6th SEMINAR ON DYNAMIC TELETIIERMOGRAPIIY

In Marseilles, from May 24th to May 27th, 1977 was held the 6th Seminar on Dynamic Telethermography, successfully organized by «Club Français de Téléthermographie Clinique», J. M. Spitalier president, R. Amalric secretary.

The 6 scientific sessions of the Seminar covered all fields of thermographic medical applications.

Most of the reports and proffered papers, were presented by European authors: for this reason the Seminar was a very useful presentations for evaluating the role of thermography in Europe.

All proffered papers were published in full text on a special issue of « Méditerranée Mé dicale »

«Acta Thermographica » is now presenting the reports hold at that Seminar, according to journal's policy which tries to give the most effective diffusion of information collected from world-wide research Centres.

INTRODUCTION

Analytical, synthetic and dynamic classification of mammary thermograms

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SUMMARY. In an analytic sense, the authors make specifications starting from 4 parameters, 4 fundamental vascular patterns, and describe 4 elementary suspicious signs and 4 malignancy signs.

In synthetic sense, they group these patterns and signs in 5 thermographic categories of increasing diagnostic weight, from THl to TH5.

A transformation of these 5 categories in 2, 3 or 4 is made and comparisons with other classifications are settled.

In a dynamic sense, the tbermographic aspects of fast growing cancers are described and the prognostic importance of thermography is emphasized.

This classification takes its full value only if a strict methodology for the thermographic examination itself is used and if we take into account the comparisons with data from other diagnostic methods.

Key words: infrared thermography, mammary images, classification, bases, criteria.

INTRODUCTION

For a valid interpretation of a mammary thermogram, it is essential that *a classification of images should be as objective as possible.* The elimination of subjective factors is necessary to enable the several clinicians to reach the same result in front of an identical thermogram.

Since 1970, we have adapted for infrared mammary thermography the same classification we have used in mammary radiography since 1957 and which includes the 5 categories of increasing diagnostic weight as that of Papanicolaou G.F. 's cytology.

This original classification has been published in 1971 [1] and at the First Seminar on Telethermography in Toulouse, in 1972[2]. Every year, light more is thrown due to increasing practical experience, and substantiated during the following Seminars: Bordeaux in 1973 [3], Bendor in 1974 [5], Tunis in 1975 [6, 28].

At the Sixth Seminar on Dynamic Telethermography (Marseilles, May 1977), after 30,000 consecutive mammary thermograms, 4,000 microscopical verifications and 7 years of permanent continual research, we bring in a last restatement. It will serve to enlighten those who use this classification world wide or those who are going to take it up.

The main purpose of the present work will be *to specify the vascular patterns and the increased thermal gradients from abnormal vascularization.* The stumbling block in mammary thermography is in fact constituted by the interpretation of the vascular anomalies. The question is to know: from when a vascular asymmetry becomes suspicious and from which criteria a hypervascularization may be graded as anarchic? This discrimination must be based on subjective interpretation but on an objective criteria.

Our classification is the result of a joint work carried out by a team from various fields: physicians from different specialities (professional thermographers, radiodiagnostic doctors, radiotherapists, surgeons, gynaecologists, endocrinologists, cytologists and pathologists) and technicians from different areas (specialized manipulators, physicists, electronics, statistical specialists, and medical photographers). This mutual security has allowed us to advance with a minimal set backs in this field which is not always easy.

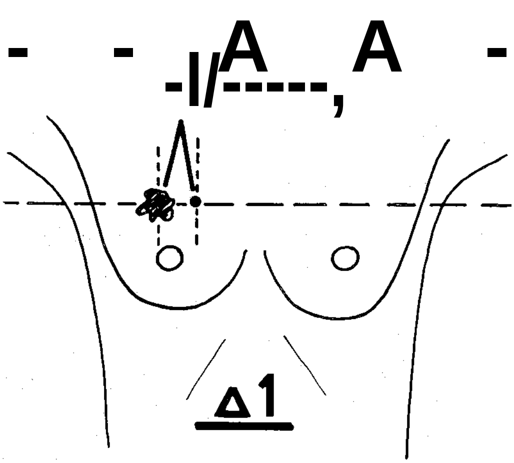


Fig. 1. Delta 1 measurement: difference in relative temperature between the abnormally warm area and the adjacent skin surface.

ANALYTICAL CLASSIFICATION

Every elementary thermographic sign before it can be documented, must be strictly defined.

Special note should be made of a *fourfold « tetrade »* as follows:

4 basic parameters
4 fundamental vascular patterns
4 suspicious signs of malignancy
4 signs of malignancy.

A) The 4 basic parameters

These are:

1. *The hypervascularization state* of mammary regions; which may be absent, normal, exaggerated or anarchic.
2. *The gradient of the local thermal increase* which will be measured at one and the same time:
   compared to the cutaneous surrounding coating of the hyperthermal zone; called *delta 1* (Fig. 1).
   and compared to the anatomical symmetrical region; called *delta 2* (Fig. 2).
3. *The extent of the abnormally hot surface* which may be:
   either a limited hot spot,
   or a more extended warm area,
   or a full hyperthermia covering the whole breast or even exceeding its anatomical limits.

   We have classified the extent of abnormal hyperthermias into 3 groups [28] according to the following scale (Fig. 3):
   - S1 hyperthermia for which the extent does not exceed 2 quadrants of the breast:
   - S2 hyperthermia exceeding 2 quadrants being able to reach the whole breast but without going beyond the limits.

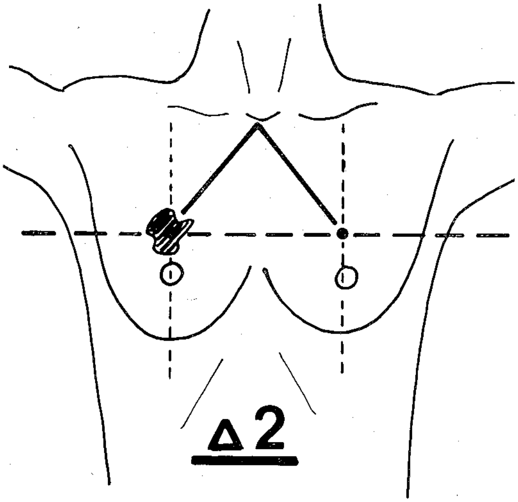


Fig. 2. Delta 2 measurement: difference in relative temperature between the abnormally warm zone and the anatomical symmetrical region.

- S3 hyperthermia exceeding the anatomical limits of the breast.

4. *The regularity or non regularity* of *the breast thermographic contours* which must remain curvilinear, regular and relatively symmetrical.

B) The 4 fundamental vascular patterns (Fig. 4)

1. *Type A: Isothermal breasts* (one compared to the other), avascular or with a simple outline of the vascular pedicles (internal and/or external mammary); this type occurs in 15% of cases.
2. *Type* B: moderated, linear, bilateral, relatively symmetrical vascularization of a non thickened caliber, without visible vessels below the areola in the lower quadrants: this type is observed in 67% of cases (Fig. 5).
3. *Type C:* with a *marked vascularization,* remaining (in the area of one of the 3 anatomical vascular networks: external mammary, internal mammary, peri-areolar) but reaching the whole breast. The caliber of vessels may be slightly thickened but in a regular way (continued) and relatively symmetrical. This pattern is met in 17% of cases (Fig. 6).
4. *Type D:* with a *hypervascularization* of *reticulated type,* generally bilateral forming sometimes a real chequer-work of breasts with possibilities of anastomosis from one side to the other. This image represents only 1% of our cases (beside pregnancy).

The mottled or spotty pattern that we have called *Leopard Type* (or Type L) should be separated. It involves thermographic demonstrations of a vaso-motor nature being related to the trunk or other parts of the body, without any mammary specificity.

There is a close connexion between our four fundamental vascular patterns [14] and those from the Strasbourg School [15]: our type L corresponds to type E.

The American Thermographic Society (A.T.S.) classification reduces the basic vascular patterns to three [10]; the following table matches them with our 4 types (Table I).

What is essential in all these vascular patterns, whatever may be their type, is that *the thermal gradients measured opposite to the vessels never exceed* + 2 C: otherwise, they would enter into the group of suspicious signs.

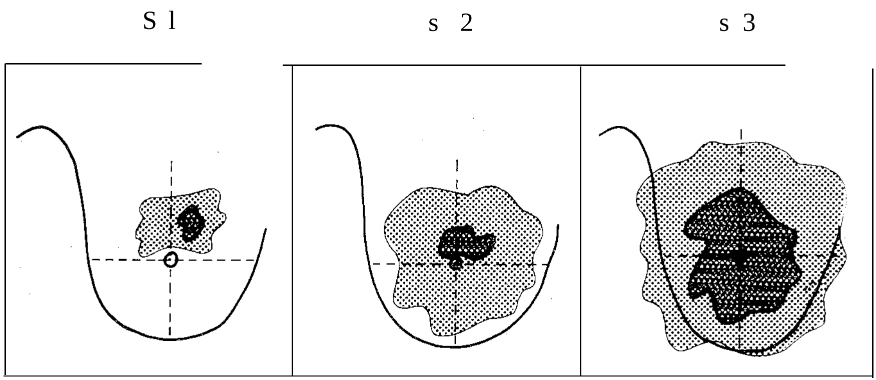
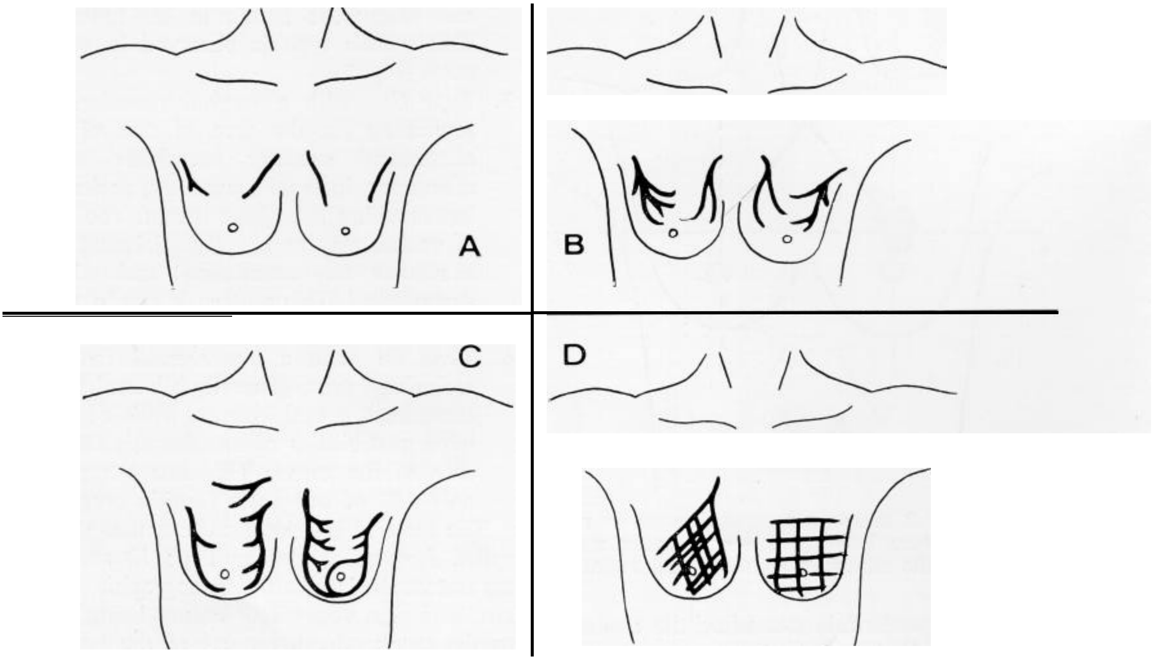


Fig. 3. Classification of abnormally hot surfaces in terms of their extent.



Fig, 4. The four fundamental vascular patterns.

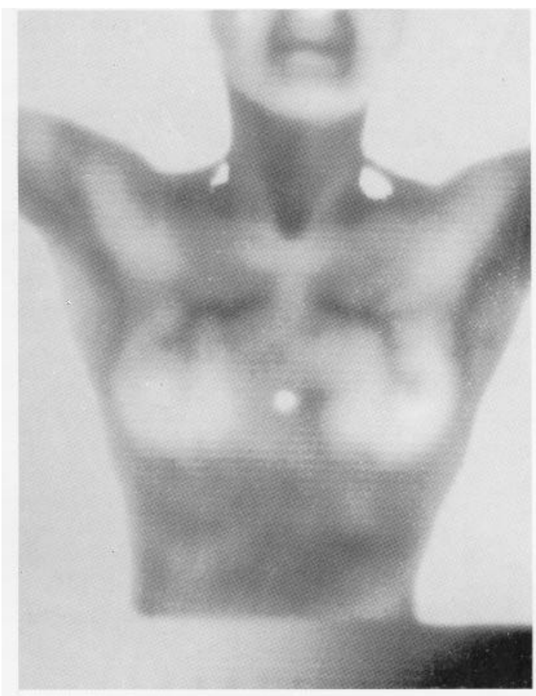


Fig. 5. Moderated, linear and relatively symmetrical vascularization covering only the upper quadrants = vascular type B. THl category.

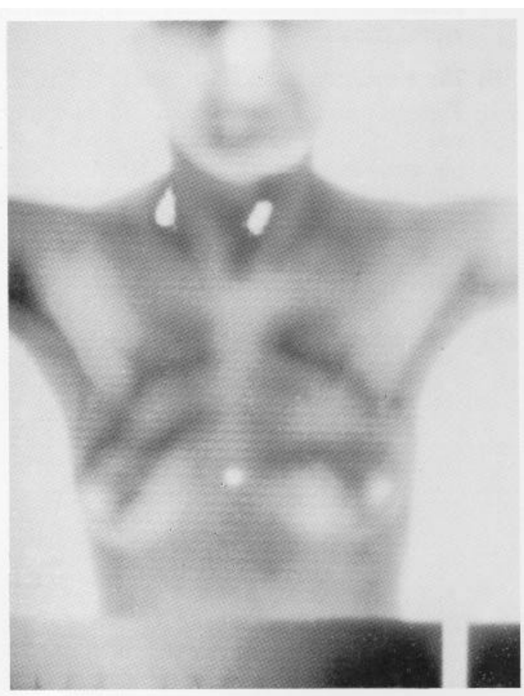


Fig. 6. Marked vascularization remaining systematic and involving the whole of breast = vascular type C. TH2 category.

Fig. 7. Bilateral hypervascularization with blood vessel on the left side. Delta 1 = 2,5°C. Suspicious thermogram. TH3 category.

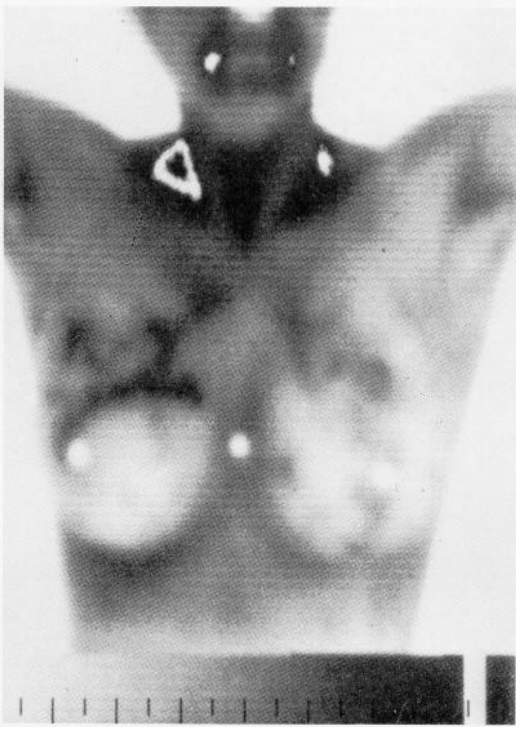


Fig. 8. Unilateral right hypervascularization with asymmetry of blood vessel. Delta 2 = 2,5 °C. Suspicious thermogram. TH3 category.

Tab. I. **Agreement between the vascular patterns according to the classification from A.T.S. and that of Marseilles.**

American Thermographic Society		*Marseilles*
Category 1	avascular or cold	Vascular type A
Category 2	linear, marked vascularization	Vascular types B and C
Category 3	reticulated or mottled vascularization	Vascular types D and L

C) The four suspicious signs of malignancy

1. *The vascular asymmetries* for which the thermal gradient measured at the level of the visible vessels is of 2,5 °C (in delta 1 or delta 2).
   There **are** indeed *constitutional vascular asymmetries* which translate a sort of « thermographic finger-print » [11] for which the thermal gradient does not exceed 2 °C and which have nothing pathological.
   Also, an asymmetry of the vessel caliber should not be considered suspicious if isolated and when its gradient does not exceed 2 “C.
   We must distinguish between *two types of suspicious vascular asymmetries* [6]:
   asymmetries of caliber in case of a bilateral vascularization, more or less symmetrical from the topographic point of view but with a thickening of the vessel caliber on one side only with a delta 1 of 2,5 °C (here delta 2 has less value due to the hypervascularization on the other side) (Fig. 7).
   asymmetries of course or configuration, in cases of a clearly asymmetrical vascularization, or unilateral a fortiori; in those cases, it is delta 2 which should reach 2,5 °C (Fig. 8).
   These varieties of vascular anomalies are often present in our suspicious thermograms: 83% of cases.
2. *A hot spot or a localized warm area by*

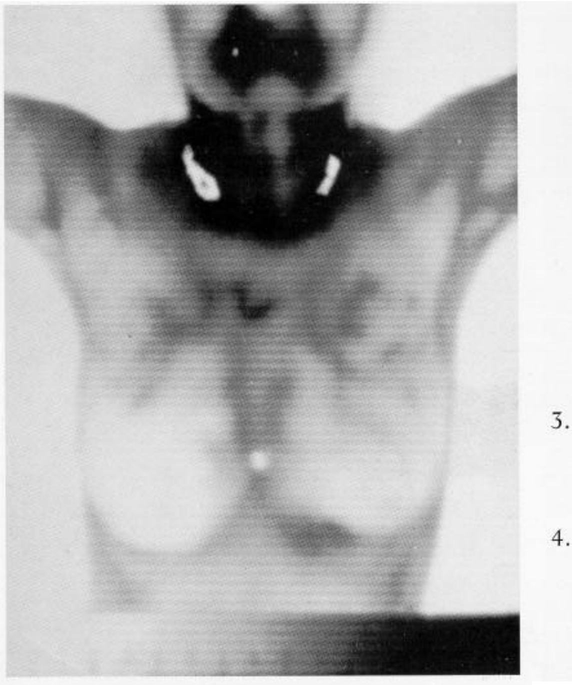


Fig. 9. Limited edge sign on the left breast (internal lower quadrant). TH3 category.

Fig. 10. Anarchy of blood vessel with a succession of dilatations and narrowings. Chaplet pattern. TH4 category.

2,5 °C or even an isolated warm nipple with a 2 °C gradient. These local, isolated, thermal anomalies are found in 6% of our suspicious thermograms.

We do not believe that « the agreement between the localization of the hyperthermal focus and that of clinical or radiological anomaly »[15] should be retained. It concerns a thermo-clinical or thermo-radiological comparison and not a thermographic category in itself. In any case the hot spot of a mammary adenocarcinoma is located by its thermal transmission outside its orthogonal projection on the skin.

3. *A global hyperthermia of the breast by 2 °C* This hyperthermia on a type S2 surface is observed in 6% of our suspicious thermograms.

4. *A limited distortion* of *the breast thermographic contour* often occurs with a linear rigidity[16] visible in preference on the black and white or three-quarter slides; 5% of suspicious thermograms (Fig. 9).

D) **The 4 malignancy criteria**

These correspond to the exaggeration of previous suspicious signs; they are:

1. *Anarchic hypervascularization* for which 2 types exist: those of altered vessel caliber and those of course followed by vessel.
The anarchy of caliber is seen when an abnormal vascular network is formed by vessels for which the caliber is thickened in an irregular way with a succession of dilatations and narrowing giving it a monoliform or chaplet pattern (Fig. 10).
The anarchy of *course or configuration* is constituted by a disorganized, confused, sometimes convoluted, vascular networks with tortuous, serpiginous vascular courses, and sometimes arborations (that is outside the 3 anatomically known vascular networks) (Fig. 11).
These 2 types of vascular anarchy may be combined. In every case, the thermal gradient of these anomalies should be *equal or superior to* 2,5 °C in order to consider them as sign of malignancy.
2. *Hot spots or warm areas by 3 °C* or more, including the nipple itself (Fig. 12).
3. *Global mammary hyperthermias oj more than 2°C* (Fig. 13).

Fig. 11. Anarchy of blood vessel on the left with vascular disorganized and tortuous vessels. TH4 category.

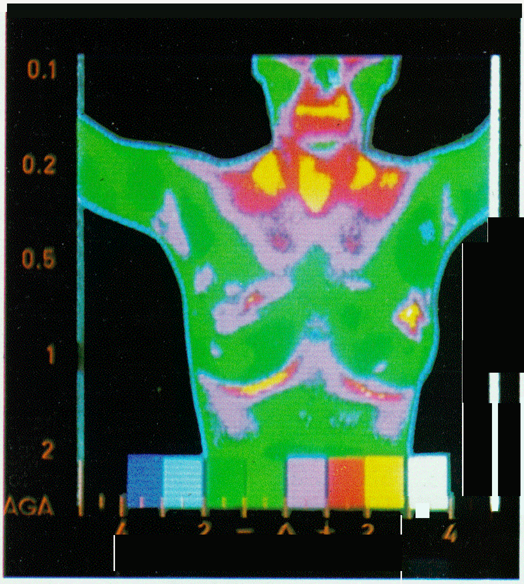


Fig. 12. Isolated, left external-upper hot spot. Thermal gradient by + 3 °C. TH4 category.

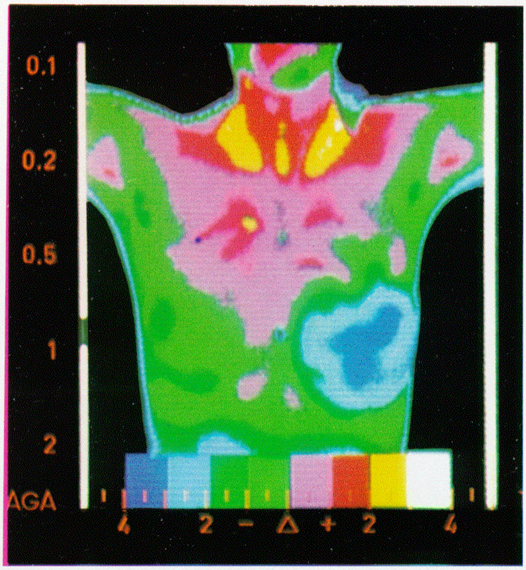


Fig. 13. Global hyperthermia on the right breast. Thermal gradient by + 3 °C. TH4 category.

4. *Extended distortions of the breast thermographic contours* (Fig. 14).

SYNTHETIC CLASSIFICATION

Table II summarizes the main features of each of the 4 chosen parameters.

We adhere to the statement that the *significant thermal level* of *suspicion is 2,5 °C* for two reasons:

Our of 3682 pulpable breast tumors (2/3 of them being malignant), we have obtained, with the 2,5 °C gradients, similar proportions of false-positives and false-negatives (Table III):

Out of 1000 breast cancers of comparable volume, all from T2 category according to

Tab. II. Synthesis of mammary thermograms semiology.

Parameters	*Suspicion signs*	*Malignancy signs*
Hypervascularization	asymmetrical	anarchic
Hot spot	2,5 °C	> 2,5°C
Full hyperthermia	2 °C	> 2°C
Rigidity of the thermographic contour	limited	extended

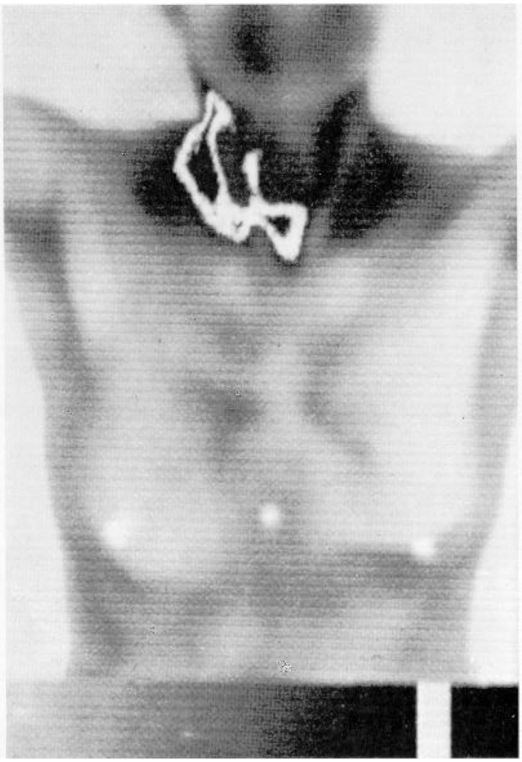


Fig. 14. Extended edge sign (lower quadrants) with a typical linear rigidity. TH4 category.

International Union Against Cancer (in a diameter ranging from 2 to 5 cm), a computer study[8] fixed middle-gradients between 2 and 3 °C. 2,18 for delta 1 and 2,54 for delta 2. (These gradients have been measured by 680 M AGA cameras after an equilibrium of the skin surface for 10 minutes at 21 °C).

The choice of another thermal level would cause:

an increase in the rate of false-positives if lowered;

or an increase in the rate of false-negatives if increased.

The aim of any mammary scanning being to invalidate or assert the presence of a *breast* cancer (probable, possible or unexpected), our classification will not escape this imperative. It groups suspicious and malignancy signs into *5 categories of increasing diagnostic weight* (Table IV).

It should be noticed that we never pronounce the terms of « benign thermogram » or « malignant thermogram » but of a benign *type* or malignant *type* thermograms. Indeed, *thermography does not give the diagnosis* but a high or very high *diagnostic probability.*

Following is **the** practical meaning of our classification regarding the probability of cancer:

Our breast cancers belong to THl category in 1% of cases (24/2226 confirmed microscopically);

Our breast cancers are from TH2 category in 8% of cases (184/2226 confirmed microscopically);

Finally, on *2533 consecutive palpable tumours* of breast with *abnormal mammary thermograms:* TH3, TH4 or TH5, we have identified 2018 cancers, that is in 80% of cases. This percentage varies according to the considered thermovisual category. (Table V).

We prefer a classification into 5 categories for it appears more flexible than the others (and this both for thermography and for other

Tab, III. 3682 **confirmed mammary thermograms: false-positives and false-negatives.**

	Number of cases	%
False-negatives (THl + TH2)	**205** out of 2226 cancers	9%
False-positives (TH4 + TH5)	174 out of 1751 malignant thermograms	10%

Tab. IV. **Synthetic classification of mammary thermograms in an increasing diagnostic weight.**

THl *Normal thermogram*
(vascular types A and B)

TH2 *Benign type thermogram*
(vascular types C, D and L)

TH3 *Suspicious thermogram*
(with one sign of suspicion)

TH4 *Malignant type thermogram* with only one sign of malignancy
(or several signs of suspicion)

TH5 *Malignant type thermogram* with *several* signs of malignancy
(or only one sign of malignancy accompanied by several signs of suspicion).

investigation methods). It tends itself to all the necessary changes found in our *clinical research*. It can be translated into *four, three and even two* categories. (Tables VI, VII, VIII). An agreement can thus be reached with

Tab. V. **Percentage of cancers in front of an abnormal thermogram (TH3, TH4, or TH5) in case of a palpable tumour.**

Thermograms	*Number of palpable tumours*	*Number of cancers*	*% of cancers*
TH3	782	441	56%
TH4	855	722	84%
TH5	896	855	95%
Total	2533	2018	80%

Tab. VI. Transformation of our classification into quaternary code for computer (Drexel University Philadelphia).

0	Negative	TH1
1	Probable negative	TH2
2	Probable positive	TH3
3	Positive	TH4 + TH5

Tab. VII, **Transformation of our classification into ternary code for computer.**

1	Negative	**TH1 + TH2**
2	Suspicious	**TH3**
3	Positive	**TH4 + TH5**

Tab. VIII. Transformation of **our** classification **into binary code.**

1	Negative	TH1 + TH2
2	Positive	TH3 + TH4 + TH5

Tab. IX. **Agreement between the classifications of mammary thermograms from the American Thermographic Society and Marseilles.**

American Thermographic Society		*Marseilles*
A	Normal	TH1 + TH2
B	Asymmetrical or suspicious	TH3
C	Abnormal	TH4 + TH5

Tab. X. Agreement between the classifications of mammary thermograms from Marseilles and Strasbourg.

	Marseilles	*Strasbourg*
TH1	Normal	Any elementary thermopathological sign
TH2	Benign type	1 or 2 signs
TH3	Suspicious	3 signs, but (a, b, e) or (a, b, g).
TH4	1 sign of malignancy	4 or 5 signs, or (a, b, e) or (a, b, g)
TH5	Several signs of malignancy	6, 7 or 8 signs

other systems, in particular for computer use (Tables VI, VII, VIII):

Agreement exists between our classification and that of the American Thermographic Society, derived from, graphic and thermal signs closely parallel to ours [10, 23] as shown in Table IX.

An analogy is also striking between our classification and that of the Strasbourg School [16], (Table X).

The value and reliability of our classification was tested again during the Sixth Seminar on Telethermography in Marseilles on over 2,000 breast cancers proven microscopically [9]:

91% of these cancers showed obvious cutaneous thermographic manifestations from TH5 TH4 or TH3 categories. And the original diagnostic contribution of infrared mammary thermography is demonstrated by the fact that 10% of these cancers had no clinical and/or radiological conclusive manifestations while they showed abnormal thermograms.

DYNAMIC CLASSIFICATION

Identifying a breast cancer, is worthwhile; assessing its growth potential, is even more so. If thermography is truly a reflection of the breast cancer thermogenesis, it must not only help in diagnosis but also contribute to the prognosis. This was evidenced by the English School with the first thermographs and has been confirmed later on by others.

For 5 years, we have studied this interesting aspect, first of all on fast growth cancers [2, 28]

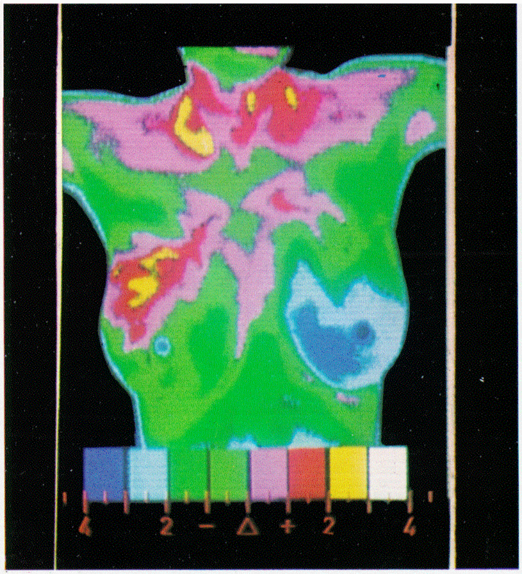


Fig. 15. Warm area by 3 °C covering the upper quadrants of the **right breast** with anarchic hypervascularization and global hyperthermia (+ 2°C) = TH5 PEV 0 category.

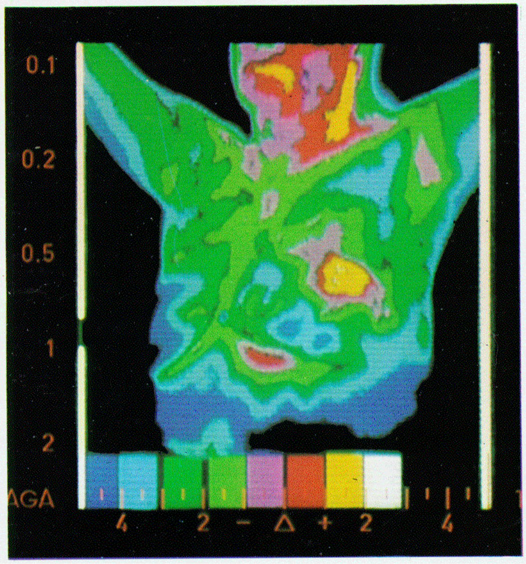


Fig. 16. Fast growth cancer. Hut **surface S1**, ther**mal gradient** by + 5 °C = TH5 PEV 1 category.

and now on the total number of cases treated by a therapeutic procedure [31].

On the 560 operable breast cancers followed up at least three years after curative treatment, we sometimes attributed to the initial mamma-

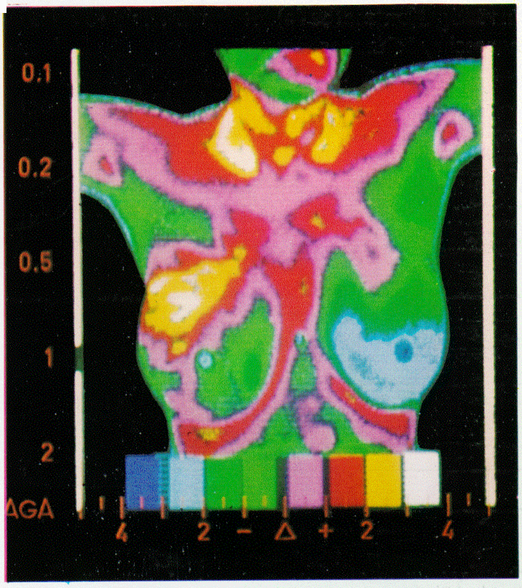


Fig. 17. Fast growth cancer. Hot surface S2, thermal gradient by + 4 °C = TH5 PEV 2 category.

ry thermograms (performed before any therapeutic action) a high & result (from 0,05 to 0,001) on the rate of cures obtained. Thus, cancers with **equal** or superior to 3 °C gradient have on average 20% less survival possibility at 3 years than the cancers with inferior to 3 °C gradients. For the sole stages II, I.U.A.C., the 3-year survival is 90% for THl - TH2 - TH3 categories and 72% for TH4 - TH5 categories.

At equal stages, infrared thermography has an advanced prognostic meaning. Our classification from TH 1 to TH5 has then both an *increasing diagnostic weight and an increasing prognostic weight.*

Whether obvious or concealed, between 15 and 20% of operable breast cancers are at fast growing. Thermography can indicate their provable presence:

when the gradient is superior to 3 °C (it may be up to 10°C),

when the warm area is extended, and exceeds the palpable cancer, and goes beyond two quadrants or even the breast.

The importance of the abnormally hot surface is at least as great as that of the thermal rise. There is between these two parameters a balance: as if thermography detected the flow of energy (Figs. 15 to 18).

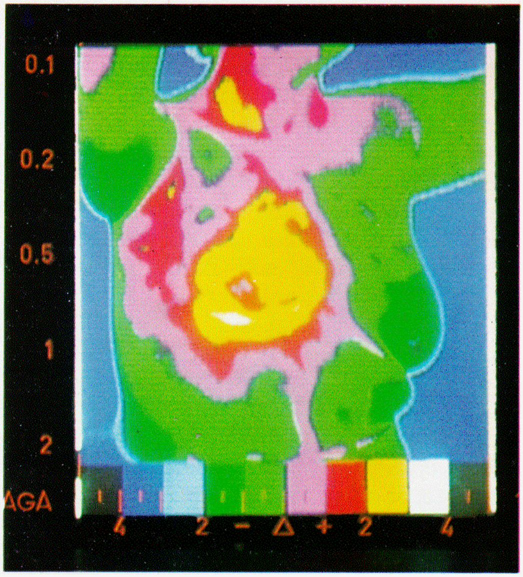


Fig. 18. Fast growth cancer. Hot surface S3, thermal gradient by + 4°C = 'I'H5 PEV 3 category.

Table XI shows the thermographic conditions we have retained [28] for considering a breast cancer being at a fast growth or in an cvolutive phase.

Tab. XI. Thermovisual definition of fast growth cancers in evolutive phase (PEV).

	Surface	*Gradient*
PEV 1 THV	Sl	⩾ **5°C**
PEV 2 THV	S2	⩾ **4°C**
PEV 3 THV	**s3**	⩾ **3°C**

The prognosis of these cancers is particularly bad, with early generalizations, even if they are apparently favorable (recent, small size, without adenopathy). it is better for a patient presenting herself with an operable breast cancer to carry a « cold giant » than a « warm dwarf » [26]. Infrared thermography is able to explain (and to foresee) unexpected success and failures according to the standing anatomical and clinical ideas.

Our computer studies in process in this area promise a more simple indexing of fast growth. For the stages II, I.U.A.C., we have noticed that in the fast growth forms, the difference between delta 2 and delta 1 was more than 1,5 °C.

The prognostic value of thermography is worth much study but already, we know that the « thermal stage » of an operable breast cancer cannot be disregarded. For the first time, clinicians now get *information of a physiological character* from a non-invasive method. It is possible that thermography will allow us to distinguish, at equal stage, from the total of operable breast cancers the two *extreme sub-populations* which would be a very useful information:

one at high-risk fuilure (equal or superior to 3 °C gradients, thermograms of fast growth type), for which we readily add general medical treatment to the localised curative treatment, even if it involves a common stage II, I.U.A.C.

the other one at low-risk failure (less than 3 °C gradients, TH3, TH2 and THl thermograms) for which we readily suggest a curative radio-surgical treatment with conservative aims, even if it concerns a common stage II, I.U.A.C.

DISCUSSION

A thermographic classification becomes of full value when it results from a well managed *diagnostic methodology* and *is subjected to carefnl* use.

In the methodological field, the technique of infrared mammary thermography is well coded now [4, 10, 12, 17, 24, 25]; we shall not refer back to it, but only point out several necessities:

- Recording at least three slides (front and three-quarter views).

-- A good initial thermoscopy by a professional thermographer himself for the possible solution of: special views, close-up.

- Black and white slides (warm being black) for an accurate assessment of vessels.

- Slides with colour isotherms for a verification of gradients and good definition of the extent of the abnormally hot surface.

The *careful use* of this classification should take into account some specific items of a general or localised nature.

A) Specific items of a general nature

1. *Chronobiology:* the circadian rythms could play a role for some authors in hyper- or hypovascularizations and it is advisable, if

we want to compare thermograms in the course of time, to perform the examinations at the same time of the day (in the morning or in the afternoon, if not at the same hour).

2. *Age* is not unimportant: young and dense breasts lend themselves better to thermography than senile and adipose breasts (it is the opposite with mammography). We should be more caution of the false-positives in young women and false-negatives in old women.
3. *The menstrual* cycle plays a role: thermography must be performed after menses. Hypervascularization of type C are seen in premenstrual syndromes and we should eliminate a pregnancy in front of a type D hypervascularization.
4. *Medicinal treatment:* this is liable to affect the breast directly (contraceptive pills, hormones) or indirectly, through other routes (anti-hypertensive cardiac drugs, psychotropic drugs etc.).

B) Specific **items of a localised nature**

1. *Anatomical asymmetries:* the interpretation should take into account the morphological asymmetries, should they be mammary (unilateral hypermastia or atrophy, umbilication of a nipple) thoracic or vertebral, congenital or acquired, medical or surgical.
2. *The mammary ptoses* on heavy breasts or in old women can lead to false « edge signs » at the level of the lower quadrants and hide in other respects a possible cancer of the sub-mammary sulcus.
3. *The previous history:* abcess lancing scars, excission of growth for a benign lesion (formation of a false edge sign or a wash-basin appearance); cutaneous thoracic mammary hemangioma (vascular asymmetry) : aesthetic surgery, irradiations.

CONCLUSIONS

Physicians have at their disposal high-speed infrared cameras and a rational interpretation of mammary thermograms (analytical and synthetic), 10% of breast cancers are not accompanied by obvious cutaneous thermographic manifestations (due to a poor thermal transmission to the skin or the lack of a sufficient thermogenesis). Some may even cause a relative hypothermia of the opposite cutaneous coating compared to the symmetrical area?. Therefore, this examination should never be implemented alone, without control by a thermographer who is a physician and without being combined with a systematic physical examination and breast X-ray images of good quality. In the case of a *non-invasive combined diagnosis,* we then add needle-biopsies for palpable tumours.

The data of each of these methods for this *diagnostic « tetrade »* are classified in the same way into 5 categories of increasing diagnostic value: from Cl to C5 for clinical examination from Rl to R5 for radiography, from Pl to P5 for cytology. This allows profitable comparisons to be made (radio-thermal and thermo-clinical particularly) and principally provides increased security for positive diagnosis since under these conditions, we get less than 1% false-negatives.

In the *strategy against breast cancer* [30] thermography has an important place in diagnosis, detection of sub-clinical and infra-radiological forms, in prognosis and in post-therapeutic follow-up.

Infrared thermography, an original method which produces *physiological thermopictures* (and not a radio-anatomy of structure), provides a highly valuable contribution to the *identification and behaviour* of breast cancers. Care and much more imaginative work is still required.

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