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Research of Acoustic Responses of Biological Objects for Detection of Malignancies

A.H. Mkrtchyan*, V. V. Nalbandyan, A. S. Hakobyan, H.T. Hovhannisyan, K.V. Avetisyan, V.S. Harutyunyan, A.A. Papazyan, E.S. Shadyan

Institute of Applied Problems of Physics NAS of the Republic of Armenia
25 Hrachya Nersissian Str., 0014, Yerevan, Republic of Armenia
*E – mail: amkrtchyan@sci.am

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Abstract: The technique of diagnosing of malignancies, in particular sarcomas like S-180, in biological objects (mice) utilizing the new contactless method of diagnostics developed on the basis of modulation acoustic spectroscopy which is carried out by scanning of objects by acoustic field formed by package of the modulated electromagnetic waves of different frequency is offered. Comparative analysis of the amplitude-frequency distributions of acoustic responses of the studied healthy and sick objects received as result of scanning gives the chance of detection and determination of prevalence of malignancies.

Keywords: diagnosing, malignancies, modulation acoustic spectroscopy

1. Introduction

Medical diagnostics represents a complex of researches permitting to conclude about existence or probability of existence of a certain disease in an organism. Discovery new methods and improvement of the existing methods of medical diagnostics are the most important fields of investigation of modern sciences and technology. Diagnostics of oncological diseases at early stages of evolution is one of the most important problems of medicine, as it is important for forehanded and successful treatment of these diseases. The problem of forehanded detection of oncological diseases is directly connected with the existence of high-precision unique equipment and the possibility to develop new techniques of definition of existence of malignancies.

The existing diagnostic resources of oncological diseases [1-4] based generally on ultrasonic and x-ray techniques are not always safe as they can lead to emergence of side effects on organism and, besides, not all areas of organism can be explored thus because of impossibility of penetration of the corresponding radiations through certain types biological fabrics. Thus development of more comprehensive and safe systems of diagnosing at an early stage of disease based on use of ultrasonic waves is relevant.

Utilization of ultrasonic waves for diagnosing of the malignancies is based on property of their rectilinear distribution in organism and diverse reflection from the borders of biological fabrics of

various density and internal structures depending on biomechanical characteristics of fabrics: density, structures, elasticity and viscosity.

The organism represents an anisotropic object with various internal structures. In healthy fabrics the anisotropy prevails, accurately there are reactions of dissymmetry [5.6]. The anisotropy defines dependence of properties of fabrics on the direction in an organism. The dissymmetry is the property of biological systems which is shown at the macroscopic and molecular levels to synthesize substance in one of two possible spatial configurations. At pathology in fabrics, in varying degree, properties of anisotropy and dissymmetry are broken. Cancer cells unlike healthy have pronounced property of an isotropy therefore ultrasonic waves interact with them differently, than with healthy. If the frequency of physical impact of standing acoustic waves on bodies and body tissues matches their natural frequency, then there is a phenomenon of a resonance which is understood as increase in the response of biological system, i.e. increase in processes of life activity of biological systems. The result of this influence is the response of system, which can be fixed by means of the registration unit.

Thus, the problem of diagnosing by means of standing acoustic waves, consists in definition of responses of biological fabrics depending on their state that will give the chance of differentiation of healthy fabrics from malignancies by comparison of their responses. The amplitude-frequency characteristic specter of responses of structures of body tissues bears information on interior and the condition of structure of fabrics. Registering variation of responses of while passing through fabrics or reflection from the relevant structures, it is possible to judge their functional state and to carry out diagnosing of malignancies.

This problem, is similar to the problem of propagation of ultrasonic waves in multilayer isotropic mediums with heterogeneous of certain type and geometrical form, which was successfully solved at Institute of applied problems of physics of NAS RA [14]. Utilizing some registration technique and methods of Acoustaphysics a new method of diagnostics of malignancies biological objects was developed [7.8].

2. Experimental setup

To carry out the experimental investigation an unique experimental setup was developed [8]. The schematic view of the experimental setup is presented in Figure 1.

Special high precision tunable generators of acoustic wave of $0.1 \div 30 \times 10^9 Hz$ frequency rage and low noise linear amplifier for the same was frequency range were developed (Figure 1,2,3,4). A unique unit providing double modulation of acoustic fields was also developed (Figure 1 5).

By the aim to register the acoustic response of all presented in biological object anatomic parts a special high precision low noise registration unit with feedback was developed (Figure 1 8).

The measurements were conducted in specially designed experimental chamber (Figure 1 7), which have appropriate possibility for connection with electronic units.

As biological objects laboratory white mice were used.

Sarcoma C-180, as one of the most aggressive malignancies of the biological object was tested.

To obtain the amplitude-frequency characteristic specters of the studied biological object scanning in a frequency range $100 \div 30 \times 10^9 Hz$ with step of $100 Hz$ was made. To gain more information about the state of organism of the studied biological object step of scanning was decreased up to $1 Hz$.

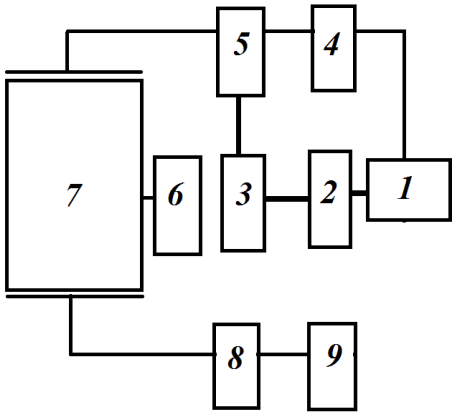

Fig. 1. Schematic view of the experimental setup. 1- Power supply, 2, 4 – fine tunable acoustic generators, 3 – linear low noise amplifier, 5 – special modulator, 6 – accelerating power supply, 7 – experimental chamber, 8 – registration unit, 9 -PC

3. The results of experimental investigations

To carry out the experimental investigation healthy and infected biological object were placed in the chamber of the experimental setup and by making scan in above mentioned frequency rage corresponding to the studied biological objects amplitude-frequency characteristic specters were obtained.

A series of experimental meserments on several groups of healthy and sick biological objects at various stages of disease were conducted. Obtained during each subsequent experiment on the same group of infected biological objects the amplitude-frequence characteristic specter of containing the acoustic responses of the biological object differed from early the obtained specters.

Relative analysis the amplitude-frequence characteristic specters obtained for the healthy and infected biological object yields the accurate information on the disease stage. Taking into account the temporary factor it is possible to elicit the dynamics of the pathology of disease.

In Figure 2 an amplitude-frequency characteristic specter for healthy biological object is presented.

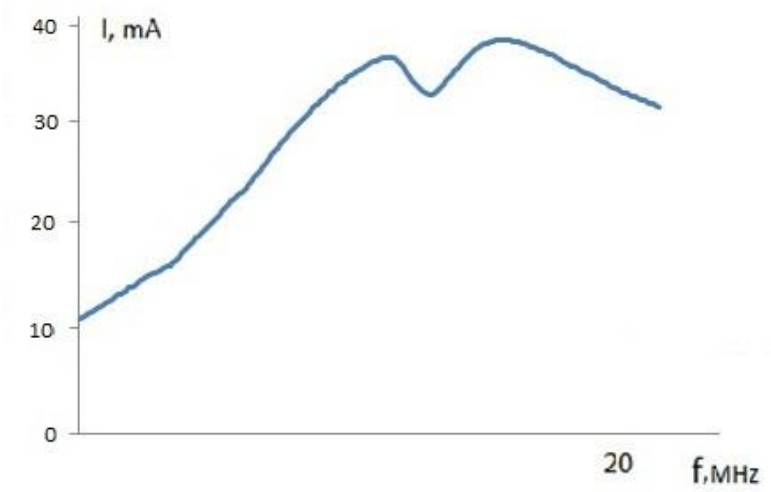

Fig. 2. Amplitude-frequency characteristic specter of healthy biological object

In Figure 3 an amplitude-frequency characteristic specter for healthy (a) and infected (b) biological object are presented. At the relative analysis of these spectrums changes caused by presence malignant formations in biological object are accurately observed. Depending on the stage of the disease the variations in amplitude-frequency charateristic specters become more valuable.

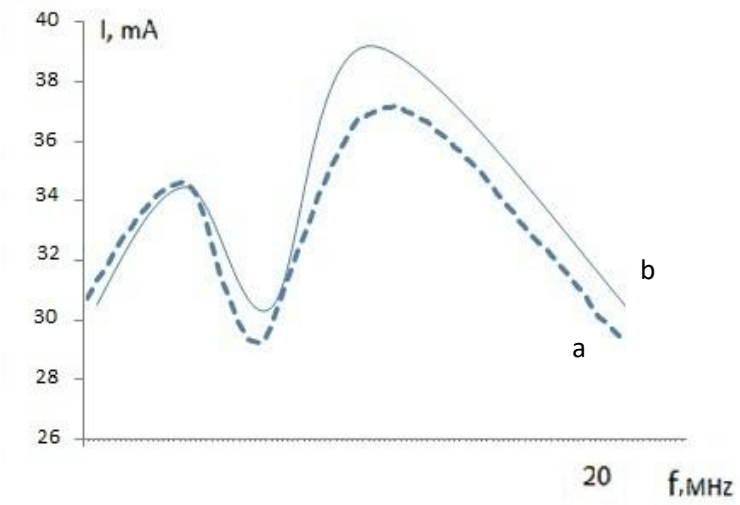

Fig. 3. Amplitude-frequency characteristic specters of healthy (a) and infected (b) biological objects.

At the last stage of disease sharp modification of relative amplitude-frequency characteristic specter of the responses (Fig. 4), which can be explained by detected high energy emission from the biological object.

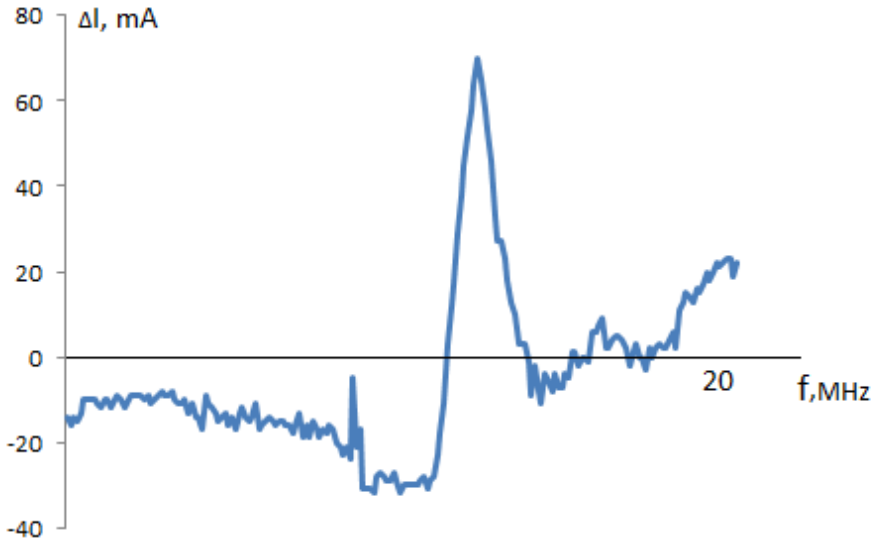

Fig. 4. Relative aamplitude-frequency characteristic specter of acoustic responces of the biological objects.

4. Conclusion

The developed method have a series advantages in comparison with existing ones [6,9]:

- possibility to make not only reliable, but also differential diagnostics of the pathological violations in tissues, by means of the analysis of spectrums of acoustic responses;
- possibility to conduct periodical safe diagnosing of malignant growths;
- possibility of achiving high accuracy diagnostics by reduction the step of scanning.

Utilization of the developed method gives the chance by means of exterior super week double modulated acoustic fields to carry out diagnostics of pathological violations in tissues of biological object. Experimental investigation in this field will be continued further on various biological objects by applying other malignant formations.

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