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COMPLEX "TERMODIN" FOR CONTACTLESS REMOTE MEDICAL DIAGNOSTICS

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Abstract. The article describes the structure and operation of the updated complex "Thermodyn" for remote non-contact diagnostics of inflammatory processes in the surface and the subcutaneous areas of the human body.

Keywords: complex; diagnostics; microprocessor; program.

Introduction. Application of a new element base in electronics changes the approach to the ideology of building of electrical devices and, in particular, devices for measuring of characteristics of radiative heat fluxes with radiation temperature, etc. As a consequence of all this has been made possible deep modernization of previously developed by the authors of information diagnostic system "Thermodyn". (Certificate of registration No. 460/97, the order of the Ministry of Education and Health of Ukraine dated 03/10/97 No. 293).

Objective. Using of microprocessor in the measuring head of the device significantly reduce its weight and size, consumption power, to make the device more versatile, compact, without changing its basic technical and consumer characteristics; use it together with modern computer systems, which greatly enhances its functionality.

Materials and Methods. At present, the scheme of the device, in a modernized version, is as follows, Fig. 1.

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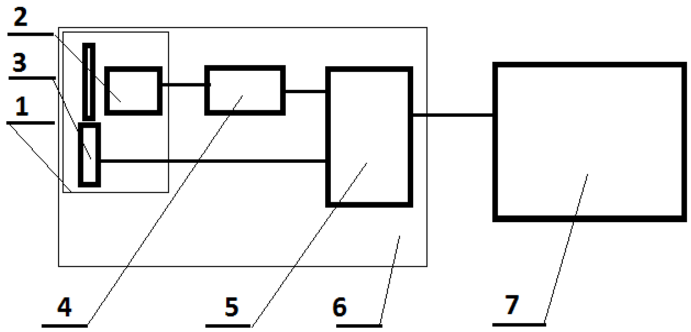

Fig. 1. Block scheme of the complex "Thermodyn"

Complex "Thermodyn" includes the measuring head 6 and a personal computer or other device it replaces 7. 1 – IR-sensor with the flat thermoelectric receiver of the thermal radiation 2 and electro-mechanical shutter 3; 4 - precision terminating DC power; 5 – a microprocessor, which controls the electromechanical shutter, measuring, recording, processing the measured signal, and communicates with the computer device, which processes the information in accordance with the procedure selected by an appropriate program and the result is displayed as a graph or table [1].

As the heat radiation detector it is used flat battery based on anisotropic thermoelements made of antimonide cadmium. The input of the receiver is closed by IR filter made of silicon, providing a good transmission in the band 8...14 microns, which is important to significantly reduce the influence of external stray light and glare, and reduce uncooled receiver noise when working with objects, where the temperature differs little from the background temperature [2].

Thermo-emf of thermal receiver inputs to a high-resistance matching precision DC amplifier, made according to the scheme M-DM, with small input currents not exceeding nanoamperes unit that provides the sensor in operation mode of EMF source, and further to an analog-digital converter of the microprocessor. The microprocessor, in accordance with a predetermined algorithm, controls the entire measurement cycle: opens the gate (shutter) to the entrance window of the thermal radiation detector, determines the beginning of the measurements, specifies the time the receiver exposure, calculates the level of the signal, converts output into the native code, transmits the result of processing to the computer, close shutter and sets the exposure time until the next measurement.

In the personal computer the data from the measuring head are processed by a given program and the result is displayed as a corresponding table or graph. The new computer program has been developed and designed especially for the modernized complex "Thermodyn". This program allows the measuring head to connect with any PC, laptop or tablet. The program provides for the accumulation and archiving survey results, the creation of databases of personal data of the patient. The presence of these bases gives

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the ability to monitor long-term dynamics of the body functioning process flow, of comparison and analysis of the various stages of this process, which is important in the selection of methods and drugs for restoration and normalization of body functions [3].

The program provides two modes of operation. The first is the continuous scanning mode displays the change of the heat flux in time from a specific point on the surface or – heat intensity distribution on the surface of the object in $W \cdot m^{-2}$. The second – a discrete measurement mode that allows you to track the relative change in the heat transfer from the specific selected points on the surface of the object in relative units (%) within a certain time. The obtained information can be stored in the archive for monitoring the progress of the process for a long time, subsequent comparison and analysis.

Table 1 shows the main technical characteristics of the modernized complex "Thermodyn".

Table 1

Specifications of the complex "Thermodyn"

No	Parameter	Value	Units
1	IR Receiver, uncooled, based on anisotropic thermoelements, the resolution is not worse then	0,2-0,4	V/W
2	Graduation digital scale, not worse then	0,05	°C
3	The temperature of the object	20-42	°C
4	one exposure (time)	1	сек
5	Time to get mode, not more then	30	min
6	Time of continuous operation, not less then	8	hour
7	Ambient temperature	10-35	°C
8	Relative air humidity at 25 °C, no more than	80	%

Fig. 2 shows the sensitive head of the device which is disassembled, the cover and the display are removed.

Fig. 2. Sensitive head of the device which is disassembled, the cover and the display are removed

Fig. 3 shows the sensitive head of the device with the displayed data at the time of measurement.

Fig. 3. The head of the device at the time of readings

After selecting the device operation mode and running the program, the measuring head is controlled by three buttons. One button turns the power supply to the head, the second – switches work of the head in discrete measurement mode or scanning, the third button in discrete measurement mode starts the measurement.

Receiving of the thermal state information of the examined organ or tissue is produced by a thermal IR receiver from projection of an organ or tissue to the surface of the body and carries in a first approximation:

1. Information on the thermal state of the interface between two media i.e. the skin in the study area.

2. Information on the thermal state of the intermediate layer of tissue beneath the surface of the study area.

3. Information on the thermal state of the examined organ or tissue inside the body.

The main interest is the last component, while the other two are, however, an obstacle.

Highlight the desired information to us is produced by a special technique, which consists in the fact that every study of the thermal state of the organ or tissue includes receiving information from two areas:

- directly from the projection of the test body;

- from the sub-area, the so-called "checkpoint".

"Checkpoint" is set specifically in each case.

"Checkpoint" must meet the following requirements:

1. It must be close to the study area;

2. It must be located above the projection of energy inactive areas of the body, which are weak or does not respond to this functional load, e.g. above bone tissue or muscle at rest.

The difference between the signals from these two areas gives us information of interest.

Due to the fact that the value of the thermal energy density, or the corresponding value of the radiation temperature of the surface of the human body veils are not normalized, and acquired information is intermediate in nature, the indications of the IR receiver are presented in conventional units [4].

The complexity of the relationship of the set of parameters in the process of heat transfer in the body with the experimentally determined value (heat transfer) as well as the impossibility of their long-term fix, because of the continuity of life process, so that is convenient to represent this value as a ratio of the current values to the value determined at a given initial time.

Thus, the evaluation of change of heat transfer from the study area produced by the degree and nature of the dynamics relative to the baseline in the selected initial time or by the level of a given symmetric field.

For single perturbation for the test can be used purely physiological, pharmacological, or 'cold' load.

The examination is used as an observation of the short-term dynamics of the thermal state, covering the period from 5 to 30 minutes, and of the long-term dynamics of the thermal state within a few hours or days.

Short-term dynamics of the thermal state allows us to identify the dysfunction of various organs and tissues, to determine the response to pharmacological agents, physiological and pharmacological tests.

Long-term dynamics of the thermal state allows us to observe the nature of the course of inflammatory processes, the healing of wound and postoperative sutures, the engraftment or rejection of the graft, to differentiate the acute stomach syndrome for children, etc.

Fig. 4 represents a flowchart of research.

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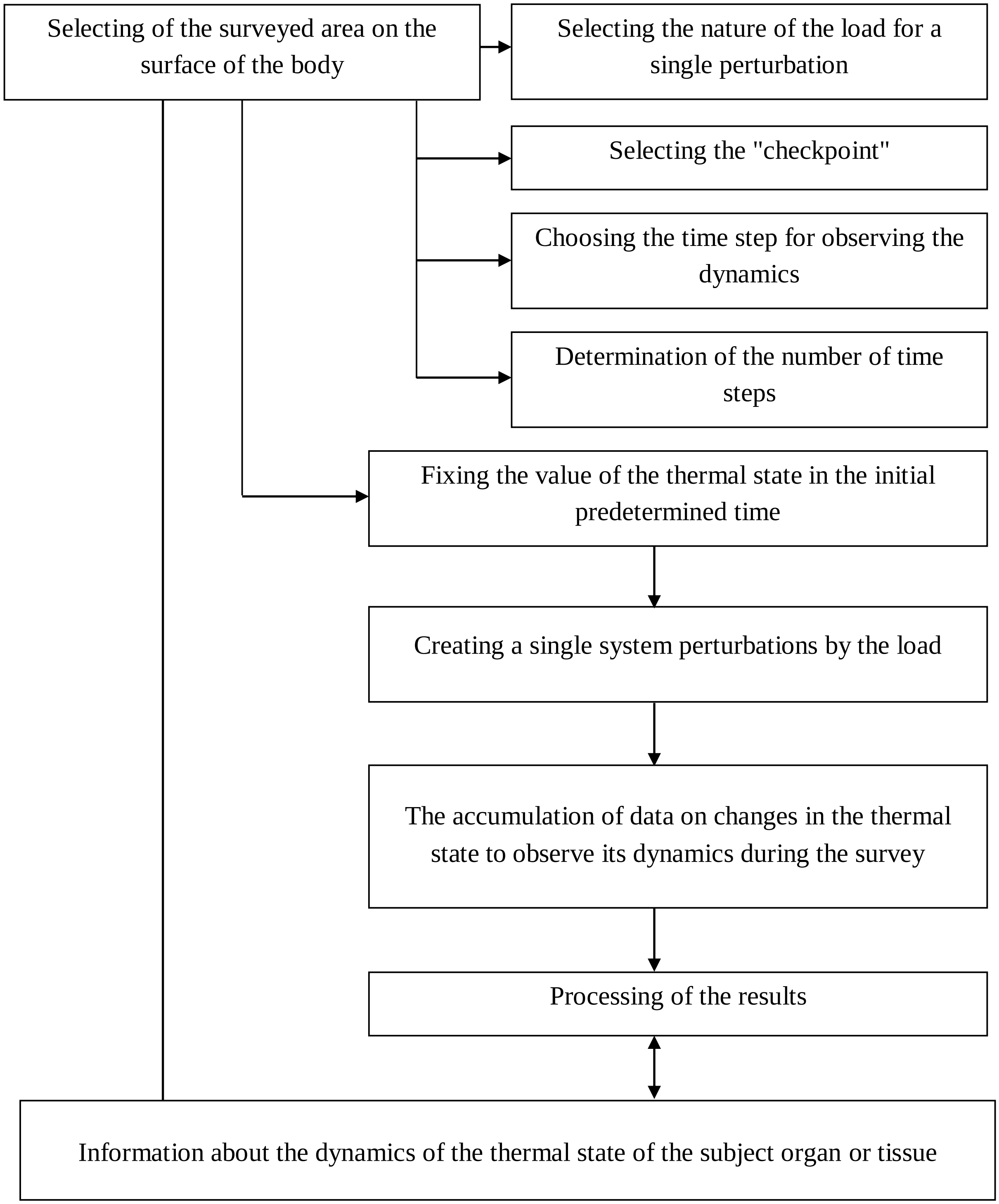

Fig. 4. Algorithm research

Observation of the dynamics of the thermal state allows us to objectively track the effectiveness of the use of drugs and medical procedures, the restoration of the function of organs during the rehabilitation period [5].

As an example, Fig. 5 shows a graph describing the thermodynamic picture of the healing incision.

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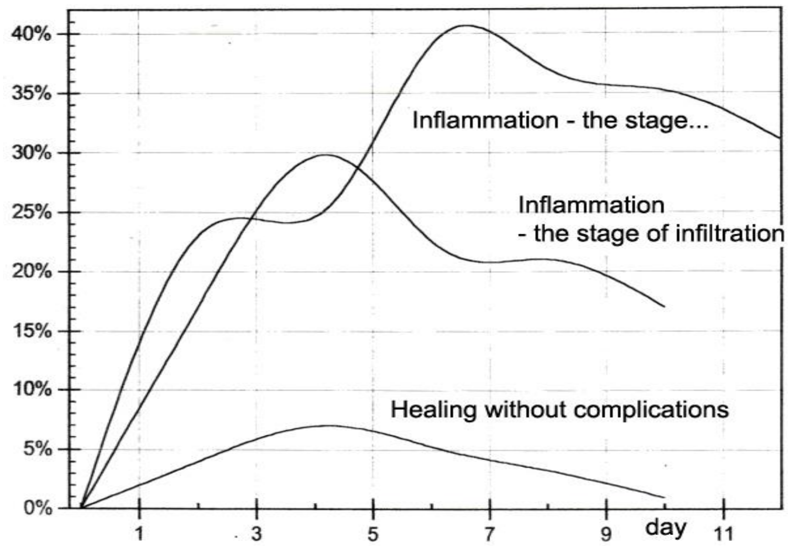

Fig. 5. The thermodynamic picture of the healing incision

Fig. 6 shows the dynamics of the thermal state, which characterizes the development of acute appendicitis.

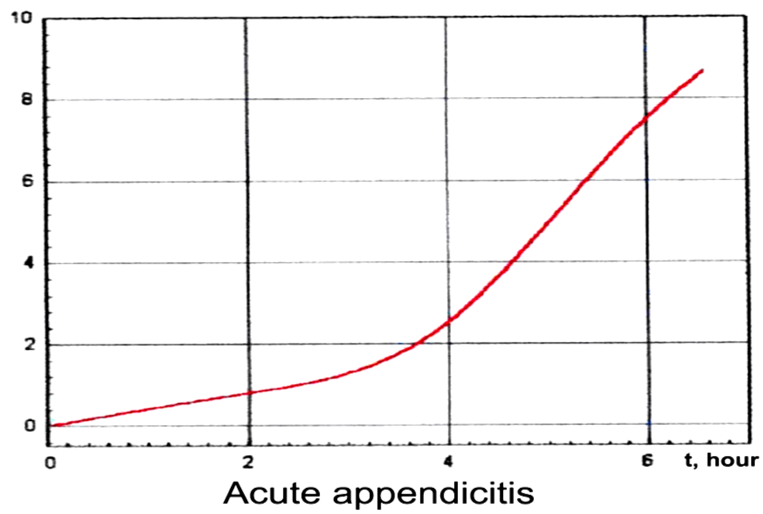

Fig. 6. Thermodynamic picture of the development of acute appendicitis

The diagram in Fig. 7 shows the level of the relative change of thermal radiation characterizing various pathological changes of appendicitis.

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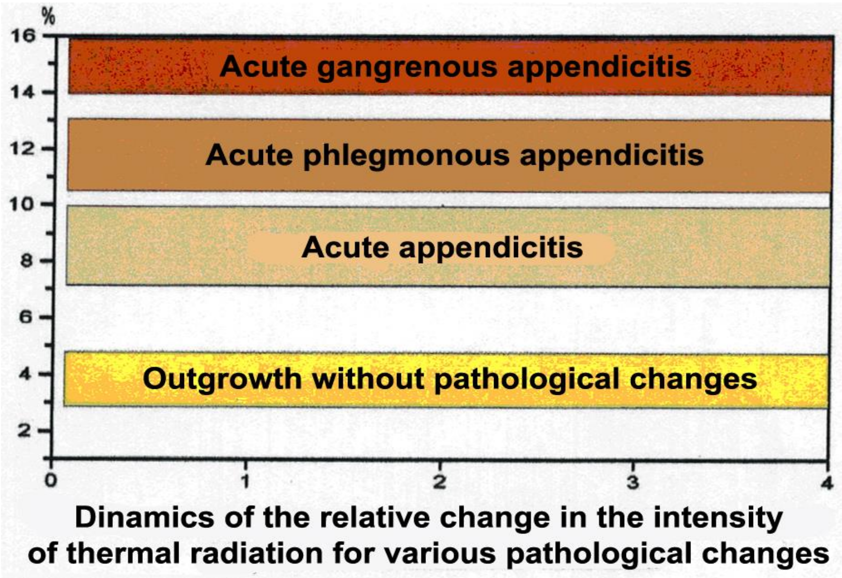

Fig. 7. The relative level of thermal radiation in various pathologies of appendicitis

Fig. 8 shows graphs of the thermal radiation from the kidneys projections after stress test characterizing a healthy person.

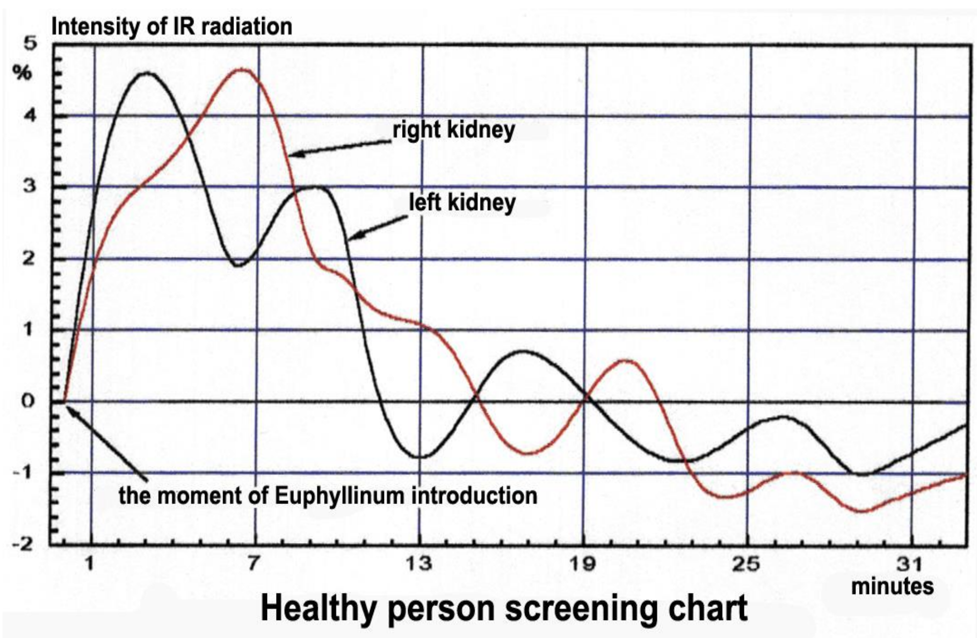

Fig. 8. Dynamics of thermal radiation in the normal kidney

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Fig. 9 shows the graphs of the thermal radiation from the kidneys projections after stress test characterizing the glomerulonephritis [6].

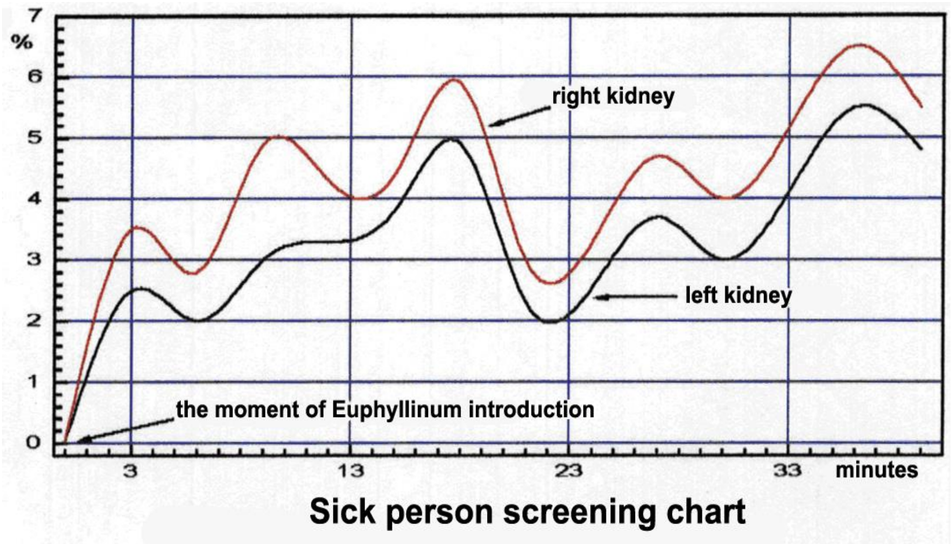
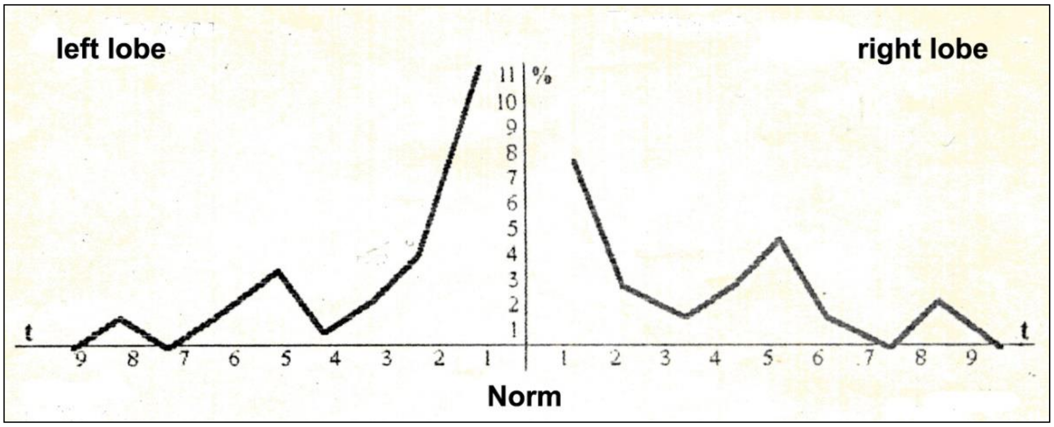
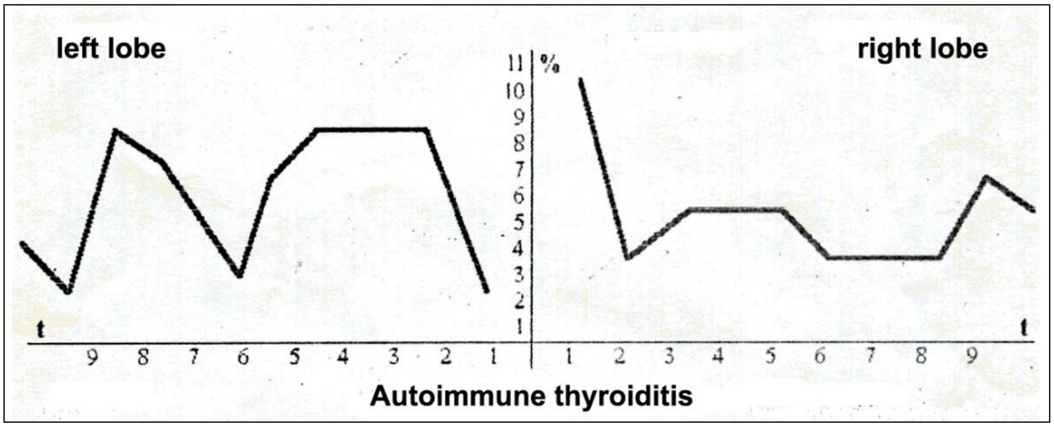


Fig. 9. Dynamics of thermal radiation of the kidneys in pathology

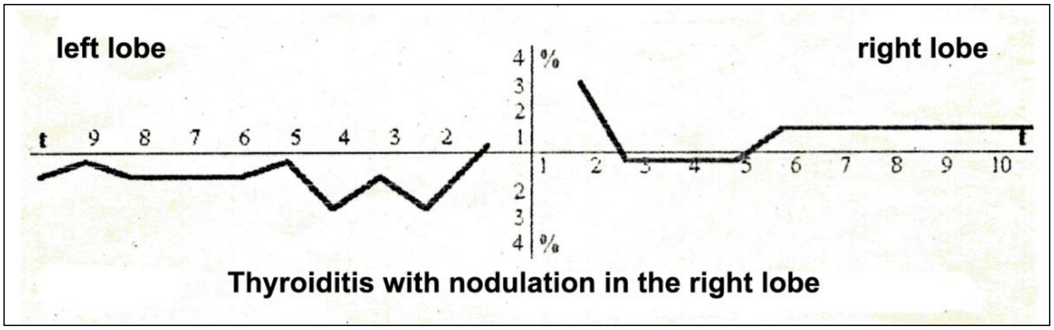
Fig. 10 shows graphs of the survey patients screening with impaired function of the thyroid gland.



(a)



(b)



(c)

Fig. 10. Dynamics of changes in the thermal radiation intensity from the projection of the thyroid gland in normal and pathological states:

(a) – dynamics of thermal radiation of a healthy person;

(b) – dynamics of thermal radiation of autoimmune thyroiditis;

(c) – dynamics of thermal radiation of thyroiditis with nodulation

Results. Studies have confirmed the effectiveness of the practical use of the complex for medical diagnosis and monitoring of patients with a number of diseases in a variety of medical and clinical settings. With the help of modernized and improved complex "Thermodyn" offers the possibility of diagnosis and studies of various human organs diseases, study parameters deviations from the normal of the body functions, monitor the effectiveness of drugs used to treat and restore the functions of the corresponding organs and tissues.

In the future it is proposed to expand the scope of the diagnostic capabilities of the complex, using it in gynecology, oncology, pulmonology, surgery and traumatology to control the speed and efficiency of healing of postoperative sutures, and also in industry when controlling a large number of technological operations related to heat treatment, casting and Other

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