AMERICAN THERMOGRAPHIC SYMPOSIUM 1979

The American Thermographic Society (A.T.S.) met March 31 and April 1,1979 at the Sheraton Center, Toronto, Canada. At this Ninth AnnualMeeting, Dr. B. Threatt *madepresidential remarks encouraging a continued study and use of Thermography.*

The sessions were facilitated by the Canadian Thermographic Society. I. W. Davidson, M. D., *President, Canadian Thermographic Association,* L. A. Reed, Ph. D. *and N.* J. Belliveau, M. *D.presided at the meeting sessions.*

The major areas of interest were pain monitoring, dermatological conditions, vascular evaluations including the heart, breast evaluations with emphasis on physiology. Technical advances including microwave, cholesteric plate improvement and equipment comparison were also discussed.

Mrs. N. Oldfield, *Executive Director, organized andprovided excellentfacilitiesfor the 200 attendees. At the official meeting of the Executive Committee,* Dr. H. Isard, *Chairman of the board,presided and two major decisions werepassed.* I. "Acta Thermographica" *will be the official Journal of the A.T.S. 2. Full cooperation with the establishment of the International Society of Thermobiology (I.S. T.) was assured.*

The agreement of representatives of the Japanese, European, Canadian and A.T.S. to support organization efforts of I.S.T. was obtained at a special meeting arranged by M. Gautherie.

Asprogram Chairman, I would especially like to thank theparticipation of ourforeign colleagues who provided the essence of the success of this meeting and I am greatfulfor the recording of thefollowing proceedings in "Acta Thermographica". *Special thanks to* Prof. G.F. Pistolesi *for his editing and cooperation in these matters.*

WILLIAM B. HOBBINS, M.D.
Program Chairman
Ninth Annual Meeting
American Thermographic Society

Muscolo-skeletal pain and thermography

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Summary. Physical examination must be appropriate to the complaint. Certain accepted «hard» physical signs are too coarse to be acceptable as the sole criteria of organic injury. «Soft» signs are more realistic measures of focal lesions. Thermography is a valuable tool which objectively reveals the influence of sympathetic activity. Findings are reliable and consistent with the degree of organic dysfunction revealed by the <<soft's signs described.

Key **words:** thermography, injury, signs, pain.

A) INTRODUCTION

The complaint of pain, unsupported by accepted objective findings, is often suspect.

1. On physical examination, hard signs, such as motor loss, deformity, restricted gross motion, real spasm, tendon reflex alteration, atrophy, etc., are coarse alterations, more consistent with actual damage than dysfunction, and are found a considerable distance along the path of the pathologic process.

2. Soft signs are more subtle and require more sensitive search, but are realistic and proportionate indicators of muscolo-skeletal derangement. Some are present as the result of neural irritability prior to damage. Examples of such signs are the impairment of passive joint mobility, cutaneous hyperalgesia in a dermatomal distribution, and dyssynchrony revealed by active repetitive bilateral bending (a clinical test developed by GOODLEY).'

3. When soft signs are accompanied by sympathetic nerve irritability, they begin to be observable on thermography (T.). The availability of clinical diagnostic sensitivity, which has not generally been focused on, is thus revealed in another way and a more realistic match of symptom and sign may then be appreciated.

Case history: A young bus driver had been injured when a boarding passenger grabbed his outstretched left arm and twisted his torso violently to the right. He developed left thoraco-lumbar pain which the Author found was associated with ((soft)) signs, consistent with the complaint. An industrial medical examiner reported, «no evidence of injury», and he was released to work, which he unsuccessfully attempted. The 2 reports submitted to the industrial commission were, therefore, in conflict concerning objective evidence except for the T. examination which visually revealed an asymmetric zone of increased heat, 2°C to 3°C relatively warmer than the remainder of the thoraco-lumbar area. The T. pattern was almost an actual overlay of the patient's pictorial pain representation which is routinely obtained prior to the procedure. Subsequent examinations have revealed reliable patterns which compare favorably with those of RASKIN et a1.[2] and WEXLER and CHING.[3]

B) CORRELATION OF THERMOGRAPHY, SOFT SIGNS AND PAIN

1. T. visibly displays infra-red radiation which, in the human body, is primarily an expression of vascular flow. In the absence of focal or regional pathology, in the properly prepared patient, the display is essentially symmetric.

2. In nerve root injuries, the anticipated T. pattern is the appearance of a linear increase in the vascular heat emission pattern (VHEP), along the course of the nerve root, and extending obliquely and inferiorly from the normal longitudinal vertebral VHEP. Occasionally the abnormality is circular or ovoid. Irritation of the sympathetic fibers about the root usually produces increased vaso-constriction within the area of its distribution, (larger than a single dermatome) producing a relative cooling. The appearence of an increase in the paravertebral VHEP, associated with distal cooling, is a ((consistent)) pattern. Not infrequently, a ((crossed)) pattern is J, seen in which the paravertebral increased VHEP is observed but the relative cooling is in the contralateral distribution. This appearance may occur from combinations of a variety of influences, such as presence ofbilateral abnormalities, reciprocal reflexes, etc.

It must be clearly understood that asymmetric T. patterns are not proof of functional abnormality of themselves. Local sympathetic alterations can occur in the absence of observable motor and sensory nerve involvement. It is likely, however, that T. and asymmetries, present on repeated examinations, are significant. Changes can also occur rapidly and, on one occasion, while the Author observed, a right S1 pattern converted to a left within a few min.

3. The Author has devised a coolant spray challenge which increases the sensitivity of the procedure, in certain cases, by revealing asymmetric and exaggerated vaso-spasm in an area associated with the injury. At this time, this linding has been seen only in cervical and thoracic injuries, predominantly the latter. The test is performed by obtaining a baseline colourphoto (Polaroid) of the area to be tested. An alcohol spray is then uniformly applied to the region and photos are then taken at 1,2 and 3 min intervals. Persisting asymmetries of at least 2°C cooler are looked for. When those areas are consistent with the patient's pictorial representation of pain and physical findings, including reported tenderness, they represent evidence of dysfunction.

C) CONCLUSION

T. examination reveals a measure of sympathetic activity which may be related to a painful condition.

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Thermographic evaluation of trauma (spine)

by C.E. WEXLER

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Summary. By utilizing a combination of proper history forms and meticulous thermographic (T.) technique, the T. can be as accurate as, if not more accurate than, the myelogram or EMG in the evaluation of nerve root irritation. 86 consecutive patients having cervical, and/or thoracic and/or lumbar T. were reviewed. Totally148 T. were performed in the 86 patients. In the 54 cases that had EMG studies, there was a direct correlation, positive or negative, between the EMG and the T. of 76%. The T. correlated with the objective clinical findings in 92% of the cases; the EMG in 83% of the cases.

Key words: spine abnormalities, intervertebral discs, thermography, pain evaluation.

A) INTRODUCTION

The appearence of the normal lumbar thermography (T.), its variations, and its correlation with the myelogram and surgical findings have previously been described in the literature.[1-4] A method of routinely screening the lower extremities in conjunction with the lumbar T. exam has also been described.' The exams in this series were performed with screening of the related extremities in conjunction with the appropriate portion of the spine.

Correlated data between the T. exam, the EMG, if performed, and objective clinical findings in 86 cases were obtained.

B) MATERIAL AND METHODS

The patients presented represent 86 consecutive cases sent for T. evaluation from the practice of a single orthopedist from August 1977 to April 1979. There was consistency of EMG technique within the series. The equipment used to perform these studies was an AGA Thermovision Model 750. The colour pictures were recorded on colour Polaroid film directly from the colour monitor. The black and white pictures were recorded on Kodak FXP 120, in a Hasselblad camera, directly from the black and white monitor. The colour display on the monitor was set so each colour represented 1°C difference. The selection of colours was arbitrary and the scale at the left side of each picture represents the sequence from the hottest to coldest with white at the top representing the hottest colour.

1. Thermal focusing

The lumbar black and white pictures utilized a specific technique for which the Author has coined the term ((thermal focusing)) (Fig. 1). Specifically, the portions adjacent to the midline, both next to and below the lumbar stripe, are the most important diagnostically. These areas should be viewed in clear detail, even if the portions wide to these areas have to be viewed on separate projections. ((Thermal focusing)) involves moving the location of the most optimally visualized portion of the grey scale (middle grey) to different positions producing a composite of pictures yielding a maximum of diagnostic information. Various pictures are taken with the maximum isotherm set at mid-point for different locations starting from the midline and moving laterally. The

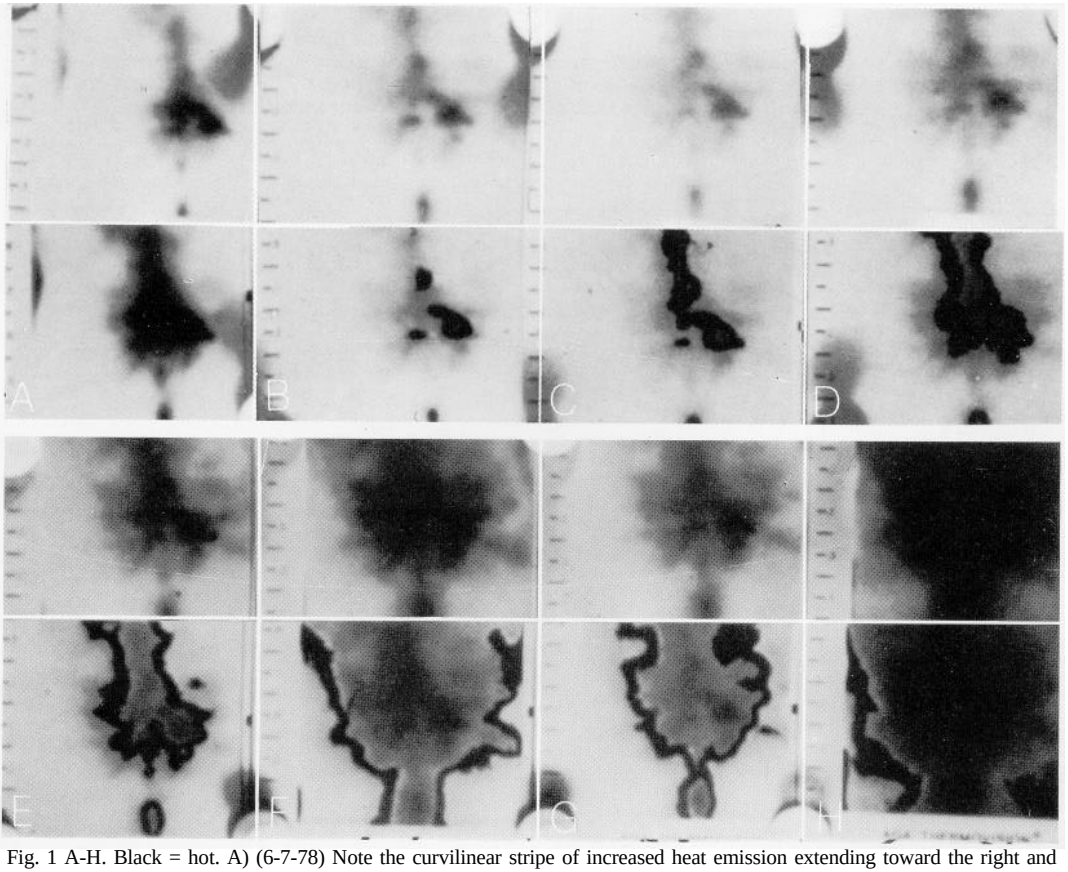


Fig. 1 A-H. Black = hot. A) (6-7-78) Note the curvilinear stripe of increased heat emission extending toward the right and downwards from the lower portion of the normal lumbar hot stripe. (the black vertical midline line). B) Same patient 2 months later (8-U-78). Note the identical findings. This series of pictures illustrates the changes in appearance with the maximum isotherm (middle grey) set at different portions of the back. The same information is always present but cannot be properly interpreted unless viewed in or close to a middlegrey setting. Pictures E through H are unacceptable.

technique is illustrated to an extreme in Fig. 1. Normally, 3 different settings are taken (without the isotherm lines present) at, adjacent to, and lateral to the midline at about the level of the sacro-iliac joints. Note the variability in ability to see the diagnostic information present with the different settings. Pictures improperly ((focused)) cannot be properly interpretated (Fig. 1, E-H).

2. Artifacts

To exclude artifacts, all abnormal findings were repeated 10 to 15 mins after the initial pictures to determine consistency of the abnormality. This may have to be done more than once depending on the case. This concept is critical for reliability. In Author's experience, abnormalities that were consistent over a 30 to 40 mins period under controlled conditions, have been present if the patient was retourned on another day, assuming no change in the patient's status. Note in Fig. 1, the 2 months difference between the A and B pictures. Current routine for consistency is to do each exam completely 3 times, at 20 mins intervals, using 3.5 mm film instead of Polaroid.

3. Preparation of patients

The neck and/or back was prepared for the exam by wiping with a damp cloth followed by blow drying with a hair dryer set on cool. The extremities were not specifically prepared. The patients were then allowed to sit and equilibrate with the surrounding ambient tem-

perature for 15 mins before beginning the exam, which was performed in a draft free environment. The patients were instructed not to smoke for 8 h prior to the exam. While the patients were equilibrating, they were requested to fill out the history form shown in Tab. I. The dermatome referral areas most commonly used were used as a basis for the T. interpretation.

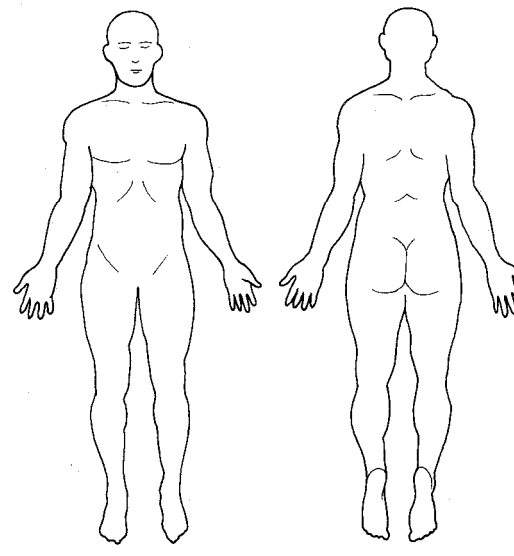
c) RESULTS

Tab. II presents the correlated results of all 86 cases. The EMG studies in this series were done by a single Neurologist and his Associate thereby providing consistency within the series. A total of 148 cervical and/or thoracic and/or lumbar T. were performed. The standard to which the T. and EMG were compared, was objective physical exam findings correlating with the patient's complaint as determined by the orthopedist. Objective criteria were: a) *muscle spasm* with restricted motion; β) the *straight leg raising test*; γ) the *Lesague test*; δ) sensory *changes* following anatomic pathways; ε) *reflex changes*; ζ) *nerve stretching tests*; and, ς) *multiple grip strength readings* using the JAUVIER dynamometer.

There was a direct correlation of 76%, positive or negative, between the EMG and the T. in the 54 patiens that had both studies. In the 13 patients in whom the EMG and T.

Tab. I. History form to be filled out while equilibrating.

1. Name: _____ Age: _____ Date: __
2. Date of accident: _____ are you left or right handed? _____
3. Please mark on picture where you have or have had pain or other symptoms since your injury. Include symptoms of pain, numbness, or tingling.



4. Are you having any pain, numbness or tingling now? _____
5. Put a circle around the areas that hurt at this time
6. Are you taking any medication? _____ what kind? _____
7. Do you smoke? _____ time of last smoke _____
8. Do you have gout? _____ diabetis? _____ arthritis? _____
9. Have you had any fractures or surgery on your arms, legs, hands, or feet? _____
   where? _____ when? _____
10. Briefly what happened to you at the time of the accident _____

Tab. **II. An UatiOn of 86 consecutive patients referred over a 20 month period by a single orthopedist.**

A) No. of patients who had EMG	54
Agreement between EMG and T.	41 (76%) (1 7 neg.; 24 pos.)
Disagrement between EMG and T.	(T. +; EMG–)
0bjectrve clinical findings agree with T.	9
Objective clinical findings agree with EMG	4
B) No. of patients with no EMG	32
Objectrve clinical and T. agree	30 (15 neg.; 15 pos.)
Objective clinical and T. disagree	(T. +; cl.-)
C) Overall agreement between T. and objective clinical findings (accuracy)	79/86 (92%)
D) Overall agreement between EMG and objective clinical findings (accuracy)	45/54 (83%)

EMG - Sensitivity - 71% (31 + cl., 22 + EMG)
Specificity - 100% (23 - cl., 23 - EMG)

T. - Sensitivity - 100% (46 -I- cl., 47 + T.)
Specificity - 85% (40 - cl., 34 - T.)

disagreed, the clinical findings agreed with the EMG in 4 and with the T. in 9.

In 32 cases only T. were performed. The clinical findings, positive or negative, agreed with the T. in 30. In the 2 cases in which there was disagreement, the T. was positive and the physical exam negative. The EMG demonstrated an overall accuracy rate of 83%. The T. demonstrated an overall accuracy rate of 92%.

Sensitivity and specificity calculations are presented in Tab. II. Sensitivity equals the true positive rate which is the number of positive T. in positive patients divided by all positive patients who had a T. Specificity equals the true negative rate which is the number of negative T. in negative patients divided by the total negative patients. Accuracy equals the true positive plus true negative divided by the total cases.

The T. and the EMG were complimentary procedures in the majority of cases.

Figs. 2 and 3 represent, respectively, the lumbar area and portions of the extremity exam done on a patient 8 months pre-operatively (Figs. 2A, 3A) and again 3 months post-operatively (Figs. 2B, 3B). Pre-operatively the complaint was low back pain radiating into the posterior lateral right thigh. The patient was asymptomatic at the time of the post-operative exam.

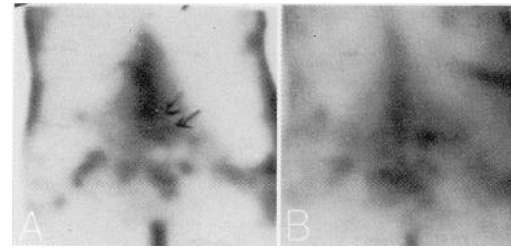


Fig. 2 A-B. Black = hot. This represents a patient who was done pre and post-operatively. A) Lumbar pattern as it was seen in March 1978, at which time the patient complained of back pain radiating into the posterior lateral right thigh. Note the tine linear increase in vascular heat emission extending obliquely downwards towards the right from the lower portion of the lumbar stripe as outlined by the arrows. The patient subsequently went to surgery in November 1978, and a herniated lumbar disc at the 4-5 level was found which was pressing on the right L5 nerve root. B) Post-operative T. obtained in January 1979. Observe that the tine linear increase in vascular heat emission outlined by the arrows on the pre-operative study is not present on the post-operative study.

Observe the findings consistent with irrita tion of the right fifth lumbar nerve root and

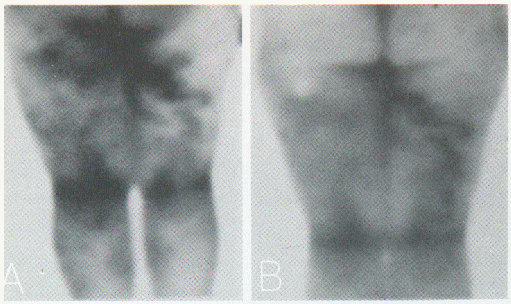


Fig. 3 A-B. Black = hot. The posterior thighs of the patient in Fig. 2. A) Pre-operative picture. Observe the relative decrease (less grey) of the posterior-lateral right thigh B) Post-operative pictures Observe the relative symmetry of the posterior thighs when the patient was asymptomatic. Observe the unchanging appearance of the varicose vein in the posterior right thigh. It is most likely that spasm of the small vessels accompanying the nerve endings account for the «cold» appearance

the regression of those findings post-operatively when the patient was asymptomatic. The myelogram report on this patient was interesting. There is a slightly prominent potential epidural space between the posterior end place of L5 and the anterior border of the subarachnoid space. In the erect projection, the cross table lateral view reveals flattening along the anterior sub-arachnoid space suggestive of a very subtle extra-dural defect here. Of interest, is that while the changes on the myelogram were minimal,the changes on the T. were obvious.

Fig. 4 is to demonstrate what an entire lumbar extremity exam sequence looks like. The anatomy is thermographed in sections and put together for interpretation. If Polaroid film is used one can be selective with repeat views, omitting the normal areas.

Fig. 5 represents the posterior thorax on a patient seen once in November 1977 and again 3 months later, the day of his second «accident». There is not only no correlation with his complaint on either occasion, there is no significant change between the 2 exams. The thoracic area should be closely correlated with the clinical complaint, more so than the cervical or lumbar.

Figs. 6-8 represent a series of cervical exams on the same patient. Portions of a cervical T. done in June 1978 can be seen in Fig. 6A. Observe the symmetry of the posterior neck. Except for a decrease in temperature of the posterior left shoulder from a scar and differences in the index fingers due to a tight ring on the right index finger, her exam was normal. Observe the similar information in the picture done 6 months later (Fig. 6B).

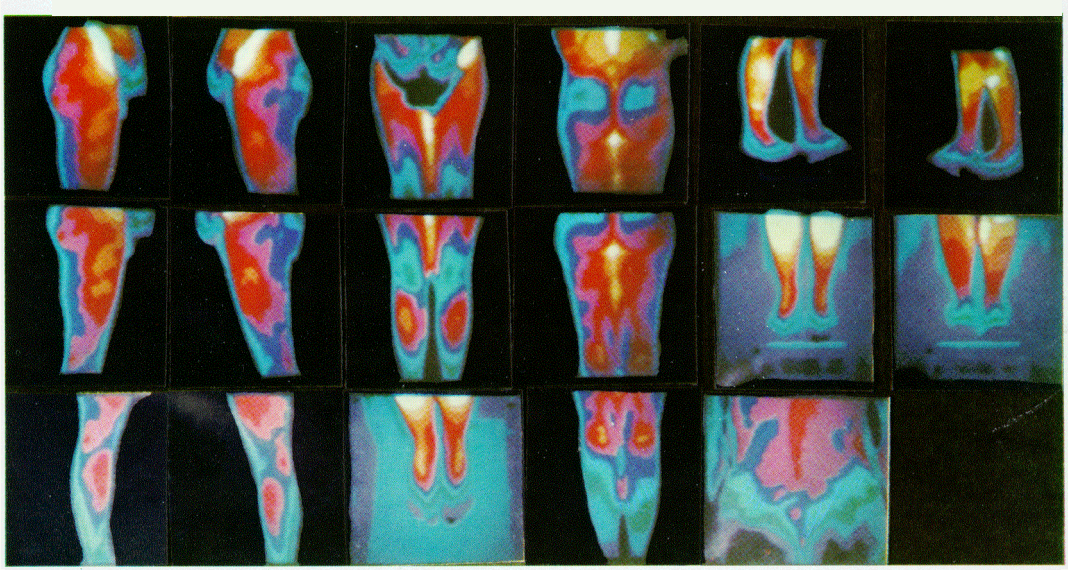


Fig. 4. An example of a composite of the colour portion of a lumbar exam as it is put together for interpretation is shown here. Observe the findings consistent with irritation of the left L5 nerve root manifested by a relative decrease in the vascular heat emission pattern of the mid left buttock, lateral left thigh, anterior left leg, dorsum of the left foot and great toe of the left foot. All pictures are done standing except for the dorsum of the feet. When necessary cardboard is used to provide a black background and separate parts of the body.

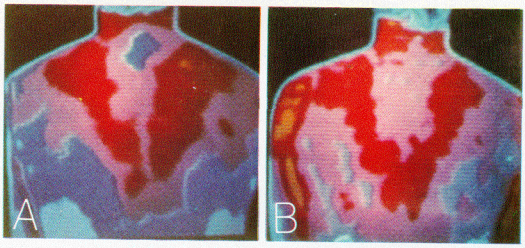


Fig 5 A-U A) Observe the relatively symmetrical thoracic pattern on the November exam, which does not correlate with his complaint. B) The almost exact duplication of this pattern in February essentially demonstrates that no signi ficant change has occurred since November and that there is still no correlation with the chinical complaint. The « cold » circular (blue) area at the T2-3 level is an anatomic variant, not abnormahty. B) was taken at a slightly lower setting on the colour scale than the first

cular changes immediately. Fig. 8 is this patient 1 wk following the accident. She was still symptomatic. Observe the relative cold of the posterior left neck, dorsum of the left forearm and fingers of the left hand. By December she was asymptomatic and her exam returned to its pre-accident baseline. This figure is also a demonstration of what an entire cervical exam looks like when it is put together for interpretation. The posterior neck, forearm and hands are done sitting, using cardboard for background when necessary. the other views are done standing. Observe the examined parts are parallel to each other and perpendicular to the infra-red detector.

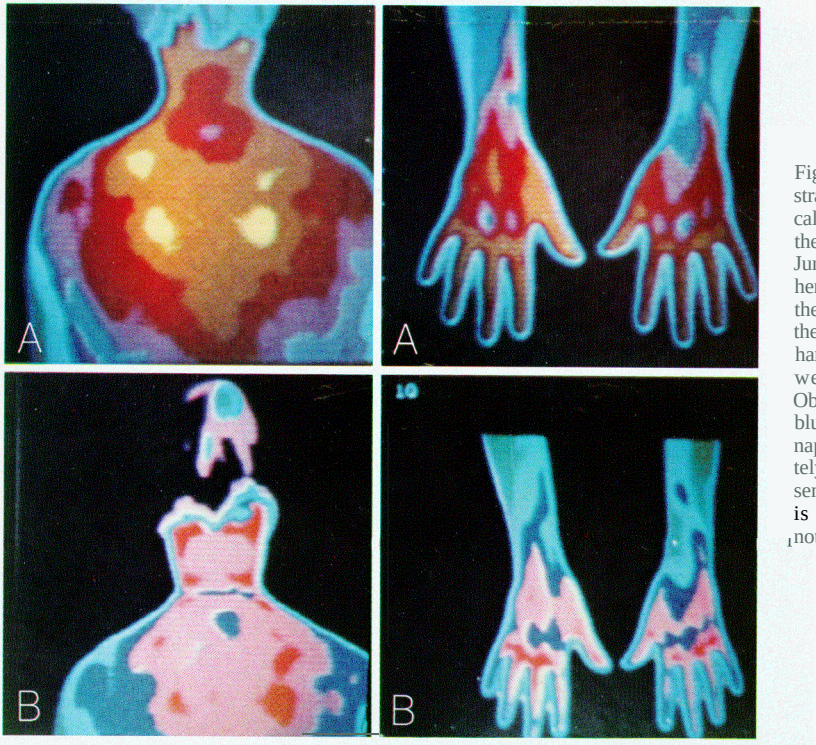


Fig 6 A-B. This is a demonstration of the posterior cervical dnd dorsal hand views on the same patient, done once in June (A) and once in Decemher(B) of the same yr. Observe the ldentical patterns in both the back of the neck and the hands on the 2 exams which were done 6 months apart. Observe the small focal cold, blue, spot in the midline at the nape of the neck at approximately the T2 level. This represents an anatomical variant that is seen quite frequently. Do not confuse it with an abnormality.

Fig. 7 demonstrates the back of her neck and her hands 14 h after a minor rear end collision. This occurred in August 1978. Observe the relative cold of the posterior left neck and the relative cold of all of the fingers of the left hand. Her complaint was one of pain in the neck radiating into the left upper extremity. Observe the ability of the T. to document radi-

D) DISCUSSION

The T. has been shown to be 80% and 71% predictive respectively, in 2 series comparing it to the myelogram in surgically confirmed herniated lumbar discs.‘.” In those studies the myelogram was, respectively, 80% and 88% predictive. In neither study were the lower ex-

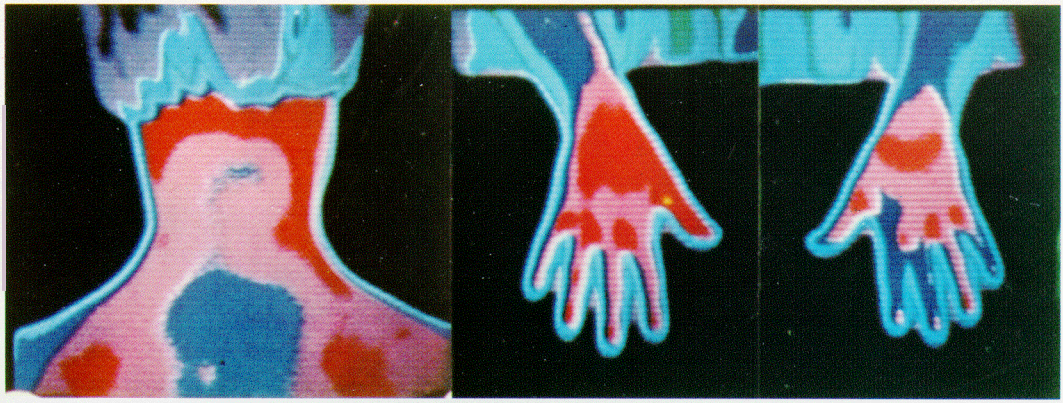


Fig. 7. This is a T. of the same patient done in August, between the 2 previous exams; 14 h prior to this exam, she had experienced a minor automobile accident She was struck from behind and evidently absorbed most of the Impact Her complaint at the time was of was of the posterior left neck radiating into the left arm and hand. Observe the decrease in the vascular heat emission pattern, less dark red, of the posterior left neck as compared to the right, and the relative decrease, less red, in the vascular heat emission pattern of multiple fingers of the left hand as compared to the right..

tremities examined as part of the lumbar T. exam.

An analysis of the buttock area in patients with low back pain revealed «cold patches» that were statistically a highly significant difference from the norm, prompting the Author to state: «T. makes it possible to corroborate patients subjective complaints even in the absence of other objective signs)).”

It appears that the T. can detect abnormalities or irritation of the sensory portion of the nerve root as well as the motor portion, thus accounting for the difference in the number of positive results obtained by the T. as opposed to the EMG. The sensitivity of the machine is such that it can demonstrate «subclinical)) evidence of nerve root irritation as well as that which is clinically symptomatic. Examples of this have been presented previously in the literature.’ The distinction has to be made between normal, intermittently symptomatic, and symptomatic. The phrase *clinically sub-liminal* refers to the intermittently symptomatic person who may not by symptomatic or overtly symptomatic at the time of the T. exam, but yet has a history of pain relating to the area of complaint.

Cases in which there are T. findings and absolutely no history of symptomatology of any kind, even intermittently, are rare. Such cases, however, do occur, and it is possible that there may be a level of nerve root irritation that has not yet approached the pain threshold of that particular patient. Usually, however, some other etiology such as a local old trauma, surgery, etc., will account for the finding.

A disruption and malunion of the healing fibers resulting in mixed messages along the course of the nerve roots to account for the T. findings seen, has been postulated.’ In addition to this, mere pressure, irritation, or scarring of the nerve root without actual disruption of the fibers will accomplish the same result. Most of the changes seen in the extremities, as noted in the literature previously, are «cold». The small vessels accompanying the dermatome distribution of that particular nerve root are put into spasm by the excess stimulation of the irritated nerve.

Analysis of the changing cold areas in Fig. 3 demonstrated that it is probably supported by a spasm of the small skin capillaries accompanying the nerve endings. Observe that varicose vein is not affected by the varying symptoms.

Sometimes, however, «hot» is seen along the course of the symptomatic dermatome. This, in Author’s experience, is rare.

Mixed patterns, and sometimes only portions of the length of the expected dermatome pattern will be abnormal. Partial explanation of these phenomena can be accounted for by the length of time between the particular trauma and time examination, as well as the degree of the trauma. Mixed patterns are usually only seen between the forearm and fingers; the

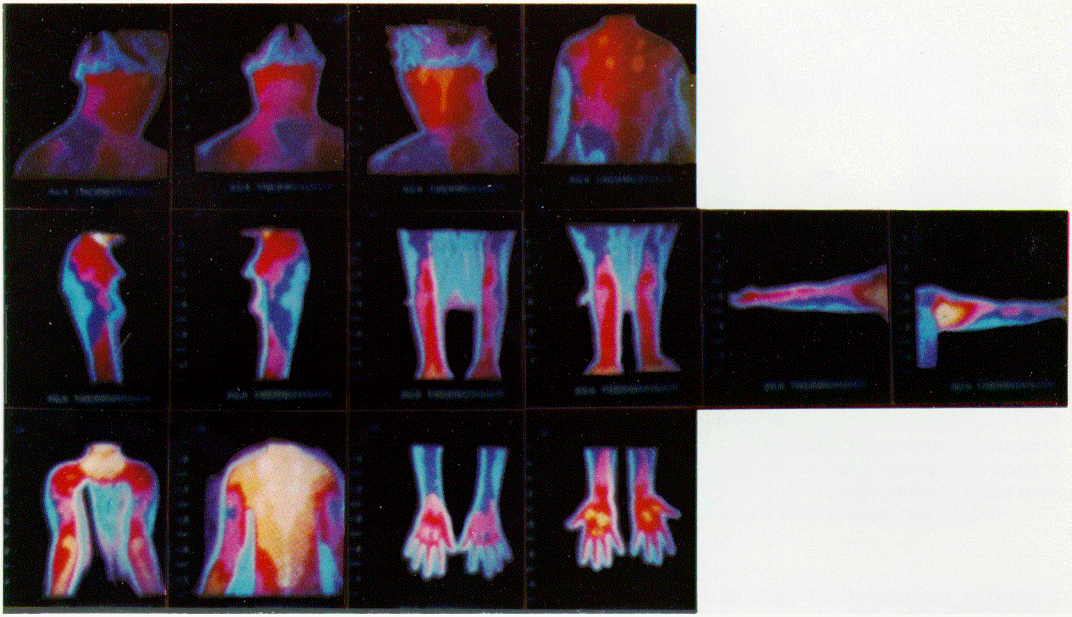


Fig. 8. This is the patient in Fig. 5-h-7 one wk post accident. Observe the relative decrease in the vascular heat emission pattern of the posterior left neck, lass red: extensor suface of the left forearm, less red, in the 3rd picture from the left, middle row; and fingers of the left hand, less red, 3rd picture from the left, in the bottom row. There may be, as anatomic variant, a one degree relative decrease in the vascular heat emission pattern of the non-dominant posterior arm, lateral arm, lateral forearm and rarely. anterior arm. Otherwise, relative symmetry is expected. These dominant-non-dominant variants do not occur in the lower extremities.

forearm cold, and the fingers of the appropriate dermatome hot relative to the opposite side.

Carpal tunnel syndrome usually presents as a relative increase in vascular heat emission of the hand in a median nerve distribution. The important thing is correlating the findings with anatomic pathways, the patient's complaint, and demonstrating its consistency. Proper positioning techniques, alcohol spray tecnique, use of proper film, the thermal focusing, and reproducability techniques are all important parameters.

Several cases of post-operative laminectomy have been observed. They will generally present a relative «cold» along the course of the dermatomes corresponding to the operative level on that side. In the patients with recurrent symptoms, if they are recurrent on the same side as the surgery, dynamic change over the course of multiple studies is necessary for determination of activity. The same would apply to previous fractures of an extremity. The T. when combined with the newer CAT scans of the spine, may preclude the need for the myelogram and its attendent hospitalization. The former would be measuring physiology, the latter, anatomy.

EI CONCLUSION

The T. provides a graphic complementary perspective to the EMG and to myelographic evaluation of nerve root irritation. Its statistical accuracy is comparable with these procedures and it provides a perspective not obtainable by them. Furthermore, it is totally harmless and painless.

The T. can: α) help judicate the presence or absence of *organic root irritation* in unresolved cases; β) help determine the *extent of nerve root involvement* pre-operatively, and post-operatively; y) it provide *a baseline* for future evaluation if symptoms recur; with a baseline exam it can; 6) determine *pre-existing nerve root problems*; ε) monitor the *course of an injury* and determine, when a return to the baseline is reached, ζ) help determine with stress testing, if a *latent abnormality*, known or unknown, will manifest itself with stress.

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Thermography in locomotor diseases

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'Summary. For medical thermography (T.) in locomotor diseases the basic principles of infrared radiation detection and physiological properties of the human temperature regulation, force to standardization. Calculation of quantitative parameters like the Thermographic Index (T.I.) is /"essential for diagnosis and follow-up of rheumatic diseases. Verbal description of thermal pattern ist not sufficient. Further image processing methods have to be developed for T. in rheumatic diseases.

Key words: locomotor diseases, rheumatology, quantitation, standards, thermography.

A) PREFACE

In medicine the term <<thermography >> (T.) means measuring the surface temperature of the human body by detecting the infra-red' energy irradiation from the surface.[7] According to the laws of Physics and to the physical properties of the human skin, infra-red detection should take place at wavelength of 8-14 pm. Accurate and repeatable measurements are only achieved if reliable equipment is used in a well prepared room and on a properly prepared patient.

B) TECHNIQUE

For the camera-system the following requirements are essential: *a) high temperature resolution*; β) *high spatial resolution*; γ) *absolute temperature readings*; δ) *high temperature/thermal stability*; ε) *isotherm and line scan functions*; ζ) *colour coding of isotherms*; η) *computer compatibility* for index calculation and image processing (Fig. 1).

When using quantitative T. in locomotor diseases the physiological and physical properties of the human body surface temperature should be carefully studied. All factors influencing the surface temperature and infrared emission have to be standardized before quantitation can take place. The surface temperature is built up by heat transfer from the body core; the local heat production in the skin is neglegible. But hormonal and nervous factors influence temperature and peripheral blood flow, thus affecting the axial temperature gradient of surface temperatures. This axial gradient is also influenced by the ambient conditions: the cooler the ambient the greater this gradient.

But the ambient temperature also alters the radial temperature gradient, which is depending on the local volume (surface to diameter relation) and of the kind of underlying skin tissues and their thermal properties. Therefore the ambient thermal conditions should be kept in a narrow range off 0.5°C around l8,l9

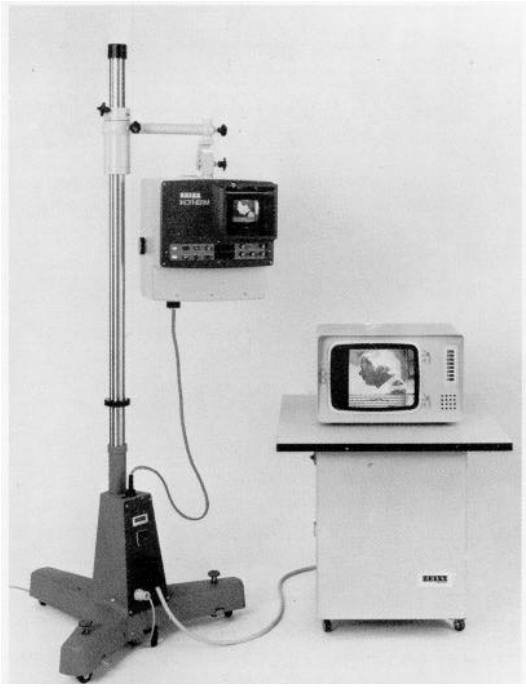

Fig. 1. Modern T. camera system (Ikoterm, Zeiss Oberkochen, West Germany) which has been used for quantitative T. in the Hospital for Rheumatic Diseases, Baden-Baden.

or 20°C; air velocity < 0,2 m/s^{-1}; relative humidity = 45%.

For T. in rheumatic patients, often disabled with canes and wheelchairs, the department must fulfill some further requirement: disrobing cubicles for pre-examination and pre-cooling, wide doors, big working area to handle the patient.

When exposing the patient to the ambient conditions a stabilization time of 15 to 20 mins is needed to reach a thermal equilibrium on the surface and to get stable readings for quantitation. Unti the equilibrium process is not finished quantitative index calculations are not possible. Further studies must show if dynamic measurements at certain time intervals during cooling are reliable. Unless then adaptation to the ambient is essential.

For quantitative T. all other factors influencing surface temperatures have to be standardized by patient preparation: no work or physical exercises, no smoking or coffee/tea minimum 1 h prior to T. Infra-red radiation is changing with angles of surface, and areas of measurement differ with magnification or patient position. Therefore angle of view, scanning distance and joint areas of interest have to be standardized. These scanning data must be coded directly into the T. for later comparison, e.g. by a little metal triangle.[4] As well all thermal data of the image should be directly coded: temperature setting (level and range), interval of isotherms.

The visual interpretation of greytone or colour coded T. is the first step in evaluation. But, as the T. reflects anatomical and physiological conditions, the Rheumatologist needs interpretation and data simple to handle for comparison. The verbal description is insufficient. Therefore the maximum information possible should be extracted from the T. by calculating quantitative figures. With those simple parameters every clinical Rheumatologist will be able to interpret the thermal data of his rheumatic patient in course of disease. T. indices and other parameters allow further calculations and normalization of thermal distribution instead of simple verbal description of thermal patterns. Correlation statistics, factor analysis and other numerical image processing can be performed. This needs at least a minimum of computer capacity to handle the digitised image. Thereafter mathematical algorithms can be applied to extract more meaningful information.

C) ROUTINE CALCULATIONS

The following parameters are calculated routinely for Rheumatology: *a) maximum joint temperature*; β) *thermographic index (T.I.)*;[1] γ) *corrected T.I.*;[3] δ) *isotherms areas*; ε) *line scan parameters* over the joint space.

Since his first publication in 1974 the T.I. has become the standard parameter that should be calculated for every rheumatic joint.[1, 2, 5, 6, 8]

The T.I. as well as the other parameters mentionned can also be applied to dynamic tests as for microcirculation diagnosis in RAYNAUD's syndrome, a complication of rheumatic diseases. The T.I. is calculated over the dorsum of the hands and over the fingers before and at certain time intervals after immersion of the gloved hand into ((cold)) water (<2O”C). Normals show a marked

increase in T.I. finger/hand relation whereas RAYNAUD'S patients have long lasting fall in distal finger temperatures. In arterial occlusive disease this test shows a different pattern: normal fingers behave normally, affected fingers show the RAYNAUD'S pattern, but later a distal to central rewarming.

D) CONCLUSION

-in locomotor diseases the inflammatory rheumatic diseases are the most important ones. The inflammation process affects joint synovium, tendon sheets, connective tissues, bones and blood vessels. The resulting change in surface temperatures, when the process is near to the surface, can be used for diagnosis and therapy control. T. gives information on site area and intensity of the disease (Fig. 2). In follow up T. aids monitoring therapy effects quickly, safely and objectively. As in clinics, rheumatology assesments are often based on subjective estimations or verbal descriptions of pain, swelling or stiffness, it does not seem essential to add T. to another semi-quantitative method. Therefore T. in Rheumatology needs quantitation in order to give to the Clinician, simple and reliable figures for diagnosis and follow up. By quantitation and use of T.I. the rate of misinterpreted T. is lower. Errors by altered temperature settings in the camera system (level/range) during imaging, resulting in different temperatures for same colours, can be avoided.

Today the Author has standard procedures for T. in locomotor diseases and a set of reliable quantitative parameters. But a lot of research has still been left for the future to evaluate further the normal range of these parameters for healthy joints. Then more work has to be done on the physiological process of heat exchange at the body surface level.

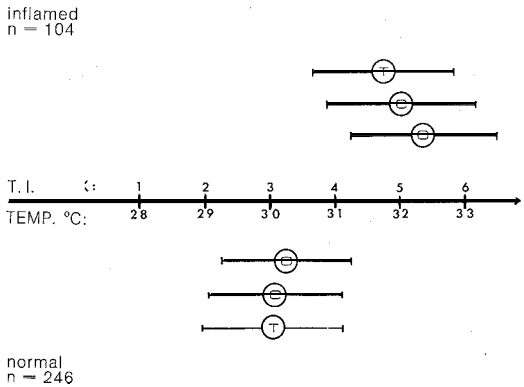

Fig. 2. Results of a consecutive horizontal study on normal and inflamed knee joints. The rangers of following quantitative parameters are dislayed: 0 = original T.I.; C = rectal temperature corrected T.I.; T = maximum temperature over the joint space (absolute values "C).

Modern camera-systems and quantitation have been the first step.

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