

THERMOVISUAL EVALUATION OF ACUPUNCTURE POINTS

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(Received November 20, 2000; Accepted with revisions January 15, 2001)

ABSTRACT:

The aim of our study is to evaluate the temperature distributions around the acupuncture points and channels by visualizing the infrared emissions emanated from the human skin. Our thermal imaging system that is the most sensitive to 10 μ m long infrared wavelength allows us to recognize the actual location of acupuncture point and analyze its functional condition by examining the temperature gradient between the point and its surrounding skin area. The temperature perception of acupuncture point on extremities is especially important since its location and functional condition have a tendency to be altered if one contract disease such as immunodeficiency, arterial hypertension, and dyskinesia of biliary ducts. Also, thermovisual examinations over the acupuncture points allow us to perform the objective medical treatments by observing the transition of temperature gradients.

KEY WORDS: Acupuncture Point, Thermograph, Thermogram, Hyperthermic, Hypothermic, Isothermic, Thermovisual Diagnosis, T-cell immunodeficiency

INTRODUCTION

The biologically active point, i.e., acupuncture point reflects functional conditions of human body. The positions of acupuncture points are well described in many books or articles about traditional Chinese medicine. But the descriptions for specifying the location of acupuncture points and channels are merely based on the statistical data collected from the human who had once lived in Chinese territory more than 2,000 years ago. Nowadays the necessity of new interpretation to identify acupuncture points and channels is emerging since mankind has been exposed to the external environments for last 2,000 years, and especially to man-made radio-electronic wave and the environmental pollution for the last several decades. Since the human has been adapting to the environmental changes, and the acupuncture points and channels reflect his or her adapted functional conditions, it is desired to bring new methodology

to detect some fluctuations of functional properties and positions of the acupuncture points.

Today, there exist several methods to estimate the functional condition of acupuncture points. Most of them are based on measuring electric-physiological characteristics of the skin above the acupuncture point[1-2]. But in these cases, the functional condition of acupuncture point can be altered due to the influence induced by electrical source, and then only the electrical reaction of acupuncture points for the input pulse is observed. Moreover if the doctors measure the electrical signals from the acupuncture points, they often acquire inconsistent signal levels. This inconsistency can be caused by the doctors' false specification of the acupuncture points since they do not take any consideration for individual particularities of the points. Thus, it is necessary to consider a device or new method to locate and specify the functional characteristics of the acupuncture points with satisfying the following requirements:

1. The device or method must not influence on the functional properties of acupuncture points (to be **passive**).
2. The device or method must examine the wide area of expected location of the acupuncture points (to be **visual**).
3. The device or method must extract not only the particular locations but also the physiological characteristics of the acupuncture points (to be **wide functional**).

Infrared thermograph can satisfy all of these requirements. It is defined as the method of determining the spatial distribution of heat emanated from the objects[3]. In fact, thermograph is a non-contact and passive device since it only receives infrared emissions radiated from the objects and converts into the thermal images. When the images are displayed on the computer screen or printed, they are called as a thermogram. Thermogram is map of thermal energy into the pseudo-colored image using the standard palette color where reds or yellows indicate high temperatures and blues represent the low temperature values. In black-and-white mode, the brightness indicates the higher temperature values. Since thermogram can display the temperature distributions over the wide skin area in real time, it can show the functional activity and pathological changes of human body at once.

MATERIALS AND METHODS

Temperature distribution over the acupuncture points

The application of thermograph to specify the acupuncture point was initiated by Vogralic[4] in the middle of 1980s. Vogralic established the basic concepts of thermovisual evaluation over the acupuncture points as follows:

- i) Skin temperature over the acupuncture point can be different from the temperature value of its surrounding area. This fact allows us to locate the acupuncture points by analyzing thermogram.
- ii) The temperature value over the acupuncture point compared to the surrounding area can be one of the following three stages: hyperthermic (**high temperature value**), hypothermic (**low temperature value**) or isothermic (**similar or equivalent temperature value**). The decision standard is the temperature gradient between the acupuncture point and its surrounding skin area. If the point is in isothermic stage, the temperature gradient between the

point and its surrounding area may not be observable in thermogram. Nevertheless, it is important to recognize the isothermic condition over the point.

- iii) Temperature over the acupuncture point reflects functional properties of body. Hence thermogram can be used to diagnose the physiological conditions of body. It can also be used to evaluate the effectiveness of administrated medical therapy.
- iv) The temperature distribution over the acupuncture point remains in relatively constant if there is no medical treatment or external stimulus to the point.

Thermal imaging system and clinical experiments

The visual examination of the acupuncture points in long infrared spectrum region can be performed by thermal imaging system. It measures the emitted infrared energy dissipated from the object, and maps the heat energy into temperature values. Since 1986, we have clinically examined thermovisual characteristics of the acupuncture points of 25,000 patients who are admitted to the hospitals in Russia, China, Bulgaria, and Italy. Our thermal imaging system, "TV (Thermovisual)-03K" (Fig.1) has an infrared sensor that is the most sensitive to $10\mu\text{m}$ long wavelength infrared. Infrared radiation emanated from an object goes into the sensor by condensing the infrared wave through optical lens. Electronic circuit system measures the intensity of infrared wave and maps to the proportional temperature value.

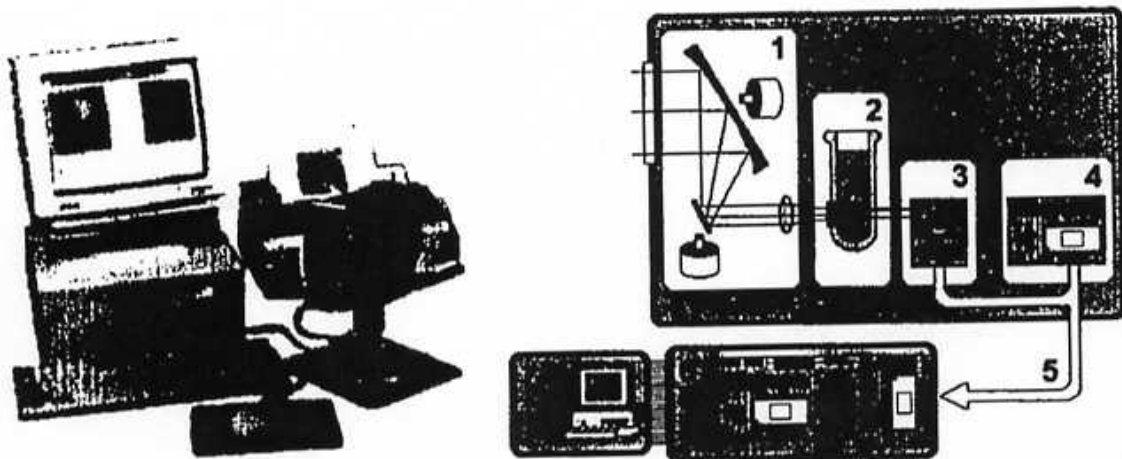


Fig.1. TV-03K Thermal imaging system and its schematic diagram

- 1: Scanning system consisting of two mirrors, condense lens and two motors to adjust the mirrors,**
- 2: Infrared sensor, 3: Analog amplifier and noise reduction circuit,**
- 4: Motor controller unit, 5: Communication cable,**
- 6: ISA card with ADC, DAC, power supply, and communication unit,**
- 7: Thermogram display.**

Table 1 lists hardware specifications associated with TV-03K.

Table 1. Hardware specifications of TV-03K.

Absolute temperature resolution	0.05 °C
Relative temperature resolution	0.002 °C
Cooling type	Liquid Nitrogen
Infrared sensor	Single CdHgTe diode
Acquisition speed	1 frame per 2 seconds

Figure 2 shows that the experimental setup to scan a patient's hand with TV-03K. The patient sits in a chair or stand from 0.5 to 3 m away from infrared camera. An operator waits for 3 to 5 minutes for the patient to adapt the temperature of examining room. The room temperature must be ranged from 18 to 22 °C . In Figure 3, our graphic user interface software (developed in Borland's Delphi programming) is shown. The patient's name is first registered with an examining date and his or her scanning body part is categorized such as chest, hand, foot and head. Using the standard palette color or monochrome gray levels, thermogram is displayed on the computer screen or printed for a hard copy.

**Fig.2. Clinical experiment setup with TV-03K thermal imaging system.**

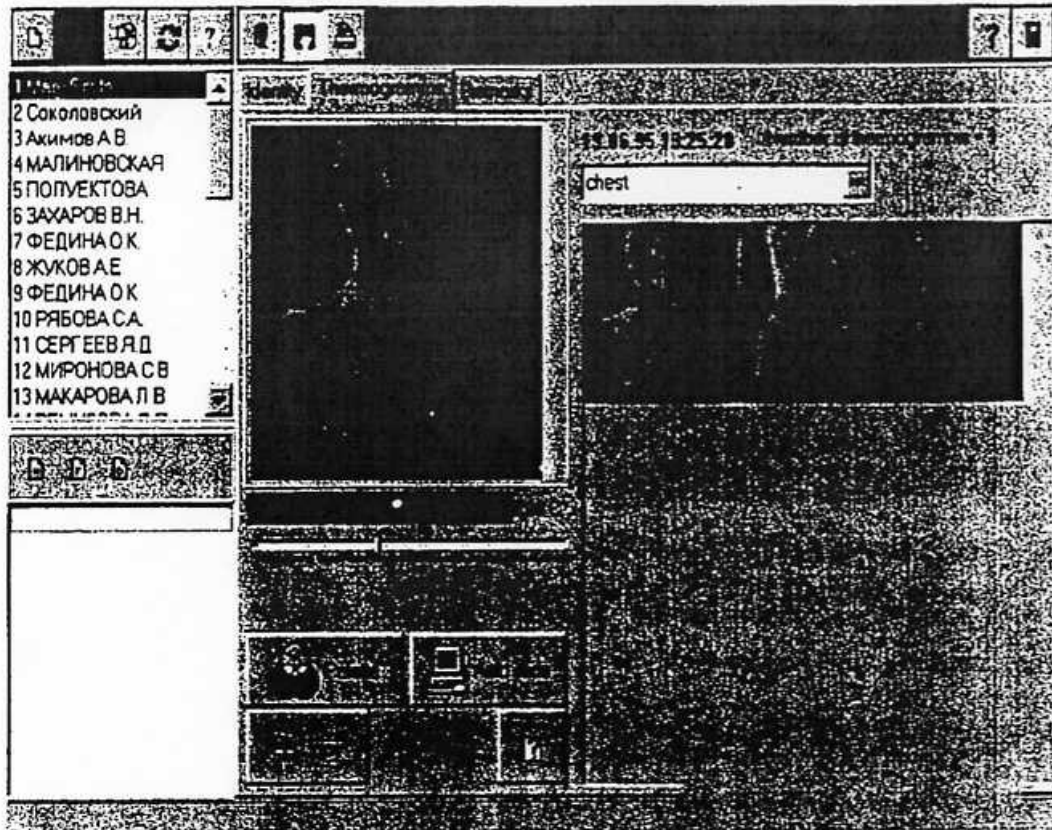


Fig.3. Graphical user interface software for TV-03K thermal imaging system

Temperature evaluation between acupuncture point and its surrounding area

By analyzing the thermograms acquired from clinical experiments on 25,000 patients, we observe that the temperature gradient between acupuncture point and its surrounding area can be existed as one of the following 3 stable functional conditions:

- i) **Hyperthermic condition:** the temperature around the center region of an acupuncture point is 0.8°C higher than one of its surrounding skin area,
- ii) **Hypothermic condition:** the temperature around the center region of an acupuncture point is 0.8°C lower than one of its surrounding skin area,
- iii) **Isothermic condition:** the temperature gradient between the center region of acupuncture point and its surrounding skin area is less than 0.8°C .

In hyperthermic condition, thermogram shows the relatively small hot spots with circular or elliptical form (Fig. 4). Here, the hot spot is denoted with an arrow mark to enhance the readers' visibility. The intensity level change of hyperthermic area is monotonous. These hot spots are usually located on the expected acupuncture's position as specified in traditional Chinese medical books. The temperature difference between the center of acupuncture point and its surrounding area is more than 0.8°C , which is usually from 1.2°C to 1.5°C .



Fig. 4. Thermogram of the right foot with hyperthermia above Zu-San-Li (St. 36) acupuncture point.

In hypothermic condition, the temperature value around the acupuncture point is relatively lower than one of its surrounding tissue. In this case, a large cold spot is usually visible around the acupuncture point. The shape of this cold spot is dependent on anatomical shapes of organs located beneath the point (Fig. 5). This cold spot is usually deviated in some distances (even up to 5 cm) from the expected acupuncture position as specified in traditional Chinese medicine. The intensity level change of hypothermic area is often jagged. The temperature differential between the center of acupuncture point and its surrounding area is more than 0.8 °C, even up to 4 °C.

A group of cold or hot spots related with several acupuncture points or channel can be seen (Fig. 6 and 7). Note that acupuncture channel itself is rarely visible as hyperthermic or hypothermic thin line. In isothermic condition, the acupuncture point is not visible in thermogram since the temperature distribution over the acupuncture point is similar to one of its surrounding area.



Fig. 5. Thermogram of the right palm with hypothermia above Shen-Men (H.7) acupuncture point. The point is deviated towards to finger about 3cm.

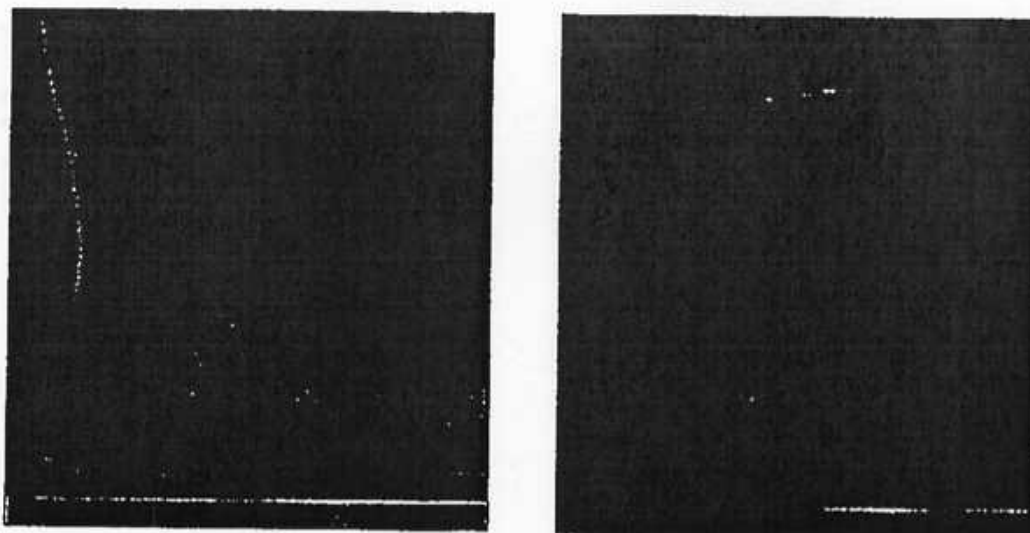


Fig. 6. Thermogram of the inner side of left foot with the spotted hyperthermia along Spleen channel and lumbar area with hyperthermic spots along Urinary Bladder and Back Middle channel.

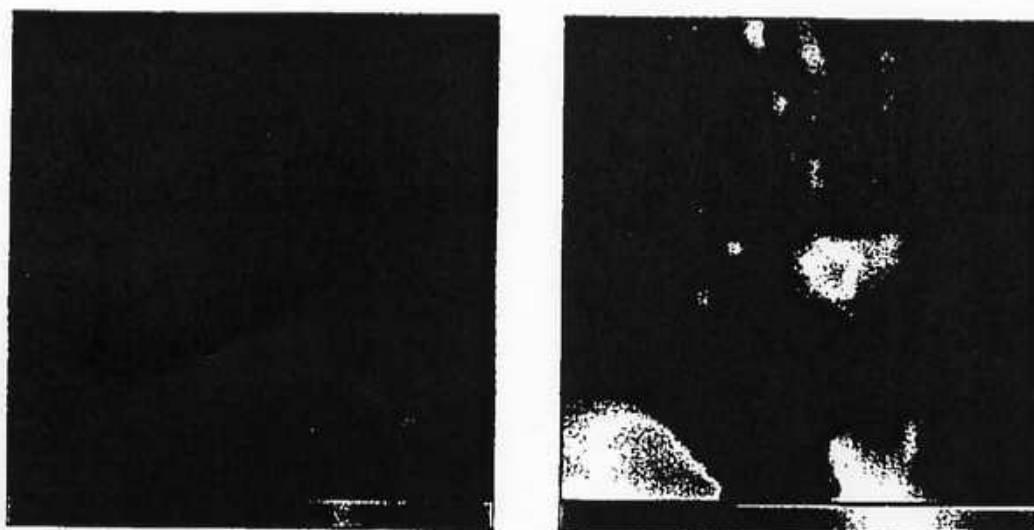


Fig. 7. Thermogram of the inner side of right foot with hyperthermia above Kidney channel and the left palm with hypothermia above Tai-Yuan (Lu.9), Yu-Ji (Lu.10), and Da-Ling (PC.9) acupuncture points.

Our clinical experiments reveal that the temperature analysis over the acupuncture points and channels can be used for diagnosing the diseases such as immunodeficiency syndrome, cardiac neurosis and dyskinesia of biliary ducts.

Thermovisual Diagnosis of Acupuncture Point (TDAP)

The first clinical application of TDAP was proposed by Vogralic [4] to diagnose the secondary T-cell immunodeficiency syndrome by detecting hypothermic spots over the acupuncture points and channels. Vogralic found that if one had T-cell immunodeficiency syndrome, hypothermic regions were observed around thymus: Hua-Gai (Ren.20), and Spleen channel: Tai-Bai (Sp.3) and Gun-Sun (Sp.4) (Fig. 8).

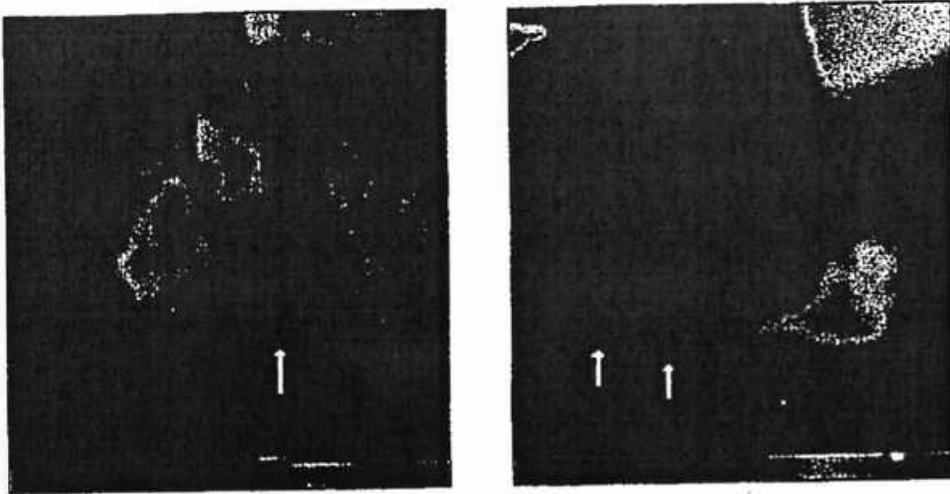


Fig.8. Thermogram of the chest with hypothermia around thymus and the inner surface of the right foot with hypothermia along Spleen acupuncture channel.

Hence TDAP shows the strong correlation between thermovisual signs and immunological parameters. Moreover, if TDAP detected a patient's immunodeficiency but the laboratory tests showed normal condition, the patient turned out to be having clinical manifestation of immunodeficiency syndrome such as cold, or chronic infections. Thus TDAP can be used to have early diagnosis for immunodeficiency syndrome without performing actual laboratory test. Klemenov[5] found that the temperature distribution over umbilicus (Shen-Qiue (Ren.8) acupuncture point) was correlated with the pressure inside biliary ducts (Fig. 9).

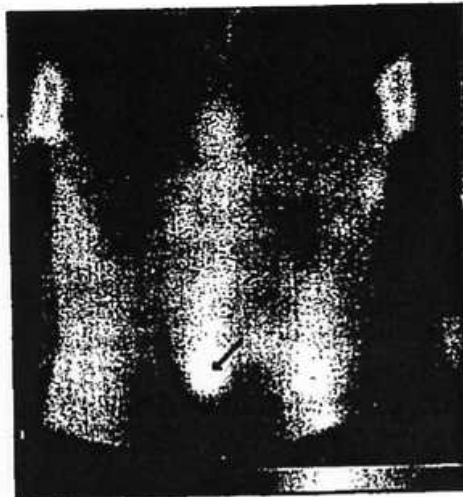


Fig.9. Thermogram of the abdomen with hyperthermia on umbilicus.

In the case of arterial hypertension, the typical thermovisual sign is hypothermia above the Wai-Guan (TW.5) point[6] (Fig. 10). Thus TDAP can be utilized for the early diagnosis of arterial hypertension especially for the young people.



Fig.10. Thermogram of the external surface of the right forearm with hyperthermia above Wai-Guan acupuncture point.

TDAP can be also used to diagnose the heart pains[7]. If the pains are caused by coronary heart disease, thermovisual sign is hypothermic spot above Shen-Men (H.7) point (Fig. 11). Sometimes this cold spot spreads along the medial side of the palm towards a finger. This phenomenon is called "thermoamputation" symptom (Fig. 12). If the heart pain is caused by non-coronary disease such as neuralgia, the temperature gradient over Shen-Men point (H.7) remains in isothermic condition.



Fig. 11. Thermogram of the left palm with hypothermia above Shen-Men (H.7) acupuncture point.

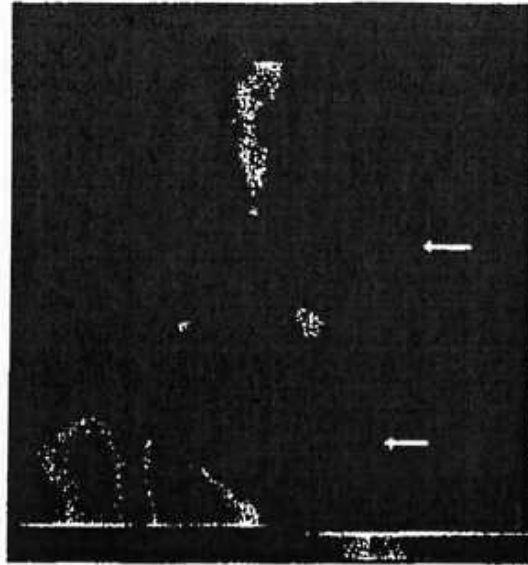


Fig.12. Thermogram of a left palm with excessive hypothermia along the inner side of a hand with “thermoamputation” symptom on a little finger.

Thermovisual interpretation of functional condition

The temperature distribution over acupuncture point can manifest functional condition of human body. If the temperature gradient above the acupuncture point is high, it indicates “excess” of the functional energy around the point. If the temperature differential above the point is small, it indicates “deficiency” of the energy [8]. Thermogram can be utilized to adopt the proper medical treatment tactics. For an instance, if temperature over the acupuncture is hyperthermic, the functional energy reduction method (“Sie”) is applied, but if the temperature value over the acupuncture point is hypothermic, the energy stimulation (“Bu”) is used [9].

In order to evaluate the severity of functional disorders from thermogram, we need to consider two visual factors. The first factor is the amount of temperature gradient between the thermally abnormal spot and its surrounding area. If temperature differential is high, the severity of functional disorders is also high. Statistically, if temperature gradient is less than 1.2 °C, the functional disorder is moderate. But if the gradient is more than 1.2 °C, it indicates that the functional disorder is severe.

The second one is physical size of thermal spot since the dimension of abnormal temperature valued spot is directly correlated with the severity of pathological process. The physical dimension of spot is largely dependent on the organ’s anatomical features beneath the acupuncture point. For example, the size of thermally abnormal area around the acupuncture point on the face or palm is rarely large (Fig. 13) whereas the dimension of thermally abnormal area on the abdomen wall is usually large (Fig. 14).

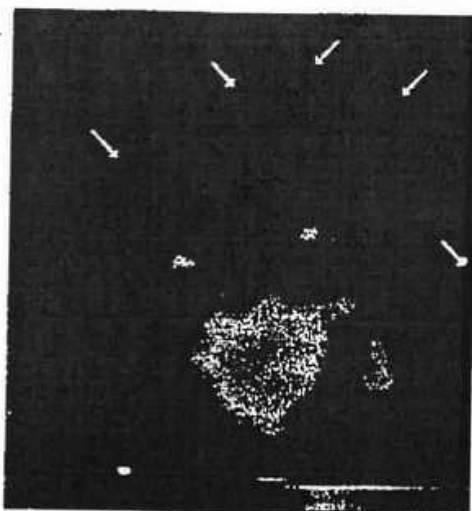


Fig.13. Thermogram of the right palm with small hypothermic region over Shi-Xuan acupuncture points on the top of the fingers.

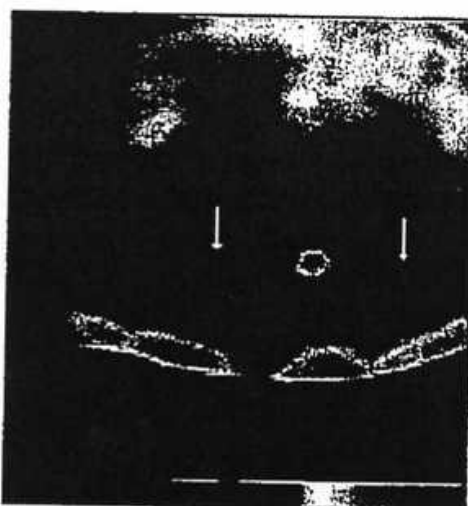


Fig.14. Thermogram of the abdomen with large hypothermic region over Tian-Shu (St.25) acupuncture points.

Since the temperature gradient and size of thermally abnormal area are variant to the individual's functional particularities, the quantitative evaluation or interpretation about the severity of pathological process can be somewhat different for each person. But this fact does not limit the usage of thermovisual method to diagnose the functional conditions of human body since TDAP can really show the dynamical changes of temperature distribution around the acupuncture point or channel before and after the medical treatments.

Thermovisual control for the medical treatments over the acupuncture points

Since the temperature distribution over the acupuncture point is relatively stable, it is possible to check the effectiveness of administrated medical treatments by visually examining the transition of temperature gradient over the point. If the administrated

medical treatments are proper, the temperature distribution over the point is changed from either hyperthermic or hypothermic to isothermic. In isothermic condition, the temperature value over the point is similar to its surrounding area. Hence if a patient undergoes the right medical treatments and consequently improves his or her functional condition of body, the acupuncture points is not visible in thermogram. But if the treatments are improper, the temperature parameters over the point remain in the previous condition.

Figure 15 shows the dynamical change of temperature distribution above the acupuncture points on a patient's chest for the case of T-cell immunodeficiency syndrome. The thermograms shown in Fig. 15 are taken before and 10 days after the microwave resonance therapy is applied to the acupuncture points which are not located on the chest. Here the temperature gradient over the acupuncture point in the patient's chest becomes isothermic after the lapse of 10 days from the treatment. This indicates that the treated medical treatment is appropriated to heal T-cell immunodeficiency. The laboratory test also shows that the patient's health condition is improved in terms of immunological parameters.

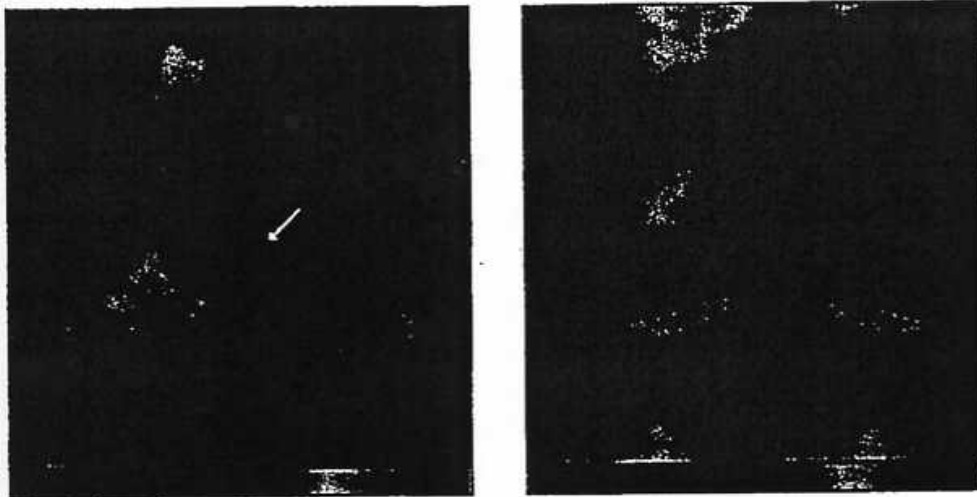


Fig. 15. The dynamical change of temperature distribution over the acupuncture points in a patient's chest for the case of immunodeficiency syndrome. The left thermogram shows the temperature distribution before the treatment whereas the right one shows the temperature gradient after 10 days from microwave resonance therapy treatment.

CONCLUSIONS

The acupuncture points are the mirrors reflecting functional condition of human body. The main difficulty in researching of acupuncture point is that there is no direct method to estimate or measure its functional condition parameters. Thermovisual method is non-contact, harmless and fast to estimate the actual locations and functional conditions of acupuncture points. The temperature distribution around the acupuncture point or channel could be one of the three states: hyperthermic, hypothermic or isothermic state. Hyperthermic and hypothermic state indicate the

excessive and deficient energy, respectively. Hence thermovisual analysis can be used to decide the proper medical treatment tactics. Once medical treatment is performed, the effectiveness of treatment is easily checked by merely examining the temperature distribution around the acupuncture points. If the treatment is properly administered, hyperthermic or hypothermic condition around the point is transformed to isothermic. In this case, the acupuncture points are not visible in thermogram since temperature gradient between the acupuncture point and its surrounding area is small. In our conclusive remarks, thermovisual method allows us to

- i) detect the acupuncture points visually,
- ii) evaluate the functional condition of the acupuncture points,
- iii) diagnose the diseases such as immunodeficiency, dyskinesia of biliary ducts and heart pains,
- iv) offer objective control or tactics during the medical treatments.

REFERENCES

1. Cohen Kuo-Gen, "Electrical properties of meridians with an overview of the electrodermal screening test", IEEE Engineering in Medicine and Biology, vol. 15, issue 3:pp. 58-63, May/June 1996.
2. Suhariningsih and Kanai H., "Observation of human impedance at 50kHz for analysis of acupuncture points", Proceedings of the 2nd Int. Conference on Bioelectro-magnetism, pp. 15-18, Feb. 1998.
3. Gerald C. Holst, Common sense approach to thermal imaging, SPIE Optical Engineering Press, 2000.
4. Vogralic V.G. and Vogralic M.V., New method of diagnostic of diseases (in Russian), Gorky, 1988.
5. Klemenov V.I. and Vogralic M.V., "On possibility of thermovisual examination to diagnose the biliary diseases (in Russian)", Temperature Measurements in Medicine, Leningrad, pp. 84-86, 1985.
6. Vogralic V.G., Vogralic M.V., Golovanova M.V., Merinova I.V., and Sizova V.F., "Possibilities of thermovisual reflexodiagnosics in detection the risk group for circulatory diseases (in Russian)", Temperature Measurements in Medicine, Leningrad, pp. 168-169, 1988.
7. Vogralic V.G. and Vogralic M.V., Way to Health: New Method of Thermovisual Screening Diagnostics (in Russian), Nyzhny Novgorod, 1997.
8. Ovechkin A.M., Essentials of Zhen-Jiu Therapy, Saransk (in Russian), 1991.
9. Kyung-Sub Lee and Young Soo Kim, "Study of the Thermal Differences on the Meridian Points us Cold Hypersensitivity", IEEE Engineering in Medicine and Biology Society, 19th Annual International Conference, pp 634-636, 1997.