THERMOGRAPHY OF THE BREAST-A SKIN ORGAN

William B. Hobbins, M.D.

The skin and subcutaneous tissue is a unique and major organ of the body.
One Square Inch of Skin

"Human skin is not only skin deep. In fact it is among the body's most complex organs. Of its three main layers only the paper-thin epidermis is normally visible. Beneath the epidermis is the dermis, and below that is the subdermis. In a square inch of skin, you will find: 20 blood vessels; 65 hairs and muscles; 78 nerves: 78 sensors for heat, 13 for cold, 160-165 for pressure; 100 sebaceous glands; 650 sweat glands; 1300 nerve endings; and 19,500,000 cells.

The sweat glands do double duty, helping to eliminate wastes and cool the body. On a hot day, the skin can release up to 2500 calories of heat-enough to boil 6 gallons of water. The body's largest organ, the skin measures about 21 square feet in an average adult. It accounts for 15 percent of total body weight and provides a protective shield against bacteria and viruses. It also absorbs shocks that might otherwise damage the bones and internal organs." (1)

One of its roles is the major protection of the body from environmental temperature change. In this role, it has a unique and distinct microcirculation, which has the capability to distribute the thermal excesses produced in the body or to protect the thermal needs of the body by adjustment of this circulation.

This phenomena of the skin performs as an almost perfect black body in that it has the emissability of 99.8. Clinical experiments as to the thermal insulatory properties of the skin have been done by Draper. (2) Only the heat brought to within .6 cm. of the surface of the dermis is emitted. Neilson and others have shown by the implantation of thermisters, which were both emitters and recorders, that the body cannot produce enough heat energy that will be, emitted *from* the surface *from* a deeper than .6 cm. Source (3,4) Thus - thermographic images of the skin are recordings of the microcirculation located between the dermis and Scarpa's fascia. As a result, various conditions that can influence the circulation of the skin can be observed.

Before the discussion of the general breast conditions observed by thermography, one must discuss a major function of the skin, control of the core temperature regulated by the thalamus through the sympathetic nervous system of the spinal cord. It has been shown that the control of the peripheral vascular bed is under the sympathetic nervous system, mostly adrenogenic with some localized cholinergic responses. Therefore, when we observe thermal change in the skin as a result of the vascular flow, we have either vasoconstriction or vasodilatation, depending upon necessity of the core to either conserve or to reduce the total temperature of the body.

This Is a symmetrical pattern In individuals with no neurological disorders or vascular disorders which could influence the symmetry by hindering the sympathetic response of the microcirculation of the skin. Normal individuals conserve heat by vasoconstriction of the skin until the skin reaches a temperature of 15°C at which point the body enters into a physiologic function of "hunting" in which it intermittently opens up the circulation of the skin in an effort to preserve the skin's metabolism.(5) Again, the symmetrical influence of the core temperature has been well studied with thermography by the Canadian Armed Forces in its survival studies. (6) This discussion points out that no matter what area of the skin we are looking at this prime control of core temperature which maintains survival of our biophysical chemical metabolism takes precedence over local conditions. It is very difficult to blush in a sauna when the circulation is at its maximum exposure. It is also difficult to blush with a fever!
The skin has many conditions and many organs which can influence the thermographic emission. The dermis and its immediate subdermal area has many conditions of pathology which can influence the thermal image. These are congenital, inflammatory, traumatic, dysplasias, and neoplasias. Dermatologists and allergists have had experience with thermography looking at conditions *from* congenital hemangiomas to the complicated disease of scleroderma (6,7) , to the neurogenic condition *of* leprosy (8). to the neoplastic conditions *of* melanoma and squamous cell carcinomas. (9,10) All *of* these observations have been recorded in the proceedings *of* the American Thermographic Society over the last decade.

The breast is an organ of the skin, and as such, can be studied extensively by the thermographic image. The thermographic image of the breast that is recorded by thermography is that of the circulation through this skin organ (11). The breasts are symmetrical embryonic oil glands of the skin. which are encased within the Cooper's ligament. a division of Scarpa's fascia. The entire circulation of the breast is that circulation designed and embryonically developed from the portion of the skin which it occupies.

The embryonic circulation of a given person's breasts is symmetrical. This has been established by the observation of over 40,000 normal thermograms(12). The expected pattern is symmetrical and, in addition the physiologic changes that occur, such necessary ones as thalmic thermal control are symmetrical. The circadian rhythm is reflected symmetrically. The influence of cigarettes, alcohol, hormones of natural cyclic influences on the tissue of the breast is recorded as a symmetrical stimulation or diminution of the circulation.

The physiology of the breast has been studied, and the scientific conclusions have been published.(13) Two major classes of normal thermal responses are seen: the symmetrical nonvascular and the symmetrical vascular. As one would expect, nonvascular pattern is in the unstimulated breast, in the dormant breast, or in the involuted breast, which no longer calls upon the body circulation to be fed abundantly. The symmetrical vascular pattern is associated with the normal physiologic changes that occur with pregnancy, lactation, hormone stimulation and any other environmental alteration brought about by a general systemic administration *of* vascular influencing substance. A unilateral pathology, be it neoplasia, abscess, or any other conditions that creates an abnormal circulation will be recorded as an asymmetrical thermo graphic pattern.

A cyst or hematoma will have unilateral nonvascular findings and thus not be symmetrical. There are individual anatomic reasons as well as pathophysiologic reasons for asymmetrical findings.

Before discussing the significance of the abnormal thermogram, it is will to discuss these factors which can create the abnormal, asymmetrical exams. Anatomically, the size of the breast, such as a small breast occasionally is hotter possibly due to the lack of insulation as compared to the larger breast. Superficial skin lesions and varicose veins or other vascular abnormalities on the surface of the breast can cause abnormalities. Pathologically, the nervous system can create a unilateral finding in the breast. Cases of spinal scoliosis have caused unilateral hyperthermia or hypothermia. The visceral aspect of the breast, the acinar and ductal tissue will cause local thermic changes due to reflex sympathetic stimulus. Parenchymal distention or incomplete involution with cyst formation will often cause a cold thermal response with vasoconstriction of the area. This process is the most common cause of mastodynia: visceral reflective pain secondary to cystic mastopathy. On the other hand, paresthesia of sympathetic blockade is usually associated with a hot spot on the thermogram. Many theories exist explaining this burning, stinging pain. Such a sympathetic reflexive pain is thought to occur most commonly with a cancerous change. Kiricuta of Romania has increased the hyperthermia in breast cancer by administration of IV glucose (14). This may be an evidence of an active metabolic process since the burning, stinging pain has a high correlation with breast cancer and hyperthermia

Stress to the nervous system may cause a vasoconstriction. Placing the hands in ice water for 45 seconds will cause the normal breast thermal response to decrease by 1 degree C. Immersion of one or both hands will cause an equal or bilateral symmetrical response in the normal person. In the presence of an active tumor in response to such stress, the reaction is opposite and the hyperthermia is increased. This paradoxical action may be explained by the fact the heat source of a cancer and its neovascularity does not have the normal nervous control of its blood vessels. Additionally, it may evidence of blockade of the normal physiological response by the tumor's biochemical effect in the area. This phenomena may be further understood when one studies the rationale of angio tension injections intra-arterially to enhance the demonstration of renal tumor in contrast studies. This causes a constriction of a non neoplastic artery and allows more selective filling of the tumor with contrast media. This may not separate abscesses from cancer in view of the fact that the neovascularity of granulation tissue also is unresponsive to vasoconstrictive drugs or nerve stimulation. Unilateral suckling of the breasts will increase the circulation in both breasts. However, the breast that is suckled is stimulated, to increase vascular flow to the greater degree as evidenced on thermography.

Four major classes of pathologic factors that unilaterally affect the thermal images are: inflammation, trauma, mastopathy, and neoplasia. The blood flow of the breast is changed by every pathologic condition and can be studied by thermography.

1. **Inflammation.** Breast infection, whether deep or superficial, usually brings forth increased blood flow. This will be observed as hyperthermia in the area and may be limited to one quadrant or affect the entire breast, depending on the severity. Tuberculosis *of* the breast has been seen to cause an abnormal thermogram test result (15).

2. Trauma. Trauma to the breast will respond in different ways. When the injury includes the chest wall and associated nerves, there may be a hyperthermic response initially. Vasoconstriction may occur as the result of sympathetic reflex and may be observed as segmental cold response on the thermogram test in other cases. Fat necrosis and hematomas are generally observed as cold segmental findings. This is as would be expected, due to decreased blood flow in the area and often surrounding edema.

3. Mastopathy. The pathophysiologic breast changes in benign conditions of breast function and repair are generally cold, as discussed elsewhere. Fibrocystic conditions, sclerosing adenosis and other such normally occurring changes will have segmental vasoconstriction associated with reflex pain when active. The heat of metabolic activity is usually suppressed by cystic spaces and dense fibrosis and the resulting reduced blood response has frequently led to an interpretation of hyperthermia in the other breast, which was normal or not showing a similar activity at the time. Thermograms must always be interpreted in light of known clinical findings in order to increase the significance of the study.(16-22)

4. **Neoplasia.** Neoplasia, as observed by thermography, is probably the most important. It must be stated that thermal response is directly proportional to the biologic significance of the tumor. (17-19, 21-24) The increase in blood flow as evidenced by hyperthermia and hypervascularlty correlate with degree of biologic actlvity.(16,8,21, 25-27) Whether this is directly from the metabolism or indirectly from host immune response, it correlates without respect to size of tumor mass-65% of less than 1 cm. malignant tumors have shown various degrees of hyperthermia. (19-21,27, 28,29) On the other hand, Inflammatory carcinoma has thermal disturbance observed by thermograms of greater than 6 °C when contralaterally compared with the normal breast.

Tumor growth has been studied extensively, and doubling time of the cell mass has been used as a measure of biologic significance (30). Mammography has aided in the in vivo observations of growth. Doubling times of 40 days up to 500 days have been measured (21,26,31). The blood now is now known to be directly related to this doubling as observed by thermal response. Fournier and others find a direct parallel between thermal gradient and doubling time by mammography (26). Although the bioengineers cannot explain the observation on the basis of metabolism of cell mass alone, the observation is consistent. (25) The influence of the autoimmune reaction of the body also must play a role and be reflected in blood flow as the organism attempts to control the cancerous process. Influence *of* stimulation by thalamic hormonal changes in defense will also reflect on the thermal biology of the host.

Benign neoplasias, such as fibroadenoma, will often show a mild hyperthermal response. The more rapidly appearing and faster enlarging ones are the hottest.

In malignant neoplasis, size of tumor is not the apparent physiologic reason for the observed hyperthermia, as previously mentioned (24,25). A large 4 cm. medullary or scirrhous cancer most often will be cold, and a 0.5 cm. nonpalpable intraductal cancer can be observed to have a 3° Delta T hyperthermia, hypervascular thermogram test. It has been confirmed by many, starting with Williams, (32) then Gautherie and Gros, (31).

Amalric, Spitalier and Giraud, (16) and others. that thermal biologic observation is an accurate method of determining prognosis for survival. This relationship of blood flow and thermal gradient is a dynamic measurement of the significance of biogenesis of the neoplasia to the host.

Henderson et el, in the New England Journal of Medicine, state: "There are at least two different populations of patients with breast cancer: one in which the tumor grows large within a breast without either regional or distant metastasis and another in which distant metastasis occurs before there is extensive growth with the breast."(33)

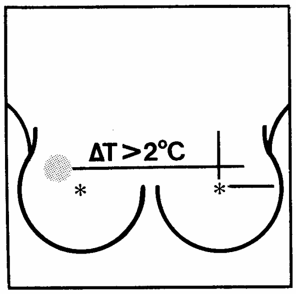
He further states that the group of patients with the best prognosis, "clinical state A with no nodal involvement really consists of three subgroups: those with aggressive disease that has limited local growth but early metastasis ('aggressive disease'); those with moderately aggressive disease that has limited local growth and has not yet metastasized; and those with limited local growth that may have been present for some time without metastasis and has a limited future potential for metastasis ('limited potential disease')."

Fox has stated that if all of these patients are treated in the same manner, it is possible that those with "aggressive disease" will be undertreated and those with "limited potential disease" will be overtreated (32). The specialized breast Cancer Treatment Center in Marseille, .France, has for ten years designed its therapeutic (preoperative) program on the basis of thermography. Amalric and Spitalier have over 1600 cases so treated with excellent results.(16,18)

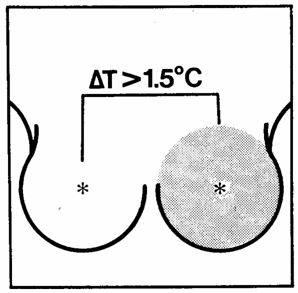
The thermobiology of the breast, as observed by thermogram test, gives the best pretreatment assessment of the suspect lesion and has been shown to correlate with nodal status and survival. All prospective studies of breast cancer should be qualified and measured by thermography so as to assess the thermobiology of the morphologic tumor.

Having discussed the conditions that produce unilateral heat disturbances, it is now important to look at the significance of such unilateral thermal responses. The abnormal thermogram, that is the asymmetrical thermogram is very important. The classification of thermograms and their significance has been established throughout the literature and at the present time there are more than 20 factors of thermal significance of the breast circulation.

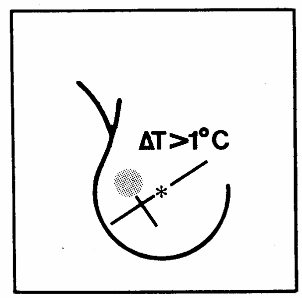
MAJOR FACTORS



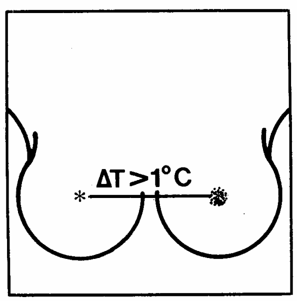
Hot Spot



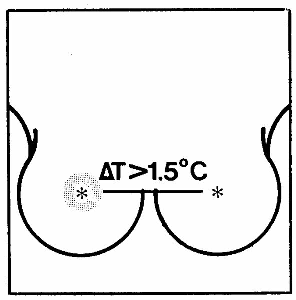
Global Heat



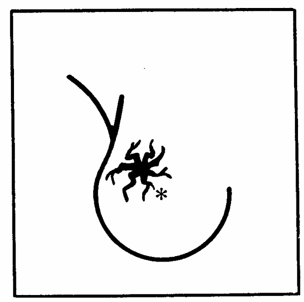
Heat in Area of Finding (finding by: clinical, x-ray or ultrasound)



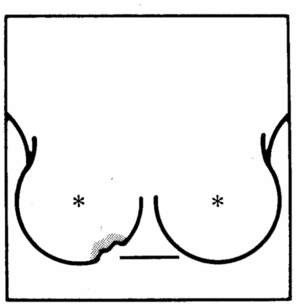
Nipplar Heat



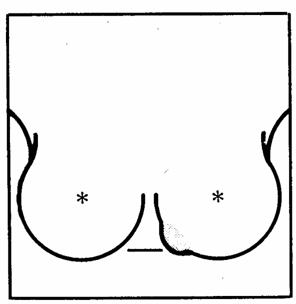
Periareolar Heat



Star Vascular Anarchy

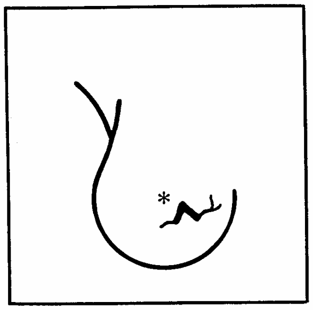


Edge Sign (backed by heat)

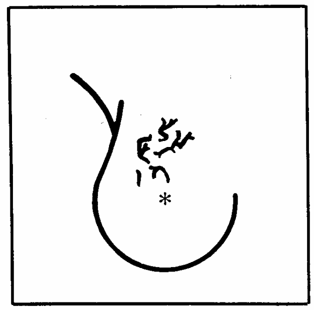


Bulge (backed by heat)

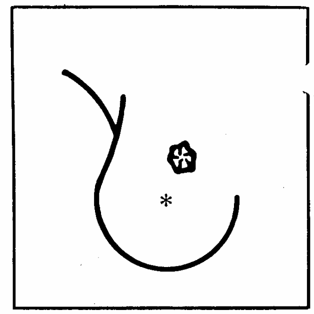
SECONDARY FACTORS



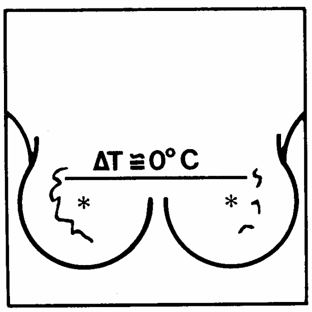
Inverted "V" Vascular Pattern



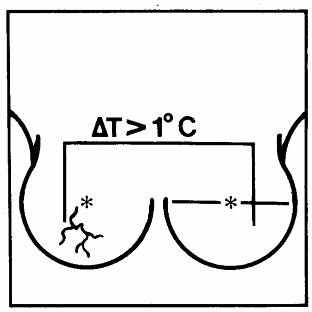
Fragmented Vascular Anarchy



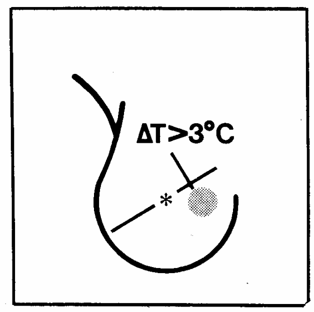
Closed Vascular Anarchy



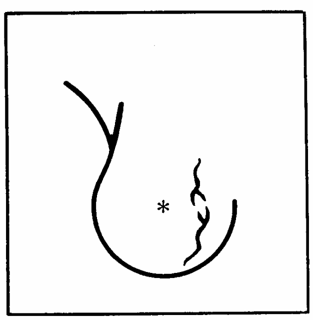
Vascular Completeness



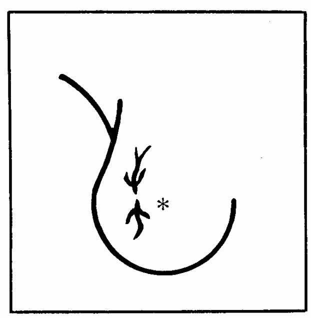
Inferior Vascular Pattern



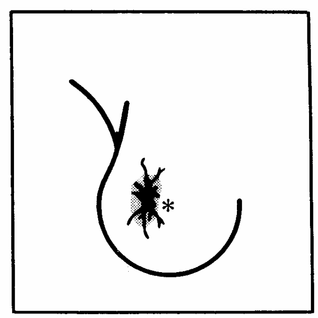
Hot Spot



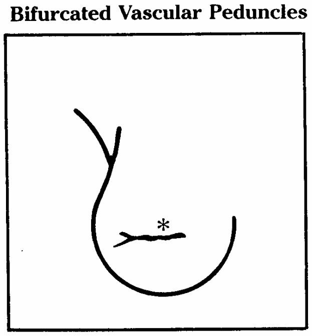
Bifurcated Vascular Peduncles



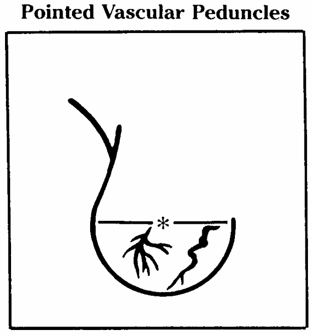
Pointed Vascular Peduncles



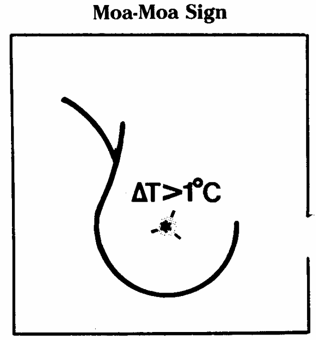
Moa-Moa Sign



Transverse Vascular



Inferior Complete Vascular



Hot Nipple

When these factors are added to the normal avascular or symmetrical vascular pattern, the levels of normal thermal interpretations are created.

Classifications of Thermal Exams

Normal	Abnormal
TH 1 Avascular Symetrical	TH III Equivocal
TH II Vascular Symmetrical	TH IV Abnormal
	TH V Severely normal

In 1982 at the annual Radiology Society of America meeting in Chicago, the world experts of liquid crystal contact thermography were gathered to discuss the significance of the individual factors that are added to the class TH 1 and TH 2 thermograms. Each of the 24 factors were then individually analyzed for significance, and the results were that 8 factors are considered almost equal in significance. Mathematically, the results were ranked as follows: (1) global heat, (2) nipplar heat, (3) heat in area of clinical finding (4) periareolar heat, (5) hot spot, (6) edge sign, (7) bulge sign, and (8) star anarchy. Prior to the classification selection, the significance of the delta T was agreed upon unanimously. There was repeated concern with setting the delta T too high as some of the current evaluation systems have done. Thus, the delta T's were set lower that the mean of the associated abnormal thermals.

The experience of the Wisconsin Breast Cancer Detection Foundation in a thermographic screen of some 7,669 women, 25% of the thermogrpahic group was considered abnormal, and this contained 89.4% of the cancers. 63.1% were in the TH 4 and TH 5 class and 26.3% were in the TH 3 class. The world's literature, which can be reviewed from the bibliography, suggests 80 to 90 percent of all patients with a carcinoma of the breast have an abnormal thermal signal. It must be emphasized again that this thermal signal Is not related *to* the size of the tumor. Three papers by Isard, Haberman, and Abernathy show that 67% of the minimal cancers, as defined by the B.C.D.P., have abnormal thermal signals.

Conclusion

It can be stated that thermography monitors blood flow of the breast, (37) and thereby records and assesses any condition which influences it physiologically (13). Anatomic and physiologic conditions can be differentiated with thermograms. A significant use is to signal those patients who need more intensive mammography, ultrasonography in order to establish a diagnosis of carcinoma before it can be felt. Also, thermography differentiates biologically significant cancers from less significant ones and can help in the establishment of treatment protocols. Thermography is an important and necessary examination of the breast (38).

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