Microwaves and Infrared Thermography - Comparative Studies in Early Breast Cancer Detection

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***Abstract*-The paper presents some recent advances concerning a non-invasive microwave method used to investigate living structures. An overview of the main investigation methods in breast cancer are presented, as well as their classification. Thermography as an early non-invasive and highly sensitive method helps on the detection of the malign tumours in the early curable stages, contributing to diminish the mortality which appears in the cases where the breast cancer was detected in tardive incurable stages.**

Infrared imaging of the breast has shown effective results in both risk assessment and prognostic determination of breast cancer. It is a non-invasive investigation method for the living structure which uses the radiation emitted by the biological structures themselves within the microwave range, according to the radiation laws of electromagnetic waves.

The microwave radiometry allows for the depth malignant structures detection because the microwaves have a greater wavelength and are less absorbed by the tissue traversed from the tumor to the surface. The temperature resolution is compatible with that of infrared thermography (0.1 ^oC). The resolution is connected to the fact that the difference between the environmental temperature (25 ^oC) and the measured body temperature average (37 ^oC) is relatively small. In the microwave range the intensity of electromagnetic radiation is almost 10^6 less than infrared radiation. Images obtained by radiometric methods for tumor structures detection are distribution maps of electrical properties of tissues.

We propose an automated approach to detect asymmetric abnormalities in thermograms.

I. INTRODUCTION

Breast cancer is the most common cancer found at women. Male breast cancer makes up about 1% of all mammary malignancies and may include tissues beyond the areolar boundary [1]. A family history of breast cancer, particularly among primary relatives (mother, sisters, daughters) significantly increases an individual's risk of developing breast cancer [2-3].

The detection methods to reveal the tumour structure are divided in two main categories: non-invasive and invasive methods. The non-invasive methods that use specific fields of the anatomic structure as well as certain mechanical properties are: Infrared Thermography (IR), Microwave Radiometry (MR) and Tactile Breast Imaging (TBI). The main invasive methods that use the breast exposure to electromagnetic, magnetic, ultrasound fields or radioactive tracers are: Conventional X ray mammography, Full Field Digital Mammography, Ultrasonography, Impedance Tomography, Nuclear Tomography and Ductography, Scintimammography, Magnetomammography, Diffuse light imaging and Laser Breast Scanner [4-8].

Noninvasive methods are preferred because they don't use ionogene radiation, it could be made as often as necessary and it doesn't seem to be harmful for the patient. In the present paper we are making a comparative study between two non-invasive methods, microwaves and infrared thermography.

Infrared imaging uses the radiation emitted by the biological structures themselves within the microwave range, according to the radiation laws of electromagnetic waves.

Compared with infrared thermography the microwave radiometry allows the detection of depth malignant structures because the microwaves has a greater wavelength and are less absorbed by the tissue traversed from the tumor to the surface. This is the most important and fundamental difference between the two methods.

The internal tissues temperature changes because of inflammatory processes. The determination of thermal activity is a measurement of tumour activity, or growth rate [9], providing date beyond the physical parameters (side and depth determinate by mammography).

The thermographic methods permit the earlier detection of tumour even of the very small size. The results obtained are more accurate if they are reinforced by the results given by other parallel non-invasive optic methods or thermography, influencing the expert's opinion in the final decision.

II. METHOD

The physical principle of the microwave thermography consists in the detection of the electromagnetic radiation in the microwave spectrum by means of a low noise highly sensitive microwave receiver.

To realize thermal image of the breast, the patient sits with thorax uncovered, placing hands on hips, 20 minutes to reach a thermal equilibrium with the environmental temperature (22–23)°C.

The microwaves antenna was placed in contact with the breast at the positions T1, T2 (Fig. 1). Radiometric sensor was placed successively in all 10 areas of the breast as software indicated on both breasts: superior, inferior, internal, external, superior-internal, superior-external, inferior-internal, inferior-external, nipples and auxiliary area [9], for 5-10 seconds. The values of the measured temperatures and the thermal image are displayed on PC.

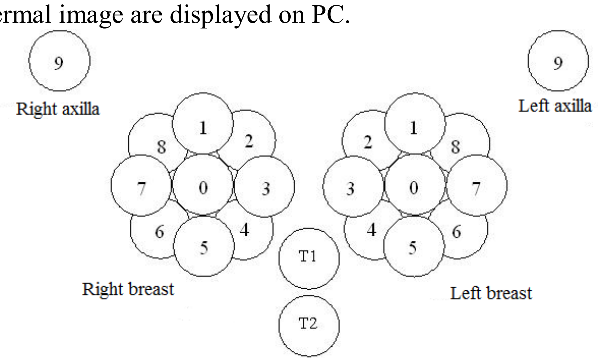


Fig.1 Measurement of temperature points

III. RESULTS

The study was made on two groups (clinic and paraclinic) for six months. The radiometer utilised is RTM-01 type.

In the case 1 (clinic) the infrared thermography provides a thermal map of the skin surface area by measuring the radiant heat emitted (Fig.2).

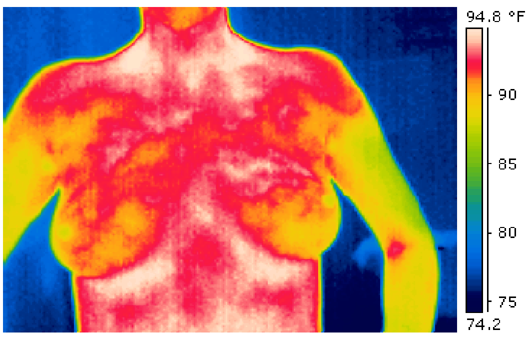


Fig. 2 The IR Image - Healthy Woman

The thermogram may be represented by using the radiometer's own software (Fig.3).

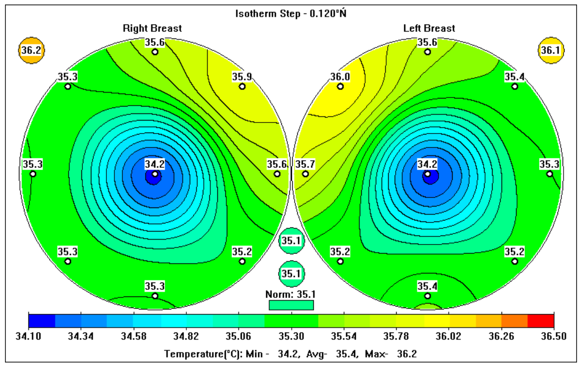


Fig 3. Image obtained by microwave radiometry

In the case 2 (clinic), second position, the subject has an increased temperature (+1.1°C) of the left breast compared with the same position of the right breast (Fig.4, Fig.5). In clinical exam it was found a structure well defined.

Between IR thermography and radiometric images is a thermal correspondence.

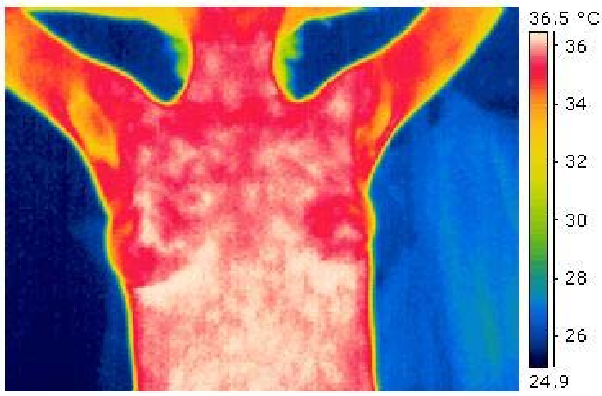


Fig.4. The IR image - front profile

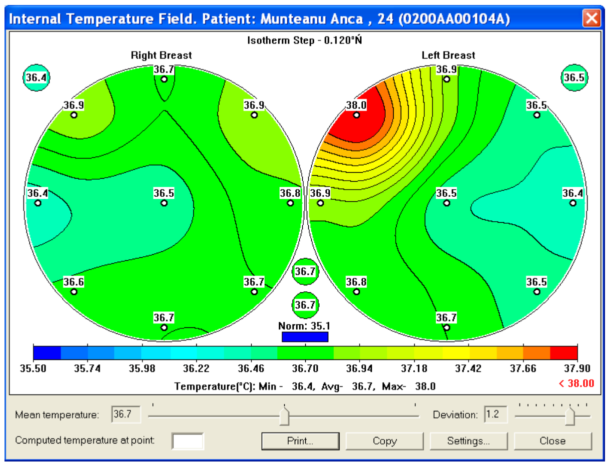


Fig.5. Image obtained by microwave radiometry

In the third case (paraclinic), at the right breast there is an increased blood circulation (Fig.6, Fig.7).

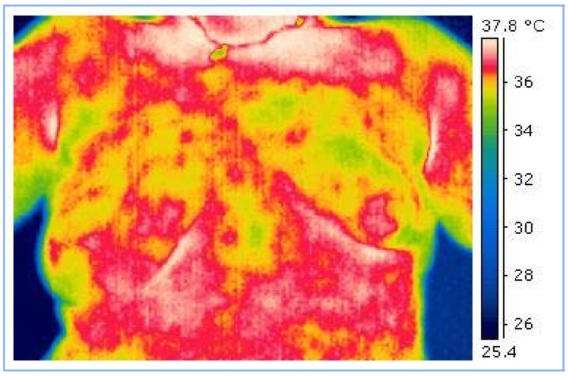


Fig.6. IR image - front profile

Although the left breast is underdeveloped there is no thermography difference from the right breast.

The subject is treated as a result of hormonal disturbances. It is found a correspondence between the IR thermo graphic and radiometric images.

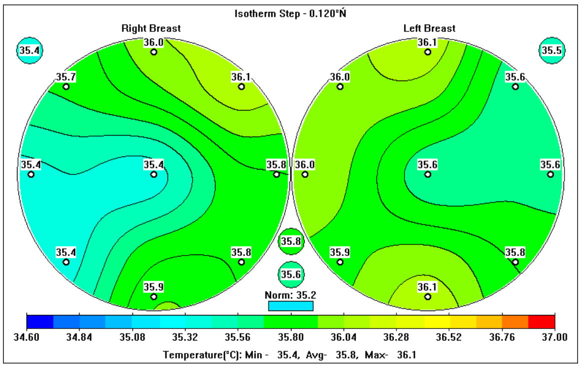


Fig.7. Image obtained by microwave radiometry

In the fourth case (paraclinic), there is a temperature difference (-0.3°C) at position 0, which anatomic corresponds to nipple, the lower temperature being at left breast, where one party describes ultrasound nodular structure (Fig.8, Fig.9).

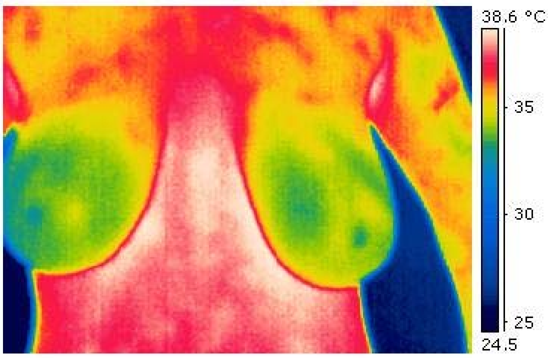


Fig.8. IR image - front profile

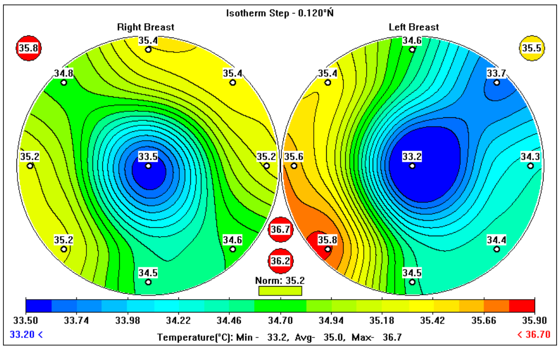


Fig.9 Image obtained by microwave radiometry

Thermography images taken are consistent with the ones that are obtained by conventional methods (ultrasound and mammography).

The presence of a severe inflammatory process can be observed at both breasts - a young mother 19 years (Fig.10).

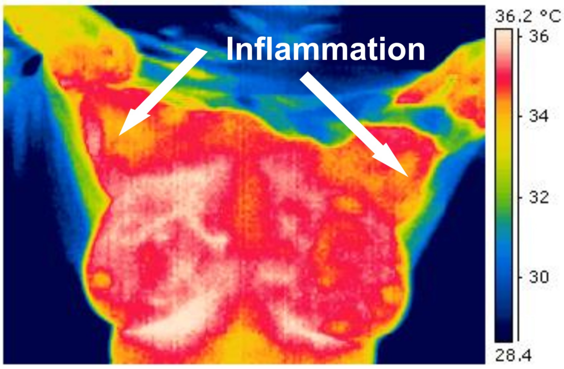
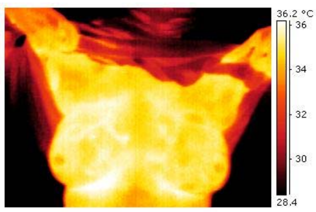
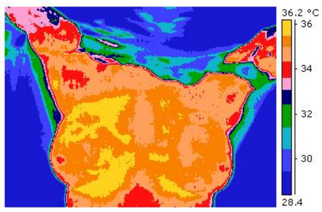


Fig.10. IR image using different processing techniques to highlight the inflamed area

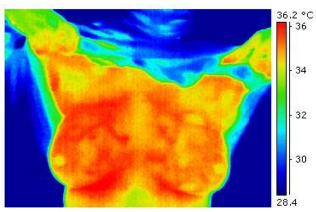
We used different processing techniques to highlight the inflamed area accounts (Fig.11)



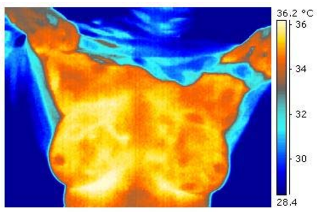
a) *Palette Glowbow*



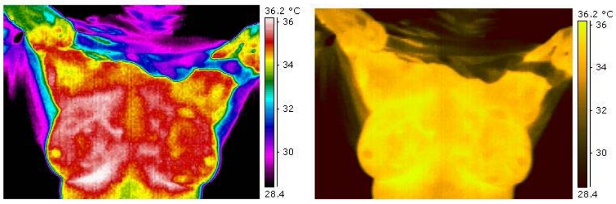
b) Palette Grey



c) *Palette Midgreen*



d) Palette Midgrey



e) *Paleta Yellow* f) *Palette Rain*

Fig.11. IR images using different processing techniques to highlight the inflamed area accounts

IV. CONCLUSION

Microwaves thermography, like infrared thermography, is a noninvasive and passive technique. It does not subject the patient to radiation, discomfort, stress and physical stress.

The cancer detection is based on the contrast between the thermal images of the mammary normal and malign tissues respectively, obtained through radiometry, the last one having a higher temperature.

In breast cancer diagnosis, this method presents incontestable advantages: low costs, repeatability (as often as necessary, even monthly), completely non-harmful.

Microwave medical imaging is a completely non-invasive technique. The microwave technique also permits to show the difference between malign and a benign tumours, thus reducing the number of invasive and expensive biopsies.

Mapping the spatial microwave emitting loci of the normal and malignant tissue we may early detect the areas with an increased biological activity.

The real spatial malignant tissue positioning is limited by the breast normal shape and the physical dimensions of the antenna.

The results obtained are more accurate if they are reinforced by the results given by other parallel non-invasive optic methods or thermography, influencing the expert's opinion in the final decision.

REFERENCES

[1] H. Ellis, GL. Colborn, J.E. Skandalakis "Surgical embryology and anatomy of breast and its related anatomic structures*". Surgical Clinic North America,* vol. 73, pp. 611-32, 1993

[2] Jacobi CE, de Bock GH, Siegerink B, van Asperen CJ. (2009) Differences and similarities in breast cancer risk assessment models in clinical practice: which model to choose? Breast Cancer Res Treat, 115: 381–90

[3] Collaborative Group on Hormonal Factors in Breast Cancer. Familial breast cancer: collaborative reanalysis of individual data from 52 epidemiological studies including 58,209 women with breast cancer and 101,986 women without the disease, Lancet. (2001), 358 (9291):1389-99

[4] Poplack S. P., Paulsen K. D., Hartov A., Meaney P. M., et all., (2004) Electromagnetic breast imaging: average tissue property values in women with negative clinical findings, Radiology, 571-580

[5] Wellman P. S., Dalton E. P., Krag D., Kern K. A., Howe R. D., Tactile imaging of breast masses (2001) Archives of Surgery, 136, 204-208

[6] Weber G, Using tactile images to differentiate breast tissue types, thesis, http://www.griffinweber.com

[7] 10. Soares D., Johnson P., (2007) Breast imaging update West Indian Med. J. 56 940, 351-354

[8] Yodh A.G, Chance B., (2006) In vivo continuous-wave optical breast imaging enhanced with indocyanine green Med. Phys. 30, 6, 1039-1047

[9] RTM (1990) Radiometry Doctor Manual, RTM, Moscow.