BIOCHEMILUMINESCENCE FROM THE SURFACE OF THE HUMAN BODY

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Considerable attention has recently been paid to the study of biochemiluminescence of various biological objects. The natural biochemiluminescence of living tissues and biological substrates provides unique information on oxidative processes taking place in them [1]. Biochemiluminescence of human blood serum is widely used in the diagnosis of many diseases [2]. The use of luminescence from the surface of the human body for the diagnosis of cancer and for evaluation of the effectiveness of its treatment has been reported [4]. As yet, however, no quantitative evaluation of luminescence from different parts of the surface of the human body has been given, nor have the factors influencing this luminescence or the mechanisms on which it is based been studied.

The object of this investigation was to study the possibility of recording biochemiluminescence from the surface of the human body by the use of a photoelectronic multiplier of "Quantacon" type, to obtain a quantitative estimate of the intensity of luminescence from different parts of the body, and to determine the spectral composition of this radiation.

EXPERIMENTAL METHOD

Biochemiluminescence was recorded on an instrument built in accordance with the usual scheme [3]. A block diagram of the apparatus is shown in Fig. 1. An FEU-130 photoelectronic multiplier, working on a quantum counting program, was used as the radiation receiver. To

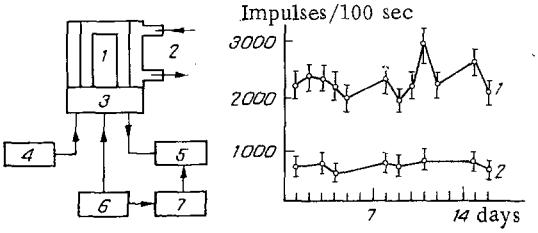

Fig. 1 Fig. 2

Fig. 1. Block diagram of apparatus for recording luminescence: 1) PEM; 2) cooling jacket; 3) amplifier-discriminator; 4) VS-22 high-voltage power unit; 5) counting unit; 6) low-voltage power unit; 7) timer.

Fig. 2. Intensity of biochemiluminescence from surface of human body on different days: 1) luminescence from palm; 2) luminescence from abdomen. Abscissa, days of measurements; ordinate, intensity of luminescence (in impulses/100 sec).

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TABLE 1. Intensity of Luminescence of Different Parts of the Surface of the Human Body

Object	Intensity of luminescence, impulses/100 sec
Left side of chest	680±158
Right side of chest	400±152
Left side of abdomen	592±158
Right side of abdomen	458±153
Lumbar region	564±153
Right leg	373±152
Forehead	2411±202
Neck	1592±184
Left palm	1689±185
Right palm	2208±202
Right foot	1590±187

Legend. Here and in Table 2 confidence interval given for 0.995 level of probability of random value of radiation.

TABLE 2. Spectral Distribution of Biochemiluminescence from the Human Palm

Spectral region	Intensity of luminescence, impulses/100 sec
Total signal	2148±195
360-400 nm Blue region of spectrum	1321±175
480-560 nm Green region of spectrum	827±160
Over 580 nm Red region of spectrum	150±140

reduce noise impulses, water cooling of the photoelectronic multiplier (PEM) was used. The PEM was powered by a high-voltage power unit (VS-22) through a voltage divider. Impulses from the anode of the PEM were led to an amplifier-discriminator, and the single-electron component of the anodal impulses was cut out by the discriminator. Impulses from the discriminator were led to the counting unit (F-5007 impulse counter), the counting time of which was assigned by a timer. The amplifier-discriminator and the timer were powered by a low-voltage power unit, made from sources of the "Aleksandrit" type.

The PEM unit was placed in a relatively dark room. The sensitivity of the apparatus was determined by means of radioluminescence standards Nos. 46 and 50 from the Leningrad Technological Institute, radiation from which lies within the 250-500 nm region. Scatter of the impulses fell within the confidence interval for random values and virtually did not exceed values for a 0.997 level of probability. To determine the spectral composition of the radiation, an adsorption filter (SS15, ZS11, or KS) was placed in front of the photocathode of the PEM. Three spectral bands respectively were studied: 360-400 nm, 480-560 nm, and over 580 nm; the transmission factors of the filters within these regions reached 60%.

Luminescence was recorded from male volunteers aged 17-40 years. Before measurement the subject was kept for 30 min in a darkened room to reduce induced photochemiluminescence; he was then moved into a dark room, where the PEM unit was applied to the test region of the body and values of signal + noise were recorded; after a single measurement the photocathode of the PEM was screened and the noise value recorded. The mean value of the noise impulses was subtracted from the signal + noise value. Before measurement the region of the test area of the body was treated with 60% ethyl alcohol to remove fat.

EXPERIMENTAL RESULTS

Values of the intensity of luminescence from different parts of the human body are given in Table 1. As regards the intensity of luminescence, areas of the body can be divided into two groups: areas with a low intensity of luminescence (500 ± 300 impulses/100 sec) and areas

with a high intensity of luminescence (2000 ± 600 impulses/100 sec). The first group includes the region of the abdomen, chest, and head, the second group — the palm, foot, neck, and forehead. The measurements were made in winter, and it is evident that the first group consists of areas of the body which are hidden from the action of light most of the time by clothing, whereas the second group consists of exposed areas, except in the case of the foot, which also has a high intensity of luminescence.

Measurements made of 10 healthy men showed that the intensity of luminescence differs in different people; from the palm, for instance, it varies from 1300 to 2500 impulses/100 sec, in the abdomen it varies from 200 to 1100 impulses/100 sec. No significant correlation with age was observed. Biochemiluminescence from the surface of the body of the same individual changed only very slightly on different days (Fig. 2).

Estimation of the spectral distribution of biochemiluminescence of the human palm, using absorption filters (Table 2) showed that the maximum of radiation lay in the blue region of the spectrum. The low value of the intensity of biochemiluminescence in the red region was possibly due to the low sensitivity of the PEM in the red region of the spectrum.

The use of modern radiation receivers thus makes it possible to design quantometric instruments which will reliably record radiation from the surface of the human body. The intensity of this luminescence is approximately 10 quanta/sec/cm^2. The maximum of the luminescence lies in the blue region of the spectrum. Different parts of the human body possess different intensities of biochemiluminescence. The luminescence recorded from the surface of the human body, which we recorded, is based on several processes connected with oxidative reactions in the tissues. Foremost among these processes are lipid peroxidation (LPO) reactions. Chemiluminescence arises either in the early stages, preceding the development of LPO reactions, or in the course of their development. The formation of activated forms of oxygen, mainly singlet oxygen, in oxidation chains is accompanied by fairly intensive chemiluminescence [5]. The fact likewise cannot be ignored that afterglow reactions, evoked by the action of sunlight on lipoprotein complexes in the surface layers of the skin, may make an important contribution to the recorded chemiluminescence. It follows from the results of this investigation that mechanisms lying at the basis of biochemiluminescence from the surface of the human body require further study and the possibility of utilizing this luminescence in clinical practice must be explored.

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