Dynamic telethermography of 2,200 breast cancers

by R. Amalric, H. Brandone, F. Robert, C. Altschuler, J.M. Spitalier
J. Ingrand, J. Deschanel

Cancer Institute, Marseilles (France)

SUMMARY. A homogeneous on going series of 2226 mammary carcinomas has been studied in clinical, thermal and mammographic detail.

The thermograms have been classified into 5 categories of increasing diagnostic meaning; details are provided on the 2 types of suspicious vascularization (TH3), tbe thermal rise of which should be 2.5 °C and on the 2 patterns of the vascular anarchy (TH4), the gradient of which has to be of 3° C.

For the whole range of cases (all clinical stages taken into account), we have registered 71% of thermograms clearly positives (TH4 and TH5), 20% of suspicious images (TH3) and only 9% of false negatives (THl and TH2).

These percentages vary considerably according to the local clinical extent of tbe involved cancer and the false negatives may reach 30% in small size cancers. But the radio-clinical comparisons show that, in these same forms, the rate of errors by default is also very high for clinical examination (40%) and for mammography (25%).

Under these conditions, only a combined diagnosis (clinical, thermal, radiographic and cytological) allows a sufficiently sure diagnosis. Owing to this, the errors of each method may be rectified and infrared thermograms especially, have made possible the detection of 217 sub-clinical or infra-radiological cancers, 25 of which were non palpable.

The false-positives of infrared thermography do not exceed 10% which makes the method sufficiently reliable to be used systematically in the framework of non invasive diagnosis of breast turmours.

Key words: infrared thermography, breast cancers, statistical results, value.

Between 1970 and 1976, we saw in Dynamic Telethermography (D.T.T.), 2,226 mammary carcinomas; all were proven microscopically and underwent a complete physical examination and mammography.

The thermograms were realized by 3 high-speed AGA Thermovision cameras (665, 680 and 680 M models) with 3 negatives in black and white and systematic control in colour.

The thermograms obtained were classified into *5 categories* following the well known fundamental vascular patterns [7] and the existence or not of suspicious thermal signs and/or malignancy criteria as have been already described [1, 2].

The classification is constructed in increasing diagnostic importance as follows:

THl = normal thermogram (A and B vascular types)

TH2 = *abnormal* thermogram of a benign type (C. D and L vascular types)

TH3 = *suspicious* thermogram (presence of a suspicious sign)

TH4 = thermogram showing *one* criterion of malignancy (or several suspicious signs)

TH5 = thermogram with several malignancy criteria (or one malignancy criterion alone and several suspicious signs).

Based on this classification, we examined the mode of thermographic appearance of the 2,226 mammary cancers considered as a whole, that is through all clinical stages (Table I).

We will note that D.T.T. was *clearly positive in 71 % of cases,* suspicious in 2O% only and falsely-negative in 9% (Fig. 1).

We will re-examine successively these three groups according to their degree of localisation according to the clinical classification of the International Union Against Cancer (I.U.A.C.), the TO category corresponds to sub-clinical non palpable cancers.
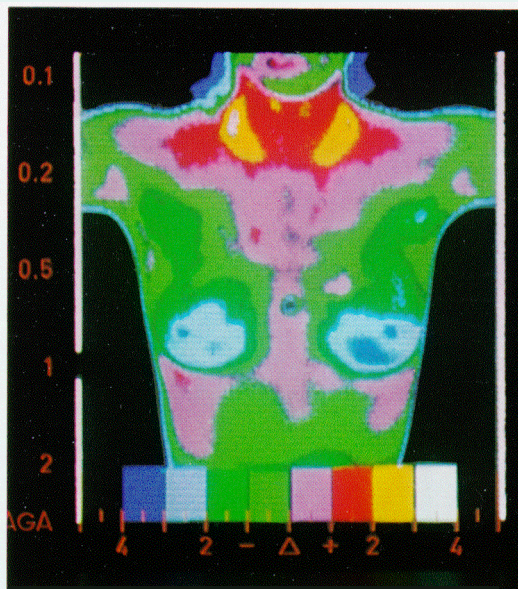
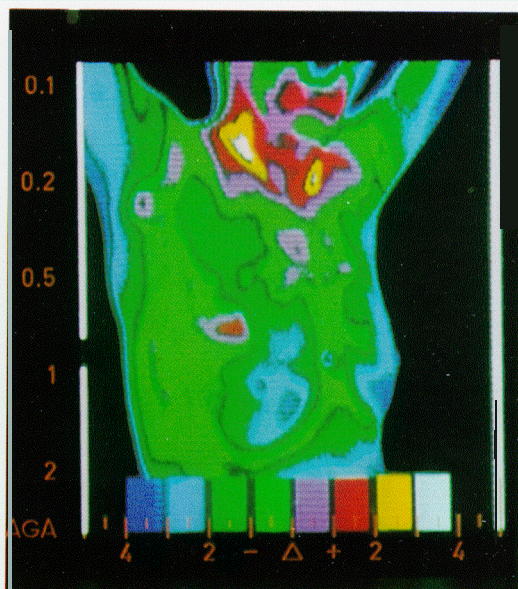Fig. 1. Breast cancer on the left presenting with a falsely negative thermographic pattern. *TH1* category.

Fig 2. *T1* category (I.U.A.C.), breast cancer on the right. The thermogram shows a localized hot spot by + 3 °C. *TH4* category.

Tab. I. Thermographic distribution of 2226 breast cancers (all clinical stages being gathered).

	Case	%	
TH1	24	1%	9% of false-negatives
TH2	184	8%	
TH3	441	20%	20% of suspicious cases
TH4	722	32,5%	71% of true-positives
TH5	855	38,5%	
	2226	100%	

This being *so,* the rate of *true-positives* (Fig. 2) varies from 32 to 94% if it implies a very small carcinoma (TO) or on the contrary an advanced phase voluminous cancer (T4). The average size cancers (T2) have a clearly posi-

tive thermogram (Fig. 2) in 64% of cases (Table II).

By comparison, the rate of thermographic *lake-positives* is set according to the microscopic verification of 1751 thermograms showing one or several malignancy criteria (Table III).

This rate varies from 5 to 15% according to the subjective thermographic category, the average being 10%. Such is the reliability of TH4 and TH5 images; what does this *mean?*

In front *of a palpable tumour* (Fig. 3) showing one or several thermal malignancy criteria, we can say that the probability of dealing with a *cancer* ranges from 84 *to 95%* (Table IV).

However the *suspicious thermograms* (Fig. 4) vary from 4 to 32% according to the pre-

Tab. II. Rate of thermographic true-positives in terms of 2226 cancers clinical extent.

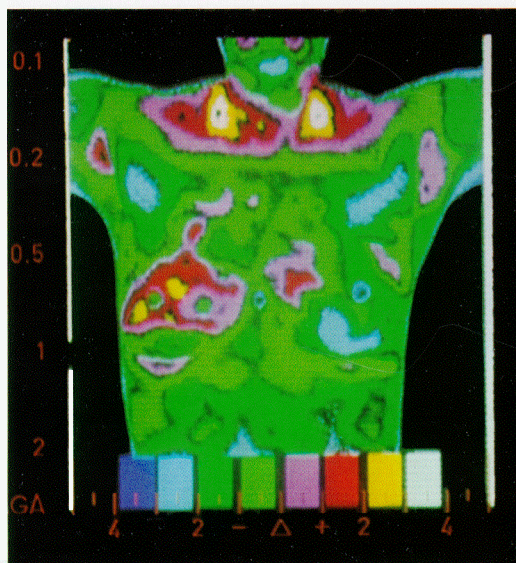|	TO	T1	T2	T3	T4	I.U.A.C.
TH4 + TH5	9	64	776	508	220	*1577*
Total n° of cases	28	170	1204	590	234	2226
%	32%	38%	64%	86%	94%	71%

47

Fig. 3. T2 category. I.U.A.C., breast cancer on the right. The thermogram shows two hot spots by + 4 °C with an anarchic vascularization *TH5* category (bifocal).

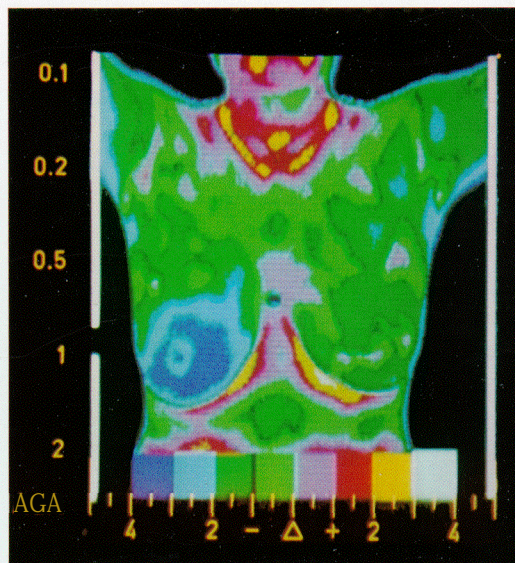Fig. 4. Global hyperthermia on the left breast by + 2 °C. Suspicious thermogram. TH3 category. (It involved a T1, I.U.A.C., carcinoma).

Tab. III. Percentage of mammary t&thermography false-positives (1751 TH-! or TH5 thermograms).

		Case	False+	%
One criterion of malignancy	TH4	855	133	15%
Several criteria	TH5	896	41	5%
Total: TH4 + TH5		1751	174	10%

Tab. IV. Probability of a prc-clinical cancers occurring before a palpable tumour with a TH4 or TH5 thermogram.

	Case	Cancers	%
TH4	855	722	84%
TH5	896	855	95 %

sence of a developed T4 cancer or a small T1 cancer (Table V).

This TH3 *category* should not be disregarded nor underrated, as, in reality, it is *highly significant:*

In case of a *palpable tumour*, it expresses a cancer in over one case out of two (441 cases out of 782 TH3 thermograms, that is *56%);*

in the absence of a palpable tumour (or visible on X-rays images) a TH3 should draw and receive special attention until

Tab. V. Percentage of suspicious thermograms in relation to the clinical extent of the examined cancers.

	T0	T1	T2	T3	T4	I.U.A.C.
TH3	16	55	296	64	10	441
Total n° of cases	28	170	1204	590	234	2226
%	57%	32%	25%	11%	4%	20%

such time as the absence of any cancerous or pre-cancerous lesions can be proven."

It should not be overlooked that 6 of our *non palpable cancers* out of 10 have been found to be due to the continuance of a TH3 thermogram.

What now is the rate of infrared thermography *false-negatives* regarding breast cancers? This is the main question for mass screening or early diagnosis.

Table VI shows that this percentage varies from 2 *to* 30% depending on the size of the examined cancers (from T4 to Tl).

matic research of micro-calcifications and control by xerography).

Under these conditions, it is out of the question to blindly trust a single examination method and far from opposing them, it is advisable to combine several methods in order to have the greatest possible security [16].

By chance, it seems that the errors are not always made in the same direction, as the methods used (clinical, thermographic, mammographic, cytologic) are based on different principles. Each one is able to rectify the other's errors, this became clear while studying the

Tab. VI. Rate of thermographic false-negatives (2226 cancers).

	I. U. A. C.					
	T0	TI	T2	T3	T4	
TH1 + TH2	3	51	132	18	4	208
Total n° of cases	28	170	1204	590	234	2226
%	11%	30%	11%	3 %	2%	9%

The figure of 30% false-negatives in small size cancers (Tl) is indeed considerable and some people have taken advantage of it in saying that thermography was useless for breast detection [12] but this figure seems much less surprising if *we compare it with the false-negatives of the clinical examination and mammography for the same cancers.*

We were able to make this comparison with an homogeneous series of 188 cancers which were less than or equal to 2 cm diameter: 30 TO and 158 Tl, I.U.A.C.; the surprising outcome of this study is shown in Table VII.

Tab. VII. Clinical, thermal and radiographic false-negatives of 188 small size cancers (30 TO and 158 Tl, I.U.A.C.).

	Case	%
Clinics	75/188	40%
Thermography	52/188	28%
X-Rays	47/188	25%

It is obvious that any *isolated method is not infallible,* not even *radiography which makes 25% of errors by default,* notwithstanding a strict methodology (molybdenum anode tubes, negatives in compression-localizations, syste-

results of the four diagnostic « methods » in connection with 3682 breast tumours verified microscopically (2226 cancers and 1456 benign lesions).

From this systematic combined diagnosis:

The false-negatives of thermography (208 cases) have been rectified by clinical examination, mammography or microscopy (any solid tumour not influenced by the menstrual cycles having undergone a systematic biopsy).

In parallel, *thermograms have enabled us to rectify 217 errors arising from* clinical examination or radiology which represented an original contribution of 10% of our cancers (Fig. 5).

There were:

25 non palpable cancers with 3 to 5 mm, in diameter.*

86 clinically benign or doubtful cancers.

106 radiologically benign or doubtful cancers.

The clinical and radiological data was classified as those of thermography into 5 cate-
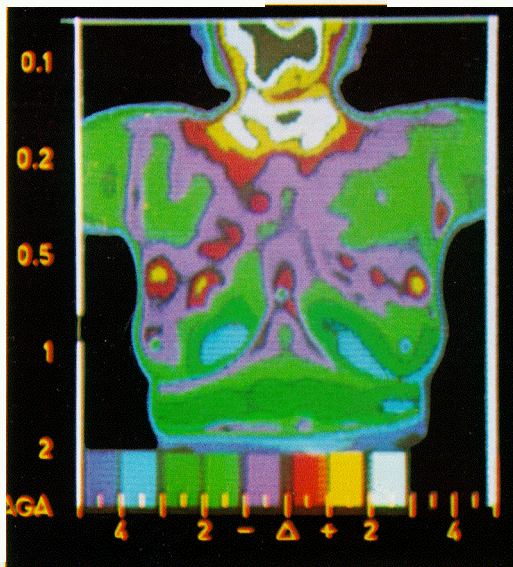
Fig. 2. Cancer on the right breast. TI, I.U.A.C. with a TH5 thermogram (bifocal). Evidence of a hot spot on the left revealing a non palpable micro-cancer and without radiological demonstration.
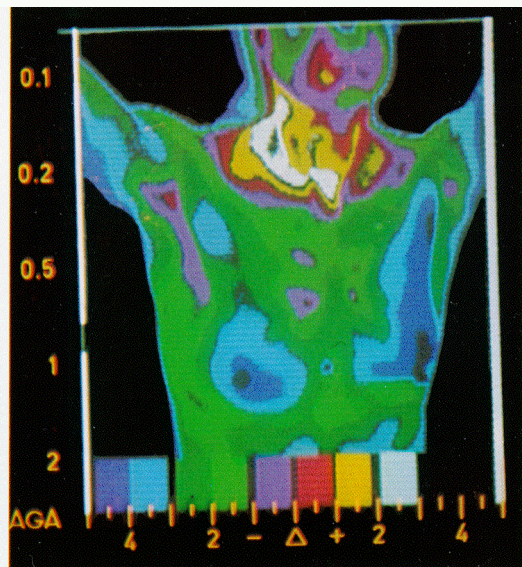
Fig. 6. Extended edge sign with linear rigidity of lower quadrants on the left breast. TH4 category thermogram (cancer of a scirrhus type).

gories of increasing diagnostic meaning. The **result** of these comparisons are as follows:

The thermo-clinical comparisons show that one in two infrared thermograms rectify the errors produced by clinical examination. This is a positive contribution of 35 to 89% according to it being a clinically doubtful **tumour or** a non palpable: micro-cancer (Table VIII).

The radio-thermal comparisons are even more clearly in favour of thermography with an adjustment of the radiographic errors 6 times out of 10.

This positive contribution is obtained in 46 to 88% of cases depending whethen it involves a radiological simply doubtful image or a small cancer without radiographic translation (Table IX).

Finally, out of 37 cancers both clinically and radiographically benign, D.T.T. was clearly positive in 29 cases, that is 8 times out of 10. On a total number of 2226 cancers, it corresponds to *a detection rate by thermography alone of 13 per thousand, uahich is far from being negligible.*

We should specify that this it does not concern mass screening but a result of the combined diagnosis for patients taking medical advice for a symptom or being followed **up after** irradiation on the opposite breast.

In total, if we consider *our cancers as a* whole, we see that they have significant thermograms TH3, TH4 or TH5 (Fig. 6) Y *times out* of 10, with extreme percentages going from 70 to 98% of cases, according to their

Tab. VI II. **Thermo-clinical comparisons (223 cancers).**

	Case	Positive THG	Yo
Non palpable cancers (Cl)	28	25	89%
Clinically benign cancers (C2)	62	39	63%
Clinically doubtful cancers (C3)	133	47	35%
Total	223	111	50%

50

Tab. IX. Radio-thermal comparisons (171 cancers).

	Case	Positive THG	%
Cancers without radiographic translation (Rl)	35	**31**	**88%**
Benign cancers radiographically (R2)	**47**	**34**	**72%**
Doubtful cancers radiographically (R3)	89	**41**	**46%**
Total	**171**	**106**	**62%**

Tab. X. Significant thermograms (TH3, TH4 and TH5) of 2226 breast cancers according to their clinical extent.

	I. U. A. C.					
	T0	Tl	T2	T3	T4	
TH1 + TH2	**3**	51	**132**	**18**	**4**	**208**
TH3 + TH4 + TH5	25	119	**1072**	572	**230**	**2018**
	28	**170**	**1204**	590	**234**	**2226**
significant THG	89%	**70%**	89%	97%	98 %	91%

clinical extent (Table X). This is well in agreement with the results given by other authors and ourselves [3, 5, 6, 11, 13, 14, 15].

Thus, D.T.T. fills a major place in the non-invasive combined diagnosis of mammary carcinomas, and more generally in the diagnostic assessment of breast cancer which it helps to make increasingly reliable.

Due to this fact, we were able to note year after year a regular increase in the number of patients presenting with a small size cancer, cases entering the T0, Tl and T2 categories, being cleared, in 5 years, *from **57** to 63%* which is very encouraging (Table XI).

In *conclusion,* in a few years, infrared thermography has been able to bring *original data* in an increasing number of breast cancers: from the *diagnostic* viewpoint, 10% detec-

tion of sub-clinical or infra-radiological cancers and that of 5% at distant sub-clinical localizations;

from the *prognostic* viewpoint, 11% objective detection of « hyperhot » fast growing cancers [18] of a clearly poor prognosis and 9% of « cold » cancers of a possible good prognosis [5, 8, 9].

Lastly, from the follow-up after conservative treatment point of view, the early diagnosis of 11% evolution and 2% recurrences [4].

This is to say that D.T.T. has become *absolutely necessary in one out of two breast cancers* where it provides original data. Indeed, it is a functional and dynamic method and not anatomical or static. It gives a reflection of the neoplastic energy.

Tab. XI. Percentage of early diagnosed cancers (TO, Tl and T2) from 1972 to 1976.

	I. U. A. C.					
	T0	Tl	T2	TO + Tl + T2	Total number of cancers	
1972	5	44	307	356	627	57%
1973	10	65	509	584	1000	58%
1974	12	101	732	845	1418	60%
1975	23	151	1001	1175	1884	62%
1976	28	170	1204	1402	2226	63%

REFERENCES

1. **AMALRIC** R., **SPITALIER** J. M.: La téléthermographie dynamique en carcinologie clinique. Nouvelle Presse Médicale, 2, 1049-1052, 1973.

2. **AMALRIC** R., **POLLET** J. **F.**, **ROBERT** F., **ALTSCHULER** C., **GIRAUD** D., **SPITALIER** J. M.: Caméras rapides à infra-rouges devant 1000 cancers du sein. *Méditerranée Médicale*, **40**, 99-

3. **AMALRIC** R., **GIRAUD** D., **ALTSCHULER** C., **SPITALIER** J. M.: Thermography in diagnosis of breast diseases. Thermography. *Bibliotheca Radiologica*, 6, S. Karger ed. Basel, 65-76, 1975.

4. **AMALRIC** R., **SPITALIER** J. M.: La surveillance téléthermographique des' cancers du sein irradies. *7. Gynéc. Biol.,* Paris, 4, 99-107, 1975.

5. **AMALRIC** -R., **GIRAUD** D., **ALTSCHULER** C., **SPITALIER** J. M.: Value and interest of dynamic telethermography in detection of breast cancer. *Acta Tkermograpkica*, 1, 89-96, 1976.

6. **GERSHON-COMEN** 1., **HABERMAN-BRUESCHKE** J. D., **BRUESCHKE** 'E. E.: Medical thermography. *J. Radiol. Electrol.*, 48, 12-24, 1967.

7. **GIRAUD** D.: *Classification des images thermovisuelles mammaires*. These, Faculté de Médecine de Marseille, 1972.

8. **GROS** Ch., **GAUTHERIE** M., **BOURJAT** P.: Prognosis and post-therapeutic follow-up of breast cancer by thermography. *Bibl. Radiol., 5, 77-90.* 1975.

9. **JONES** C., **GREENING** W. P., **DAVEY** J. B., **MC KINNA** J. A.. **GREEVES** V. I.: Thermography of the female 'breast: a five-year study in relation of the detection and prognosis of cancer. *Brit. J. Radiol., 48, 532-538, 1975.*

10. **LAWSON** R.N.: Implications of surface temperatures in the diagnosis of breast cancer. *Canad. Med. Ass. J., 75, 309, 1956.*

11. **MELANDER** 0.: Les images du sein en thermovision. *Corse Mediterranée Médicale, 216,* 101-104, 1972.

I2. **MOSKOVITZ** M., **MILBRATH** J., **GARTSIDE** P., **ZERMENO** A., **MANDEL** D.: Lack of efficacy of thermography as a screening tool for minimal and stage I breast cancer. The New-England *J. of Med., 295, 249-252, 1976.*

13. **OHASHI** Y., **YAMAZAKI** Z., **ONAI** Y., **UCHIDA** I.: *The diagnosis of breast cancer by thermography.* In Medical Thermography by K. **ATSUMI,** University of Tokyo Press ed., 215-252, 1973.

14. **PISTOLESI** G. F., **DALLA PALMA** F., **GORTENUTI** G., **LOVISATTI** L.: Termografia e cancro della mammella. *Radiol. Medica, 59, 881-919, 1973.*

15. **ROCCHI** L.: La *termografia mammaria.* Costantini ed.. Cesena (Italia). 1976.

16. **SPITALIER** J. M., **AMALRIC** R.: Diagnostic combine des cancers du sein. *Medicorama*, 191, 6-36, 1975.

17. **SPITALIER** J. M., **LEOTARD** J., **CAYRET** A., **POLLET J.** F., **AMALRIC** R.: Conduite à tenir devant un thermogramme mammaire douteux ou suspect (catégaorie TH3). *Méditerranée Médicale;76, 107-113, 1975.*

18. **SPITALIER** J. M., **CLERC** S., **GIRAUD** D., **AYME** Y., **PIETRA** J. C., **AMALRIC** R.: La notion thermovisuelle de croissance rapide dans les cancers du sein. *Méditerranée Médicale, 76,* 15-26, 1975.