DYNAMIC RADIOTHERMOGRAPHY OF THE HUMAN LIVER

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The intensive oxidative processes taking place in the liver suggest that it is a leading organ of chemical thermoregulation [1, 3]. An important role in the maintenance of temperature homeostasis and in modification of the distribution of heat in the human body is played by the vascular system [2], hence the great importance of a detailed study of the distribution of heat in the body and of changes in heat production depending on the level of metabolism and the intensity of the blood flow in the organs and tissues of the body. Only noninvasive methods of determining the core temperature of the body are acceptable for the study of this problem. One such method, based on determination of the temperature of an object by measuring its emission in the superhigh-frequency range, has been developed in the Institute of of Radioengineering and Electronics, Academy of Sciences of the USSR.

The aim of this investigation was to study, by a radiothermographic method, the topography of human body temperatures during imposition of a load on liver function.

EXPERIMENTAL METHOD

The multielement radiothermograph is a radiometer working on a frequency of 1.5 GHz, with a transmission band of 300 MHz, and with an antenna changeover switch on p-i-n diodes (sensitivity 0.07°K with integration time of 1 sec). Radioantennas were distributed over the projection regions of the liver, spleen, and stomach, over the forearm and thigh muscles, and also on the head in the forehead region (Fig. 1). This arrangement of the antennas enabled the temperature of different parts of the body to be measured simultaneously and changes in their temperatures at intervals of time during function tests to be correlated. This dynamic schedule of observation ensured continuous monitoring of thermograms in different parts of the body by computer; temperature curves characterizing heat emission from different parts of the body on a real time scale were plotted simultaneously on the display screen. On the basis of these data it was possible to judge the results of dynamic radiothermography of the human body.

The investigation was conducted on 15 healthy male volunteers aged 25-35 years. The subject lay in the horizontal position in a thermostatically controlled cabinet, and in order to stabilize the temperature of both body and cabinet he lay there for some time stripped to the waist. After the temperature curves had reached isolinearity a liver function test was carried out. There were four series of experiments, each involving a different function test: series I) 200 ml of 40% glucose solution per os at a temperature of 20°C; series II) 200 ml of water per os at a temperature of 50°C; series III) 200 ml of water per os at a temperature of 7°C; series IV) irradiation of the region of the subject's liver for 4 min 16 sec by "Uzor" semiconductor laser (wavelength 0.89 μ, pulse power 9 W, pulse duration 70 nsec, frequency 80 Hz, diameter of beam at outlet 7 mm), in order to stimulate the intrahepatic blood flow.

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Technique of radiothermography

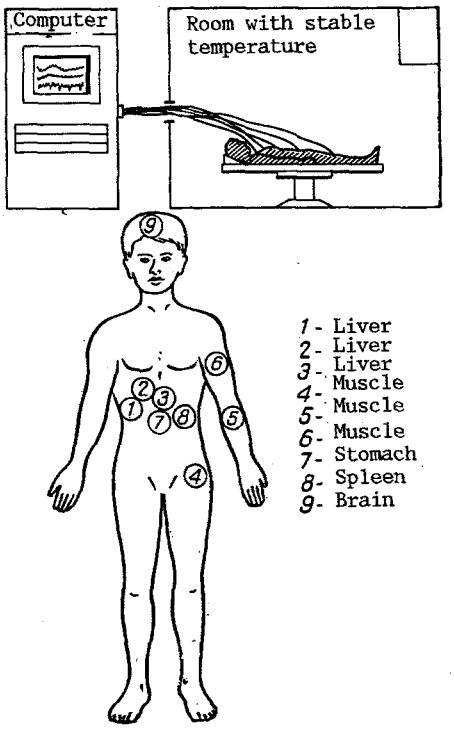

Fig. 1. Technique of radiothermography. 1-9) Arrangement of antennas on human body: 1-3) over liver; 4-6) on muscles; 7) over stomach; 8) over spleen; 9) on head (over frontal lobes of the brain).

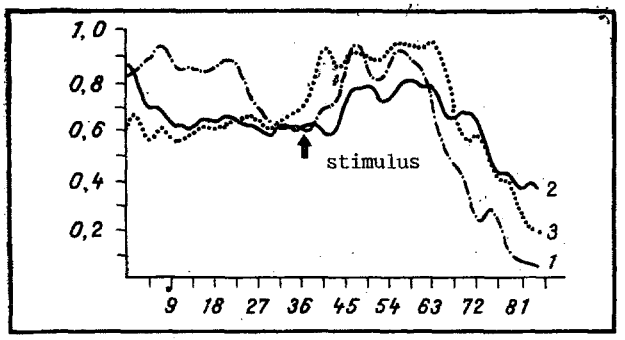

Fig. 2. Dependence of liver temperature on time during glycolytic test. 1-3) Antennas over liver. Arrow indicates beginning of test. Abscissa, time (in min); ordinate, temperature (in °K).

EXPERIMENTAL RESULTS

After administration of glucose solution per os (series I) the temperature rose in response to the stimulus at all projection points of the liver (Fig. 2). The reaction time varied from 0.5 to 6 min. Some degree of topographic gradient of temperature was noted, due to the fact that in the region of the lesser lobe of the liver the reaction time was longer than in the region of the greater lobe. The temperature curves for the liver were very similar in shape and values of the maximal rise of temperature (A = 0.39, 0.38, and 0.23°K) and of its duration (c = 31, 27, and 31 min) were close, evidence of synchronization of metabolic changes in the different lobes of the liver. So far as the other organs were concerned, a rise of temperature was noted in the projection regions of the stomach and spleen, although the numerical values in this case were somewhat

TABLE 1. Changes in Intrahepatic Temperature Recorded by Radiothermography during Various Function Tests

Series	A	c	p
I	0,05—0,34	6—56	0,5—7,0
II	0,14—0,56	4—54	0,5—5,0
III	0,34—1,06	—	0,0—4,0
IV	0,09—0,38	9—42	0,5—9,0

Legend. A) Value of maximal deviation from background temperature during function test (in °K); c) duration of deviation from background temperature (in min); p) reaction time of temperature response (in min). In cold water test values of A are negative in direction, but the value of c was not calculated because after the test the temperature did not return to its background level during the experiment.

smaller (A = 0.12°K, c = 33 min for the stomach and A = 0.36°K, c = 48 min for the spleen). The response of the muscles was weaker than that of the liver and the temperature in the limb muscles showed only a tendency to rise.

In series II, in which the subject took 200 ml of water at a temperature of 50°C, the antennas over the liver recorded a rise of temperature of 0.14-0.56°K, which lasted about 5-50 min (Table 1). After cold water was taken (7°C) there was only a tendency for the liver temperature to fall (series III). In series IV, in response to laser stimulation of the blood flow in the liver the intrahepatic temperature rose by 0.09 and 0.38°K (Table 1). The phase of raised intrahepatic temperature lasted 10-40 min; the reaction time varied from 1 to 9 min.

In the experiments described above radiothermography showed itself to be sufficiently sensitive to detect changes in liver temperature during the glycolytic test and laser stimulation of the intrahepatic blood flow within the therapeutic dose range. The drinking of cold or hot water by the subject is accompanied by heat exchange between the temperature core of the subject and liquid entering the stomach. If the water temperature is higher than the temperature of the organs of the temperature core, the surrounding organs and tissues, including the liver, will be heated due to heat transfer. The temperature in the liver may also rise as a result of stimulation of the intrahepatic blood flow [1]. When the subject drinks cold water the opposite process is observed: heat emission by the liver increases and its temperature falls. During the glycolytic test, on account of triggering of metabolic processes in the liver the temperature rises, and under these circumstances temperature curves of the same type are recorded in points of the liver located topographically close together. The fact that the liver as a whole responds quicker to the glycolytic test than to laser stimulation can be attributed to different mechanisms of elevation of the temperature in the liver: in the first case initial activation of metabolism takes place in the liver, whereas during laser irradiation metabolism is activated by stimulation of the intrahepatic blood flow.

Analysis of the temperature changes in different parts of the body shows that the greater lobe of the liver and the stomach are the first to respond to the glycolytic test, followed by the lesser lobe of the liver, the spleen, and muscles; the strongest response is given by the liver and stomach. Laser stimulation of the liver had virtually no effect on the temperature of the muscles, stomach, and spleen, but the liver temperature was clearly raised. The temperature of the head was virtually unchanged during function tests, except the glycolytic test, during which a weak heating effect was observed.

The technique of dynamic radiothermography thus proved itself sufficiently sensitive for the study of the thermotopography of the human body. The response of the intrahepatic temperature to function tests was characterized by specificity. Radiothermography gives information on the dynamics of temperatures and their topography both throughout the human body and within a single organ.

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AGE DIFFERENCES IN RNA TRANSPORT THROUGH THE NUCLEAR MEMBRANE

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A controlled stage in the expression of genetic information in eukaryote cells is the process of RNA translocation through the nuclear membrane. RNA transport from nucleus into cytoplasm is controlled by interaction of two systems. The first, an energy-transforming system, unites specific sites of interaction of pore complexes with mRNA, nucleotide triphosphatase, and several other enzymes involved in the active transport of mRNA through the nuclear pores. The second, a system of cytoplasmic factors, regulates selective transport [3, 10].

To study nucleo-cytoplasmic RNA transport a simplified model of the outflow of prelabeled RNA from nuclei into a cell-free system is used [12]. An important fact established with the aid of this model is that the velocity of RNA transport depends on ATP [7]. During aging, the production and concentration of ATP are reduced, especially in liver cells [1, 2], and this may play an important role in the course of energy-dependent processes, including the expression of genetic information.

To study age differences in nucleo-cytoplasmic RNA transport the investigation described below was undertaken.

EXPERIMENTAL METHOD

Wistar albino rats of two age groups were used: 6-8 months (adult) and 26-28 months (old). The animals were given an intraperitoneal injection of 2[^{14}C]-orotic acid (molar activity 25.2 × 10^4 MBq/mmole) at the rate of 3.7 MBq/kg body weight, and were killed by decapitation 30 min later. Liver nuclei were isolated by the method in [5] and the cytosol by the method in [12]. The DNA content of the nuclei was determined spectrophotometrically and the protein content of the cytosol by a modified Lowry's method [8]. The nuclei were washed with 0.25 M sucrose solution in 50 mM Tris-HCl, pH 7.5, containing 25 mM KCl and 5 mM $MgCl_2$ (medium A), after which the suspension of nuclei was diluted with medium A to a final concentration of 200 μg/ml DNA and incubated at 30°C with continuous shaking. At definite time intervals aliquots of the nuclear suspension were taken and immediately centrifuged in a refrigeration centrifuge at 3000 rpm. Aliquots of nuclear suspension and supernatant were applied to Whatman 3MM or Filtrak FN-18 filter paper, washed 3 times with cold 5% TCA, once with 95% ethanol, and once with a mixture of ethanol and ether, dried, and transferred to flasks containing ZhS-106 scintillation mixture. Radioactivity was determined in a Mark 3 scintillation spectrometer. The yield of RNA was expressed as the ratio of radioactivity of acid-insoluble material of the supernatant to radioactivity of the acid-insoluble material of the nuclear suspension, in per cent. In

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