of Drugs on the Rate of Carbon Dioxide Elimination and Oxygen Absorption [1]

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Cutaneous respiration is the result of two distinct processes: (1) the passage of carbon dioxide out of the blood by diffusion through the skin, and (2) the intrinsic metabolism of the skin. The extent to which the metabolic requirements of the skin are supplied by cutaneous gas exchange depends on the relative tension of oxygen and carbon dioxide in the air and in the blood. With a constant oxygen tension of the air, the rate at which the skin absorbs oxygen from the air varies inversely with the oxygen tension of the blood (1). Similarly, there is evidence that, with a constant carbon dioxide tension of the air, the rate at which the skin excretes carbon dioxide into the air increases as the carbon dioxide tension of the blood rises (1). In addition, increased carbon dioxide tension of the blood probably accelerates the rate at which carbon dioxide passes out of the blood by diffusion through the skin. In view of these considerations, alterations in the blood supply to the skin would affect the rate of cutaneous respiration under normal atmospheric conditions if the changes in blood flow were accompanied by changes in the rate of cutaneous metabolism or in the tension of carbon dioxide and oxygen in the blood. Similarly, variations in the degree of activity of the sweat glands would influence the rate of cutaneous respiratory exchange if such variations were attended by changes in the rate of cutaneous metabolism or by alterations in blood flow accompanied by changes in the tension of the gases in the blood. This paper deals with the effect on the rate of cutaneous respiration of drugs capable of altering the blood supply to the skin or the degree of activity of the sweat glands.

METHOD OF STUDY

The apparatus and technical procedure were essentially the same as those employed in preceding studies (2, 3, 4) on the rate of cutaneous respiration in normal individuals and in subjects with pathologic conditions of the skin. Certain modifications, however, were introduced.

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The interval between the collection of samples was reduced to two hours in order that two successive experiments could be made on each subject. In each experiment the first sample of gas was collected after a preliminary mixing period, twenty minutes in duration. The subject's arm was removed from the plethysmograph between the two observation periods, and the apparatus was washed out with room air. The first experiment, in each instance, was a control observation, and the drug whose effect was being studied was administered at the end of the mixing period of the second experiment.

In brief, measurements were made of the total amounts of carbon dioxide eliminated and oxygen absorbed through the skin of the entire arm in two successive two-hour periods, the second of which immediately followed the administration of one of the drugs under investigation. The relative humidity of the air in contact with the skin was kept at the saturation point by means of a moist woolen stocking worn on the arm. The temperature of the air in the system varied between 26° C. and 31° C. in different experiments but was maintained practically constant during individual experiments by regulating the temperature of the room. All measurements were made with the room temperature between 20° C. and 26° C. The results of each experiment were expressed in terms of cubic centimeters per hour per square meter of skin surface, and were transposed by interpolation to the value they would have had if the temperature of the air in the plethysmograph had been 27° C. The manner of making this correction has been described previously (3).

All drugs were administered by subcutaneous injection.

RESULTS

Measurements were made of the effect of epinephrine, pituitary posterior lobe extract, histamine and pilocarpine on the rate of cutaneous respiration in three normal subjects. During a considerable part of the second observation period in each experiment the subjects presented symptoms and signs characteristic of the action of the drug which had been administered. Particular attention was paid to changes in the color of the skin. Epinephrine caused moderate pallor and pituitary posterior lobe extract, intense pallor. Histamine produced intense flushing of the face and slight flushing of the arms. Pilocarpine caused slight flushing and, in addition, profuse perspiration attended by a decided decrease in the temperature of the skin. None of the drugs produced constant changes in the rate of carbon dioxide elimination and oxygen absorption through the skin (Table 1).

TABLE 1

The effect of drugs on the rate of cutaneous respiration *

Subject	Drug	CO_2 excreted			O_2 absorbed		
		Control period	After drug	Difference	Control period	After drug	Difference
		cc.	cc.	cc.	cc.	cc.	cc.
9...	Epinephrine hydrochloride, 1 cc.	140	139	− 1	107	104	− 3
23...	Epinephrine hydrochloride, 1 cc.	132	143	+ 11	92	108	+ 16
6...	Pituitary extract, 1 cc.	153	149	− 4	113	105	− 8
9...	Pituitary extract, 1 cc.	154	146	− 8	114	120	+ 6
23...	Pituitary extract, 1 cc.	156	156	0	103	115	+ 12
6...	Histamine hydrochloride, 0.001 gram	151	155	+ 4	113	104	− 9
23...	Histamine hydrochloride, 0.001 gram	134	122	− 12	88	92	+ 4
6...	Pilocarpine hydrochloride, 0.008 gram	134	146	+ 12	88	69	− 19
6...	Pilocarpine hydrochloride, 0.008 gram	132	115	− 17	83	83	0
9...	Pilocarpine hydrochloride, 0.015 gram	122	132	+ 10	85	97	+ 12
23...	Pilocarpine hydrochloride, 0.008 gram	128	131	+ 3	75	86	+ 11
23...	Pilocarpine hydrochloride, 0.015 gram	140	158	+ 18	88	99	+ 11

* Calculated in cubic centimeters per hour per square meter of skin surface at 27° C.

DISCUSSION

In an earlier investigation (3) repeated measurements were made of the rate of cutaneous respiration under practically identical conditions of temperature and relative humidity in a series of normal subjects. The average individual variation in the rate of carbon dioxide excretion was ± 3 cc. per hour per square meter of skin surface, and the greatest variation was ± 10 cc. The average individual variation in the rate of oxygen absorption was ± 5 cc. per hour per square meter of skin surface, and the greatest variation was ± 15 cc. Since the temperature of the air in the plethysmograph remained practically constant throughout each complete experiment in the present investigation, any change in the rate of carbon dioxide excretion should exceed 20 cc. per hour per square meter of skin surface in order to be significant. Similarly, changes in the rate of oxygen absorption of less than 30 cc. per hour per square meter of skin surface may be disregarded. The rate of cutaneous respiration, therefore, was not significantly affected by any of the drugs employed (Table 1).

The changes produced by the drugs in the color of the skin indicate that cutaneous blood flow had been altered. Although these changes

affect the tension of carbon dioxide and oxygen in the venous blood, their failure to influence the rate of cutaneous respiration suggests that the tension of the gases in that portion of the blood in equilibrium with the tissues had not been altered.

Epinephrine, pituitary posterior lobe extract and histamine probably have no significant effect on the metabolic rate of the skin. The accelerated activity of the sweat glands produced by pilocarpine may be accompanied by an increase in the rate of cutaneous metabolism; but the results of the present investigation indicate that this increase, if it occurs, is of very small magnitude in comparison to the total metabolism of the skin.

SUMMARY

1. Measurements were made of the effect of epinephrine, pituitary posterior lobe extract, histamine and pilocarpine on the rate of cutaneous respiration in three normal subjects.

2. None of the drugs significantly altered the rate of carbon dioxide elimination and oxygen absorption through the skin.

3. The failure to affect the rate of cutaneous respiration indicates that the drugs did not significantly alter the metabolic rate of the skin or the tension of the gases in that portion of the blood in equilibrium with the tissues.

BIBLIOGRAPHY

1. Shaw, L. A., and Messer, A. C., Am. J. Physiol., 1931, xcviii, 93. Cutaneous Respiration in Man. III. The Permeability of the Skin to Carbon Dioxide and Oxygen as Affected by Altering their Tension in the Air Surrounding the Skin.
2. Shaw, L. A., and Messer, A. C., Am. J. Physiol., 1930, xcv, 13. Cutaneous Respiration in Man. II. The Effect of Temperature and of Relative Humidity upon the Rate of Carbon Dioxide Elimination and Oxygen Absorption.
3. Ernstene, A. C., and Volk, M. C., J. Clin. Invest., 1932, xi, 363. Cutaneous Respiration in Man. IV. The Rate of Carbon Dioxide Elimination and Oxygen Absorption in Normal Subjects.
4. Ernstene, A. C., and Volk, M. C., J. Clin. Invest., 1932, xi, 377. Cutaneous Respiration in Man. V. The Rate of Carbon Dioxide Elimination and Oxygen Absorption in Subjects with Diseases of the Skin.