THE INFLUENCE OF ULTRAVIOLET IRRADIATION ON THE PERMEABILITY AND ON SOME OTHER INDICATORS OF THE FUNCTIONAL CONDITION OF ANIMAL AND HUMAN SKIN

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(Received January 21, 1956. Presented by Academician A. D. Speranskiy)

Many investigators studied the permeability of the skin, but only in the last decade have convincing proofs been obtained that water solutions of electrolytes penetrate the intact skin [5, 14, 15, 22, 27]. In our work [8, 9, 10] it was shown that the permeability of the skin to radioactive iodine and phosphorus varied at different times of the year and under different functional conditions of the central nervous system.

The study of changes in the permeability of the skin under the influence of external factors, in particular of radiant energy, which acts on the system under normal conditions and is widely used in physiotherapy, is of special interest.

In this work the influence of ultraviolet irradiation on the permeability and on some other indicators of the functional state of animal and human skin was studied.

EXPERIMENTAL METHODS

An artificial radioactive isotope of iodine, administered by ionophoresis, was used as an indicator in the study of the permeability of the skin.

A nonpolarizable hollow electrode with a base 2.5 cm^2 in area, containing 5 ml of a solution of radioactive iodine with a total activity of 1 μ C, was used for the ionophoresis. The active electrode was placed on a shaved section of the abdominal skin, the indifferent one (equal in area) on a shaved area of the dorsal skin. The current was 0.5 ma, with a density of 0.2 ma/cm^2, duration of irradiation of 5 minutes.

After the current was disconnected and the corresponding skin areas were washed (in order to remove radioactive contamination of the skin surface), a probe, with the assistance of which the amount of radioactive iodine which penetrated the skin and tissues lying under the electrode was determined on the "B" apparatus, was inserted in the place where the I^{131} was administered.

Preliminary experiments established the fact that under these conditions almost all the isotope which was administered into the system was found in the skin and tissues lying under the electrode immediately after the procedure; it was not found in the blood, urine and internal organs.

The relation of the amount of radioactive iodine found in the tissues under the electrode to the total activity of the solution adapted to electrophoresis was used as the indicator of permeability.

A stationary quartz lamp LKT-2 with a mercury-quartz filament PRK-2 (voltage of the grid was 220 v, of the filament 120 v) served as the source of ultraviolet rays.

In experiments on rabbits we irradiated an area of the skin of the left half of the abdomen, 120 cm^2 in area, the rest of the body was covered with oilcloth. The irradiation was carried out at a distance of 30 cm from the filament with an intensity of 2–4 biodoses (1 biodose corresponded to 3 minutes on the average).

In observations on healthy persons a section of the skin of the inner surface of the forearm 30 cm^2 in area was subjected to ultraviolet irradiation. The distance from the filament was 50 cm, the duration of the irradiation was 6 minutes. The investigations of skin permeability were carried out in the irradiated area by the methods described above. In addition, the total activity of the I^{131} was decreased to 0.5 μ C and the duration of the ionophoreses to 3 minutes.

In all the experiments, radioactive iodine was administered before irradiation, then again at various lengths of time after it. The electrical resistance and temperature of the skin were determined simultaneously using a Mishchuk apparatus.

EXPERIMENTAL RESULTS

Investigations showed that changes in the permeability of the skin were observed after a single irradiation with ultraviolet rays (experiments on 5 rabbits). Only an hour later the permeability of the tissue to I^{131} was considerably lower than the original level in the irradiated zone. A sharper decrease in the permeability of the skin was observed after 24 hours, during the period when erythema developed. After 48-72 hours the penetration of the isotope into the skin increased somewhat, but during 3-6 days it was significantly lower than the original level. Decreased permeability of the skin was found not only in the zone of irradiation but – to a lesser degree – in the symmetric unirradiated areas of the body (Fig. 1).

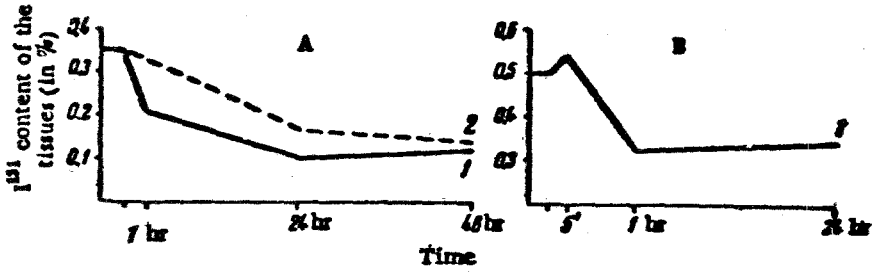

Fig. 1. Changes in the permeability of the skin of rabbits under the influence of a single ultraviolet irradiation.
1) On the irradiated side; 2) on the opposite side of the body

In individual experiments it was possible to observe a brief increase in the permeability of the skin immediately after irradiation, later (even after an hour) changing into a decreased permeability of the tissue to radioactive iodine (Fig. 1, B).

Along with changes in the permeability of the skin we observed also a number of changes in other indicators of its functional state. Even 30 minutes after a single irradiation, in the absence of visible changes an asymmetry of the skin temperature was observed: an increase in the irradiated zone in comparison with the symmetrical area of the body (Fig. 2).

Such changes were more obvious 24 hours after irradiation, during the period when erythema developed. After longer intervals of time asymmetry of the skin temperature was not found after irradiation with 1-2 biodoses, but was preserved when the intensity of the irradiation was greater.

Short lengths of time after irradiation, changes were also found in the electrical resistance of the skin. After 30 minutes, the resistance decreased in the irradiated zone in comparison with the symmetrical unirradiated areas. The asymmetry was more noticeable during the period when erythema developed, while a decrease in the electrical resistance of the skin was observed on the unirradiated half of the body. As the experiments showed, the extent to which the electrical resistance was lowered was in proportion to the intensity of the irradiation.

Under the influence of repeated irradiation with ultraviolet rays (5 procedures) a significant decrease in the permeability of the penetration of radioactive iodine into the skin was observed during the entire series of irradiations, as well as after it (experiments on 9 rabbits). A less sharp decrease in the permeability of the skin was observed on the opposite side of the body, which was not subjected to irradiation.

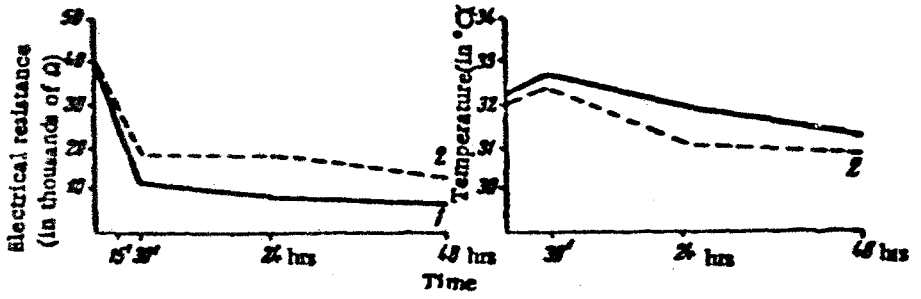

Fig. 2. Changes in the electrical resistance and temperature of the skin of rabbits after a single ultraviolet irradiation.
Symbols are the same as in Fig. 1.

As individual experiments showed, the permeability of the skin of remote areas of the body (the skin on the back) was decreased insignificantly in comparison with the irradiated zone and the symmetric areas of the body (Fig. 3, B).

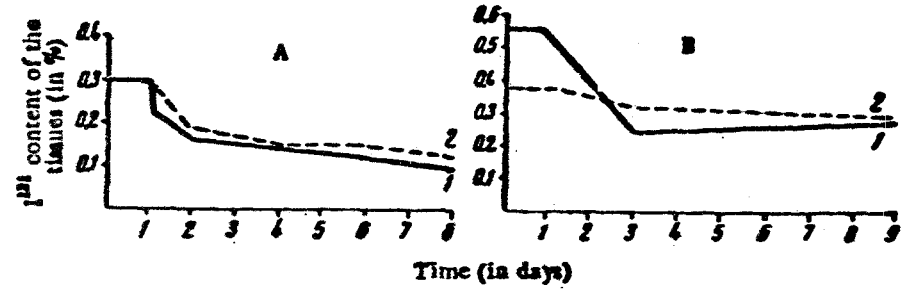

Fig. 3. Changes in the permeability of the skin of rabbits subjected to repeated ultraviolet irradiation.
Symbols are the same as in Fig. 1.

After the first irradiation an asymmetry in the electrical resistance of the skin was found which remained during the following days. The temperature of the skin in the irradiated zone was higher than in the symmetrical areas. The same relationship was observed during repeated procedures also. However, in a number of experiments asymmetry of the skin temperature was not observed or the skin temperature was lowered in the irradiated zone in comparison with the symmetrical areas after 3-4 irradiations, when erythema was accompanied by a thickening of the skin and scaling.

The results of investigation of the permeability of the skin of healthy persons are presented in the table.

As is apparent from the data which are presented, the permeability of the skin increased immediately after irradiation. However, 24-48 hours after irradiation the permeability of the skin proved to be significantly lower than the original level in the erythematous zone in the majority of cases.

Thus, clinical observations confirm the data we obtained in experiments on animals.

The results of the experiments which were carried out indicate that significant changes occur in the permeability of the skin under the influence of ultraviolet irradiation. At the same time the permeability of the skin increased immediately after irradiation in man and in part of the experiments on rabbits, although already an hour later and especially during the period when erythema developed a decrease was observed in the permeability of the skin.

TABLE 1

Changes in the Permeability of Human Skin After a Single Irradiation

No. of patient	Subject	Amount of I^{131} penetrating into the tissues *				Notes
		before irradiation	after irradiation			
			5-10 minutes	24 hours	48 hours	
1	M.	1.06	1.33	0.76	0.73	Slight erythema after 24 hours
2	K.	0.51	0.95	0.48	0.56	Limited, moderately evident erythema after 24 hours
3	B.	1.24	1.30	0.52	0.60	
4	S.	0.45	0.71	0.49	0.29	Very evident erythema
5	S- a	0.52	0.57	0.32	0.25	" " "

* In % of original activity.

Decreased permeability of the skin during the period when erythema develops can be explained, apparently, by an increase in the protective function of the skin during the local inflammatory reaction which is produced by irradiation. Biologically active substances which are formed in the skin under the influence of ultraviolet irradiation play a definite role in the mechanism of the changes which develop in the permeability of the skin [6, 16, 17, 19, 21]. Apparently, the morphological changes which have been noted by many authors also have significance [1, 6, 7, 13, 18, 20]. However, the fact should be taken into consideration that changes in the permeability of the skin are found soon after irradiation; they are observed in symmetrical areas of the body although to a lesser extent. Therefore, the phenomena which have been noted cannot be explained save by a local reaction of the skin.

The guiding role of the nervous system in the regulation of the trophism of the various tissues of the systemic has been shown in the works of I. P. Pavlov [25], in the investigations of L. A. Orbeli [24], of A. D. Speransky with collaborators [26] and others.

Multitudinous bibliographical data testify to the important role of the nervous system in the mechanism by which irradiation with ultraviolet light acts on the system [2, 3, 4, 6, 11, 13, 23]. This lends a basis for the hypothesis that the changes we observed in a number of indicators of the functional state of the skin under the influence of ultraviolet light can be regarded as trophic changes of the skin of a reflex nature.

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