Dynamic telethermography and static mammary morphology

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SUMMARY. The thermographic image in breast cancer is a consequence of hyperthermia (hot spots) in relation to metabolic, and vascular factors and to changes in conductivity. Among these factors, we believe that the vascular is the most important, and that it should be studied from two aspects: intra-tumoral and peri-tumoral vascularization. In the intra-tumoral vascularization there is a neoangiogenetical and blood stagnation factor in the capillary lakes and altered vessels. The nourishment and growth of the tumour depends on these factors which lead to heating of the blood inside the tumour, and, ultimately, cause hyperthermia (hot spot). The peri-tumoral vascularization added to the tumour blood-flow and blood temperature, is a fundamental factor in thermography.

In the same way, the increase of conductivity by perivascular, periductal and cutaneous elastosis, when it occurs, will favor thermal representation. Studies carried out with different morphological parameters have demonstrated a positive correlation only with those changes which are related to vascularization, conduction or biological factors. In the study of the thermographic signs that may be derived from these changes, we give special value, because of their frequency, to vascular anomalies, the most important of which we have analysed.

We could finish by saying that thermography, an eminently dynamic and biological exploration, must not seek comparisons with the static morphology of breast cancer, because its true value lies mainly in the fact that the information it offers us is different from and complementary to that given by other methods.

Key words: telethermography, breast cancer, morphological studies, vascular factor, conductivity.

Medicine in this century is considered morphological for its development is based upon morphology, even in functional investigations, a structural confrontation of the findings is often sought. We have now come to know medicine as a more biological and less anatomical area, and a growing tendency to study illnesses through functional alterations at the biochemical level is evident.

There is however a transitional stage in which, often, in order to understand even the functional phenomena observed, we must search for their morphological basis.

Thermography, is a biological exploration technique par excellance. Because its functional basis had its beginnings at this stage, exploration through morphological changes, and comparison with other anatomically based techniques such as anatomical pathology, radiology, etc., could not be avoided.

We are convinced that better results are obtained from thermography, when it is considered as an exploration based on different parameters from those of other techniques. It is complementary and not in competition with such other techniques.

Having defined clinical thermography as the graphic representation of temperature changes originating in the skin through a pathological process, we must take into consideration two different facts for a better understanding of thermography:

a) The cause of temperature changes which depend on metabolic, cellular, and vascular factors, and conduction to the skin.

b) The effect of this energy displayed in the thermogram, consists mainly of hot spots (hyperthermia) and vascular alterations.

The separate study of these causes and their effects, in addition to the correlation of the thermographic image with differing morphological aspects of breast cancer, provides us with data that should be kept in mind when studying mammary thermography.

CAUSE OF THE THERMOGRAPHIC IMAGE

1. Hyperthermia (hot spots) of breast cancer

After Ray Lawson's demonstration of blood heating the tumour mass, and with the study and definition of the « thermogenic power » of breast cancer [2], tumoral thermogenesis of a metabolic and cellular origin is postulated. This can be explained from the biochemical-metabolic [3] point of view. There is anaerobic glucose degradation of the tumorous cell, following the glucose-lactic acid cycle, which uses much more energy on the production of the same amount of ATP than in normal situations. Furthermore increasing cellular activity in cellular populations causes a correlative increase in temperature.

2. Vascular factor

This in our opinion, may be the principal factor responsible for hyperthermia (hot spots), whether directly or indirectly. Its study should be carried out at two levels: intratumoral, where it contributes to the tumour's temperature; and peritumoral, which is very important in thermographic image formation.

Intratumoral vascularization is essential for the growth of the tumour. Folkman [3] described and isolated his TAF (tumour angiogenic factor) which logically removes the necessity of conceiving the tumour's growth. Even though the cells might nourish themselves by diffusion during the first stages, the growth of the tumour can only be conceived with angiogenesis. A direct growth - angiogenesis correlation can be established: the greater the growth, the more neovascularization will lead to necrosis of the tumour.

On the other hand, Tannock [9] studies the kinetics of capillary endothelial cells in a mouse mammary tumour with tritiated thymidine and autoradiography. He found a turnover time of 22 hr. for the tumorous cells, 50 or 60 hr. for endothelial cells and, 70 to 80 for fibroblasts. He also found with labelled erythrocytes a high proportion of capillary stasis. From that he deduced that the tumour growth depends on capillary growth and blood stasis; if both factors exist in the tumour, they are capable of increasing the temperature. The existence of these 2 factors in the tumour is responsible for temperature increase.

Vogel [10] also studies the ratio of the vascular surface and the tumoral area, emphasizing the existence of sinusoidal vessels in relation to capillary-like vessels, which, by blood-stagnation, prevent cellular nourishment.

We should also keep in mind that neovascularization and stasis, together with metabolic factors, will contribute to tumoral hyperthermia (hot spots).

The tumoral blood flow is, in part, the cause of the vascular increases which are of diagnostic significance.

Rogers [7] and his collaborators studied blood flow in experimental tumours, using antipirine I-13a and issamine green, proving that blood flow diminishes as tumour size increases, except in some types of tumours. This is related to the progressive appearance of necrotic zones, and to the lack of neovascularization and the appearance of abnormal vessels with low and irregular circulation. Small tumours will therefore have a relatively greater blood flow which will slow down with size increase. Other authors have also demonstrated that there is a greater blood flow at the periphery of the tumour than in its central regions.

We have made histological studies of the presence of blood vessels in peritumoral regions, especially in those located between the tumour and the skin, by means of the tautness of elastic fibres, which allow us to see a greater number of middle-and large-diameter blood vessels, on the tumoral periphery. On the other hand, the cases where we have been able to follow the thermographic development of untreated carcinomas, have shown an increment of vascular images proportional to the tumour's growth, which do not contradict the experimental data. The diminution of flow is studied by unit weight, but when the tumour grows significantly, there is an increase in the absolute blood flow.

There is also an increase of peritumoral vascularization, which can be demonstrated histologically and is caused by a blood-flow increase. It is related to tumorous growth and is relatively more important in small-volume tumours. From this we can deduce the importance of vascular changes demonstrable by thermography, which will not always be directly related, from the morphological point of view, to the location of the tumour. Other factors - especially conductivity, may interfere with the visualization of these images. We shall find, in principle, the origin for thermographic signs in the increase of blood flow and in peritumoral neovascularization. This relates to the increase in number of vessels, and their diameter, and the appearance of anomalous vascular images. In particular an increase in thermal intensity is dependant on the highest temperature of the blood draining from the tumour.

3. Thermic conductivity

The possibility is that the thermal variation produced inside the tumour by peritumoral vascular alterations changes reaching the skin will be modified by the conductivity of the tissues that separate it from the surface. Fat is a heat insulator and temperature will be transmitted better by fibrous structures. We have already discussed in previous papers[9] the appearance, as a para-neoplastic phenomenon, of elastosis in the breast affected by cancer. This periductal elastosis, perivascular and cutaneous, might be the response of the connective tissue to the triggering factors in the epithelial vascular neoformation. These may be necessary for the tumour's growth, and not as a reactive factor, and might explain a better transmission of the thermal message. In this context, we have frequently found tumorous elastosis in the neoplasias associated with more positive thermography. At the same time it can be found in correlation with a histological sign of connective proliferation, as the increase of the galactophoric cone is a paraneoplastic symbol in mammography.

If we accept that breast neoplasia is not only an epithelial proliferation but is accompanied by an endothelial and connective tissue proliferation, and that the latter is present in structures distant from the tumour, this may explain the temperature transmission from the tumoral focus through structures of greater density to distant points of the gland.

HYPERTHERMIA (HOT SPOTS) EFFECTS: THERMOGRAPHIC IMAGE

The principal thermographic signs for obtaining information on breast cancer are hot spots (hyperthermia) and vascular alterations. Taking into consideration the established theoretical premises, it can be accepted that hot spots (hyperthermia) topographically related to the malignant tumour will be due to the direct conduction to the skin of the tumorous hyperthermia (hot spots), originating in cellular metabolic and vascular alteration (angiogenesis and blood stagnation). The images of vascular alteration and of generalized or distant hyperthermia (hot spots) will be related to vascular peritumoral neoformation. There is an increase of tumour blood flow, and a flow of hotter blood, facilitated by blood stagnation within the tumour. The increased conductivity and distant dispersion are made easier by the periductal, perivascular and cutaneous elastosis that often accompanies mammary neoplasia as a paraneoplastic phenomenon.

From this we can deduce, that there will be signs of tumoral hyperthermia (hot spots) through indirect means which will be mainly of vascular origin.

CORRELATION OF THE THERMOGRAPHIC IMAGE WITH DIFFERENT MORPHOLOGICAL ASPECTS

The results are based on a detailed study of tissue removed in 50 mastectomies, involving thermographic and radiographic pre-operative investigations.

1. The thermographic category of 50 cases was studied. It is not diagnostically reliable, because they are proved cases of neoplasia, excluding the false-positive cases. Nevertheless it is important to point out the small proportion of false negatives with a diagnostic 'agreement of nearly 80%. Equally important is the percentage of cases which were considered P.E.V. positive and that required pre-operative treatment.

2. There was no significant correlation between thermographic category and age, time of appearance, or histopathological type of carcinoma.

3. The study of the correlation between thermal gradients delta 1 and delta 2 and the number of metastatic adenopathies shows no statistical significance.

4. The correlation between the thermal gradient of the tumour ,and the type of radiological contour, also shows scattering from which it is

impossible to obtain statistical significance. We believe this indicates a lack of correlation between the radiological contour and prognosis.

Radiological glandular density and particularly galactophoric cone density does show a correlation with thermal gradient. As has been already stated, this is due to the greater conduction facility in breasts which are more dense and especially in the presence of elastosis.

The correlation between thermal gradient and the minimal distance from the skin surface and between thermal gradient and the tumorous surface, have been calculated according to the diameters in radiology. The results do not contradict the data supplied by other authors," that the greater the hyperthermia (hot spots) the larger the tumour volume and the smaller the depth from the skin surface. Nevertheless, small tumours do often show significant thermal gradient.

The study of vascular anomalies found in breast cancer cases, shows that these signs are the most frequent. These vascular anomalies, in order of frequency, consist in the first place of an increase in the vascular diameter; then follows the increase in the number of vascular images. After the interruption of the vascular images, the appearance of vascular loops is less frequent in the anomalies described. Such anomalies are often related topographically to the location of the tumour, though on many occasions may appear at a distance from it.

There exists a direct correlation ,between thermographic category and degree of tumour and peritumoral elastosis.

Even though we do not have sufficient data due to of the difficulties with a cell cultures, and the number of variables affecting growth, we have found faster growth rates in the cultures of tumours with a higher thermal gradient.

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