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BREAST THERMAL IMAGING - ANGIOGENESIS OF BREAST DISEASE

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In 1956, Ray Lawson showed increased heat on the breast surface and venous blood of breast cancer. Gros and Guthrie of Strasbourg, France, Pistolesi of Italy and Atsumi of Japan correlated neoplasia and thermal breast skin signal. Because of believing that heat was generated by the tumor, it was thought that the thermal signal would be directly related to the size of the tumor and therefore was not an early signal or good screening tool. Not until 1978 when Jean of Mellon-Carnegie University demonstrated an angiogenesis factor in breast cancer and breast tissue were we able to find TO tumors. British Surgeon, Lloyd Williams of Bath, England, showed survival was directly related to the thermal expression better than any size, tumor marker or other method of calculating survival. This was done once in the late 1960's and again in the mid-80's by the same surgeon.

Judith Folkman from Harvard in 1988 demonstrated that angiogenesis was necessary for neoplasia to move from in situ to invasive disease. She also demonstrated that an enzymatic stimulation of the vasculature took place from this angio-ge nesis factor. Presently, 300 or more drugs are being tested in stage three FDA trials to halt angiogenesis.

The 21st century paradigm is that when a normal breast thermal study changes, time for antiangiogenesis and expected thermal turn-off as demonstration of tumor regression will be the protocol. This will occur without identifying the tumor.

The thermal signal precedes clinical (including x-ray, ultrasound, dia- phanoscopy, and MRI) by 6-12 months (1). Now, early detection and acceptable nontoxic therapy is available and will be the protocol in the decades ahead for conquering this dreaded disease of women.

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EQUINE THERMAL IMAGING

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This presentation will yield a generalized overview of how thermal imaging is incorporated into veterinary medicine. Areas to be covered will include; proper imaging technique of the horse, overcoming artifacts, type of equipment used, suitable applications, as well cases representing normal and abnormal thermal patterns.

EFFICACY OF COMPUTERIZED, DYNAMIC INFRARED IMAGING IN ASSESSING BREAST MASSES UNDERGOING BIOPSY

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Introduction: A computer-aided system, which evaluates infrared (IR) emission, for the differential diagnosis between benign and malignant breast masses was assessed in subjects undergoing biopsy. The IR technique employs a computerized, dynamic imaging scan to capture a series of sequential images that provide an assessment of the obtained IR information in a suspicious area identified by mammography. Unlike present imaging systems, the CTI system uses a proprietary imaging table, software managed cold challenge, and algorithmic data analysis.

Methods: Subjects scheduled for breast biopsy were recruited at five hospitals located throughout the U.S. over a five-year period. Prior to biopsy of suspicious masses, digital IR images were acquired of each breast using CTI's proprietary protocol and algorithm. Three independent radiologists experienced in mammography, but who were blinded regarding the pathology outcome, determined the IR results of these biopsied lesions. The suspicious area was localized for assessment on the IR image by the evaluating radiologists using the subjects' mammography films. A pre-determined threshold resulting in a negative or positive assessment occurred prior to unblinding of the pathology results.

Results: Biopsy of 490 masses resulted in 385 benign outcomes and 105 malignant outcomes. Assessment by IR resulted in excellent sensitivity and negative predictive value. It is quite important to note that malignant masses as small as 0.1cm received a positive IR assessment. This is significantly smaller than the claimed recognition abilities of traditional mammography. It was also demonstrated by regression analyses that increased breast density was associated with accurate IR results in malignant masses ($p=0.02$) whereas breast density in patients with benign masses did not produce statistical evidence of a relationship ($p=0.14$).

Conclusion: Computerized IR imaging assessment with the CTI system offers a non-invasive, safe procedure that shows promise as an adjunctive technology to mammography in determining whether a lesion is benign or malignant. This IR technology provides a dynamic, physiological assessment that complements the anatomical information obtained by mammography. It may be particularly useful in dense breast tissue and could provide physicians with an important new diagnostic tool in the war against breast cancer. When used as an adjunct to mammographic assessment, the IR imaging information should reduce the number of biopsies of benign masses.

COMPUTERIZED THERMAL IMAGING SINGLE VERSUS MULTIPLE AUTONOMIC CHALLENGES IN BREAST THERMAL IMAGING.DOES ADDITIONAL GENERAL AUTONOMIC CHALLENGE CHANGE SPECIFIC AUTONOMIC COLD CHALLENGE FINDINGS?

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Introduction Heat produced by organ function does not conduct directly to the surface of the body. Heat is dissipated through the bloodstream to be distributed throughout the circulatory system. This core body heat is cooled by the process of convection through the superficial vascular networks. The regulation of cutaneous blood flow and thus heat loss occurs primarily under the control of the sympathetic division of the autonomic nervous system. It is the radiation of the thermal energy to the external environment that is measured by the infrared camera.

The stimulation of sympathetic dermal receptors via cold water causes vasoconstriction. The cold stress test to the hands was developed in different forms since the 1970's. Other chemical and mechanical tests have been used to induce a response in skin temperature recorded by infrared imaging.

This study examines the question: do multiple autonomic challenges change or intensify post cold challenge findings, thus revealing different, more intense or no change as opposed to single autonomic challenges?

Methodology: The room temperature is standardized to 68 degrees Fahrenheit.

Equipment used is AGA 680, scanning liquid nitrogen cooled long wave system.

Twelve subjects: Age range 21 to 75

Race: Caucasian: 8 Asian: 4

Using hormones: 6

Have a lesion of concern: 9

Exclusion:No history of sunburn, trauma or costochondritis.

Procedure: After a 15-minute cool down with both hands on the head, no clothing from the waist up, no touching of the breast area, no prior consumption of caffeine for the day, thermal images were taken. These include a bilateral frontal, left and right oblique, and left and right unilateral. A cold challenge of having the patient hold a frozen ice pack in each hand for one minute is performed. The same series of pictures is taken. An additional challenge is then performed: asking the patient to "think of something that will bring on an emotion, either positive or negative, whatever will bring on the strongest emotion. Close your eyes and feel it and when you are ready, signal me by raising your hands to your head, and then I will take the picture." Immediately an additional bilateral thermal image was captured. There are three to five minutes between the cold challenge image and the emotional challenge image.

Results and Discussion. Out of the 12 subjects, 10 showed an enhancement of the cold pattern, one degree colder and a slight increase in the area of the increased cold than in the cold challenge images or in the images before any challenge. In one of the 12, who had a diagnosed breast cancer of a large size, the area of the cancer became warmer by one degree and there was a larger area of warmth than in the cold challenge image or in the image before any challenge. In one other of the 12, there was greater warmth than the cold challenge images, but less than that shown in the images before challenge. This subject had difficulty feeling emotion in the emotional challenge, whereas the others did not.

The mechanism causing these results could be that the subject who had the cancer and the increased warmth had dilated blood vessels in the area of increased warmth due to nitric oxide and neoangeogenesis produced by the cancer cells. The blood vessels that could constrict due to the emotional challenge could have shunted their blood to the larger caliber, cancer related blood vessels.

The majority of the subjects showed increased cold after the emotional challenge. This could be because there was no neoangeogenic growth or nitric oxide expanded blood vessels. These may have simply responded to the additional challenge with increased sympathetic caused constriction of blood vessels.

There was one subject that did not follow the patterns above. She was the one who was unable to feel emotion during the emotional challenge. She had less cold/constriction of blood vessels after the attempt at emotional challenge than she had after the cold challenge, but still more cold than there was in the before challenge images. I believe this increased warmth after the attempt at emotional challenge could simply be the diminished sympathetic constriction with time after the cold challenge.

Subjects:: P. M, Age: 23; Asian; Hormones: No; Lesion: Tender lumps felt in both breasts; Result: Increased cold area of right breast in area of tenderness by one degree with a larger area of cold than on cold challenge image. No change in left breast.

J.T.; Age: 30; Caucasian; Hormones: No; Lesion: Tender lumps in left breast; Result: Increased cold at bilateral armpits and nipples.

P.H.; Age: 54; Caucasian; Hormones: No; Lesion: Lump in right breast;Result: Increased area of cold in right breast, especially around area of lump. Increased area of cold by one degree in left breast.

W.W.; Age: 54; Caucasian; Hormones: Triestrogen; Lesion: Tenderness in both breasts around nipples. Bilateral increase in breast size.. Result: Increased area of cold and colder temperature by one degree in both breasts, inferior medial and lateral.

B. B.; Age: 62; Caucasian; Hormones: No; Lesion: Lumpectomy in right breast five months prior, with chemotherapy and radiation therapy to the right breast concluding two months prior to thermogram. Recent mammogram showed calcification in upper lateral left breast.; Result: Decreased heat in the right breast (more area of colder temperature by one degree) and increased area of cold in left areola by one degree and diminished warm pattern in upper left breast (larger area of cold than in the previous images).

K. L.; Age: 39; Asian; Hormones: No; Lesion: None; Result: Slight increase in area of cold in left breast around an apparent fibrocystic area and increase in distribution of end range cold in that area. There is also diminished heat in the upper right chest from the pattern shown by cold challenge, yet more than shown by before cold challenge.

B.A.; Age: 58; Caucasian; Hormones: Natural progesterone; Lesion: None; Results: TH2 rating. Had difficulty eliciting emotion. The cold pattern that was increased in the cold challenge decreased slightly but was still larger than the pre-challenge pattern. There is greater heat in the area of the upper right sternum than after the cold challenge, but less than before challenges.

C.Y.; Age: 50; Caucasian; Hormones: Bi est and natural progesterone; Lesion: Pain and tenderness of left and right breasts

in lateral mid breast area; Result: TH4 rating. Increased area of cold in left breast lateral and medial. Increased cold in right breast, upper medial, and lateral at mid breast area.

S. M-M.; Age: 45; Asian; Hormones: Natural progesterone used one time per month; Lesion: None; Result: TH2 rating. There is greater diminishment of the heat pattern seen in the lateral left breast and sub areola area on the left.

J. M.; Age: 21; Asian; Hormones: No; Lesion: Upper, medial right breast is tender and harder than other breast tissue.; Results: TH3 rating. There is greater area of cold and one degree colder in the right breast and left breast after the emotional challenge.

A. C.; Age: 75; Caucasian; Hormones: Pregnenolone for two years and occasional natural progesterone; Lesion: Left breast above nipple has large confirmed cancer; Results: TH5 rating. There is greater heat (one degree) and a larger area of heat in the left breast in the cancer area.

C.T.; Age: 44; Caucasian; Hormones: Orthocycline birth control pills; Lesion: Below right breast a blue bean shaped lump was removed.
Results: A slight increase in cold in the inferior left breast, right armpit and lateral right breast.

SINGLE VERSUS MULTIPLE AUTONOMIC CHALLENGES IN BREAST THERMAL IMAGING PART II HOW DOES GENERAL AUTONOMIC CHALLENGE BEFORE SPECIFIC AUTONOMIC COLD CHALLENGE AFFECT BREAST THERMOLOGY RESULTS?

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In a previous test group we performed the general autonomic challenge after a cold challenge and found generally enhanced results on thermographic images. In order to test if the result was the same with general autonomic challenge before cold challenge, we performed this study.

Methodology: The room temperature is standardized to 68 degrees Fahrenheit.

Equipment used is AGA 680; scanning liquid nitrogen cooled long wave system.

Eight -subjects: Age range 44 to 58

Race: Caucasian: 7, Asian: 1

Using hormones: 4

Has a lesion of concern: 4

Exclusion: No history of sunburn, trauma or costochondritis.

Procedure: After a 15-minute cool down with both hands on the head, no clothing from the waist up, no touching of the breast area, no prior consumption of caffeine for the day, thermal images were taken. These include a bilateral frontal, left and right oblique, and left and right unilateral. The patient is asked to "think of something that will bring on an emotion, either positive or negative, whatever will bring on the strongest emotion. Close your eyes and feel it and when you are ready, signal me by raising your hands to your head, and then I will take the picture." Immediately an additional bilateral thermal image was captured. After these pictures there are three to five minutes between the emotional challenge image and the cold challenge is immediately performed. The patient holds a cold pack in each hand for 1 minute, and then an additional set of images is taken.

Results and Discussion: Out of the eight subjects, two showed a progression pattern of enhanced heat and cold reactions after emotional challenge and still more after cold challenge. Neither of these two was using hormones.

Three of the eight women showed no change at all after emotional challenge, but an increase in cold and heat after the cold challenge. Two of these were using no hormones; one was using birth control pills. These women had difficulty with feeling emotion strongly also.

Three more out of the eight-showed no change after emotional challenge or cold challenge. All three were using natural hormones. It is not clear how much emotion they were feeling.

Taking hormones or not had no effect on the part one study where the emotional challenge was given after the cold challenge. Therefore it is unlikely that it had an effect here, however, the three non-responders to sympathetic challenge were the ones using natural hormones. It could be speculated that the use of hormones may be a sympathetic challenge of its own, due to the effect of these hormones on the hypothalmus, which also mediates sympathetic response. Possibly the hormones stabilized the sympathetic nervous system and made the breast tissue less shockable.

An important influence on this study is the difficulty some women had in eliciting emotion on command. We noticed that the participants who felt deep emotion had more significant heat changes in both studies. In hindsight, it would have been valuable to have the participants rate the amount of emotion they were feeling on a scale of one to ten, so this could be more accurately compared.

Another speculation regarding these results is that stress in the form of the sympathetic challenge may aggravate a previously stressed area. Just as a patient with chronic neck pain feels more neck pain when under emotional stress, a general sympathetic stress may aggravate a pre-existing pain area, one that is perhaps dominant to the nervous system. In the prior study with emotional challenge following cold challenge, the cold caused sympathetic stress visible on the thermogram and the emotional challenge caused additional aggravation to the prior stressed areas, accentuating those heat patterns.

In this study, perhaps the emotional challenge non-responders were actually responding in another more painful area. Possibly the emotional challenge may have caused reaction in areas of body priority, old injury or damage, which may not have been the breasts. We wondered if other more painful areas might show thermal changes with emotion and then cold challenges even if the breasts did not.

Due to a lack of time, we obtained thermal images of only one additional individual in order to investigate this possibility. This Caucasian woman, age , who did not use hormones, was having a migraine headache at the time of her breast imaging. Images were observed of both head and breast areas before any sympathetic challenge, after emotional challenge, and after additional cold challenge. This woman easily felt deep emotion, due to the recent death of her son.

These images showed definite heat changes after the emotional challenge, more cold in the cystic breast areas, more warmth in a shoulder injury area, and more warmth in both the symptomatic area of the head and the non symptomatic area of the head.

The subsequent cold challenge did show a deepened cold pattern in the cystic breast areas and no change in the head and shoulder areas, even a slight diminishment of heat in those areas.

This study did not answer our questions about the non- emotional responders in the breast studies. The images did not support the theory that a dominant pain area would react more to a general sympathetic challenge than the less painful breast area. Here all areas reacted.

What we can say is that emotions do have effects that can be visualized thermographically. We also believe we have found that thermography can verify when a genuine emotion is elicited. Genuine emotions do seem to make thermal findings more obvious in all parts of the body.

Subjects:: P.F.; Age: 50; Caucasian; Hormones: Birth Control Pills; Lesion: No; Result: No change after emotional challenge, but mild increase in cold with cold pack challenge.

E. V; Age: 56; Caucasian; Hormones: No; Lesion: No; Result: No change after emotional challenge. Increased warm pattern after cold challenge.

J. G.; Age: 58; Caucasian; Hormones: No; Lesion: Lump in right breast; Result: No change after emotional challenge. Mild increased cold after cold challenge

R. L.; Age: 44; Caucasian; Hormones: No; Lesion: No; Result: Progression increase in cold after emotional challenge and additional increase after cold challenge.

C. C.; Age: 49; Caucasian; Hormones: No; Lesion: Pain, tenderness and lumps bilaterally; Result: Progression intensification of heat pattern in upper chest and cold in lower breast tissue after emotional and slight increase in cold with cold challenge.

C. M.; Age: 49; Caucasian; Hormones: Natural progesterone, estriol and testosterone; Lesion: No; Result: No change after emotional and cold challenge.

C. D. Age: 45; Asian; Hormones: Natural progesterone.; Lesion: Lumpectomy 9 months prior right breast, no chemotherapy or radiation; Results: No change after emotional and cold challenge.

B.A.; Age: 53; Caucasian; Hormones: Natural progesterone; Lesion: Tenderness and previous TH3 left breast; Result: No change with emotional challenge, small increase in cold with cold challenge.

PRESENTATION ON MEDARRAY™

Ben Lamfers

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MedArray is a new and powerful thermographic software program that enables medical professionals to take patient views up to 25 views of a patient into an array, which is saved and displayed as a group for analysis and trending. It has been proven with more than a year of clinical trials and actual use for the past 7 months. This has application to many kinds of medical practices. MedArray™ is unique to the software industry.

MedArray description

1.Introduction – Moves the software into the concept of the taking of views. For Breast Cancer – for example 3 views are taken of the patient – right, frontal, and left. This is repeated for a second row of 3 views with a cold challenge taken by placing the patients hands in cold water. A total of 9 images are then taken

2.Views are given a row description, Patient identification and description with time and date. Taking of images is facilitated by a single click of a mouse and captured by another click. MedArray displays patient view as live views at the frame rate of the supported camera, which can be up to 60 frames per second to facilitate positioning of the patient.

3.MedArray™ saves captured images automatically with correct information. It allows the making of reports by capturing individual views to Windows Clipboard, and many file formats such as BMP, JPG, BMP, and TMF. The entire MedArray™ is saved as one file and can be sent to other facilities by e-mail, placing onto CD. Editing, changing, at a later date or by other agencies, is easy with all the temperature, palettes, level set information saved into the file.

4. MedArray™ supports all the tools of ThermoSoft II as an application within ThermoSoft II so that the user can use as much or as little as they wish.

THERMOGRAPHY: THE FUTURE OF THE INDUSTRY

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From liquid crystal thermography to sophisticated infrared cameras, technology has certainly evolved. Considering the roller coaster ride of political economics, what lies ahead for the thermographic industry?

As a newcomer to the industry, I have found that one tremendous task is in melding several decades of history with current conditions to predict a future. Logically, history should go unrepeated… but will it? Intuitively, the thermographic proposition is long overdue… so why isn't it more available? What's getting in the way?

Indeed it's a perplexing situation. Technology has advanced, but the industry has back-stepped. That is, thermography was once more accepted by insurance providers, but now is not. Every technology provider says, "our system is the best". "Well, I guess that depends on your criterion", I reply. And every thermographic service provider has a story to tell about the value of thermography: "Yeah, it's a great technology, but…" Apparent judgments based on history. And from the public I hear, "I wish that my insurance provider covered thermography". "Oh, but the potential for litigation," I think. Then there are the many associations… each with their own reasons for being, moving in different directions and speeds.

So what's the crux? Is there a reason that the industry hasn't moved forward? Well, consider the opposite: "What if?". What if there were no more than a few associations? And what if these associations, or at least their boards, met with some frequency to agree on how best to expend their energies, developing ***synergy***, towards common goals?

- What if a goal was to create national standards and protocols?
- What if those standards and protocols include training and certification requirements?
- What if those standards and protocols are enforceable by medical/government agencies?
- What if those standards and protocols are accepted by insurance providers?

If it were so:

- it seems plausible that the past would not be repeated,
- that thermography could approach a "standard of care" criterion,
- that untrained and uncertified service providers would be eliminated,
- that fraud and litigation would be reduced,
- that a fair and objective playing field for technology providers would exist,
- and that the abundance of patients would have access and availability. What if it were simple?

HISTORICAL PERSPECTIVES OF THERMAL PHYSIOLOGY AND THERMOGRAPHY

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The purpose of this presentation is to provide a historical perspective that clarifies the importance of thermal measures in the study of physiological functions. This perspective affirms the thermography practitioners role in providing a valuable source of information for diagnosis, screening, and evaluation of medical pathologies that are expressed in neural and vascular cutaneous changes in temperature. The infrared technology has also been an effective investigative tool for re searchers who seek a better understanding of thermoregulation. Alterations in skin temperature and blood flow are tightly regulated in order to manipulate and control the heat transfers between the body's core temperature and external environment. In both medical and physiological applications, the development of thermographic imaging provides a non-invasive, no contact technique by which skin temperature can be quantified. The latest generation of infrared thermography machines are capable of capturing the dynamic changes in cutaneous temperature for measuring acute dynamic responses to stimuli or stressors.

STANDARDS FOR THERMOGRAPHY DATA COLLECTION AND INTERPRETATION FOR HUMANS

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Infrared thermography provides an image of the thermal patterns of the skin surface. Changes in skin temperature are the result of dynamic physiological responses that include both the neural and vascular systems. Due to the dynamic responsiveness of skin to internal and external stimuli or stress, thermal temperatures and patterns can and will be altered. The validity of an image is dependent upon the conditions under which this thermal image was obtained. Therefore, the conditions under which images are recorded need to be controlled and standardized when possible. Factors that influence the thermal response of the skin and are extraneous to the pathology or thermoregulatory response should be accounted for or eliminated. In all cases, accurate documentation needs to be taken regarding the subject/patient, testing conditions, and image (thermal scale- sensitivity, mid range) for proper interpretation of the thermogram. When challenge testing is used, the procedures and time sequence need to be clearly stated in all publications.

INTERACTIVE CASE STUDY: INFRARED THERMOGRAPHY AS A CLINICAL DIAGNOSTIC AID

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The non-invasive, diagnostic technique of infrared (IR) thermography was used to evaluate a 62 year old male who presented for photonic stimulation treatment of chronic left shoulder, knee and heel pain. The individual demonstrated asymmetrical surface temperatures of as much as 2.0° C. Serial IR imaging demonstrated decreased surface temperatures along the left thigh and right foot. Thigh temperature asymmetries ranged from 0.5° C. posteriorly and laterally to approximately 1° C. at the knee. Mean dorsal foot temperature asymmetry was 1.7° C. Within twenty minutes after cold water immersion testing, dorsal left foot temperatures were within 0.1° C. of pre-immersion temperatures. The right foot remained 0.5° C. colder at thirty minutes' post-testing. Lower body strength was bilaterally normal. Vascular supply and deep tendon reflexes were normal on both sides. However, vibratory and pinprick testing demonstrated sensory impairment in the left foot. The individual's fasting blood glucose level was within normal limits. Preliminary physical diagnoses have included calcific bursitis, tarsal tunnel syndrome and plantar fasciitis of the left shoulder and foot respectively. Thermographic screening and cold water challenge testing demonstrated a slow recovery response in the asymptomatic right foot. The individual awaits further evaluation.

INFRARED THERMOGRAPHY IN SPORTS MEDICINE

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The purpose of this presentation is to demonstrate the efficacy of infrared thermography in sports medicine. Infrared thermography provides the sports medicine physician and staff with a technique for the screening, diagnosis, and evaluation of sports related injuries. Athletic populations may experience multiple traumatic injuries or repetitive injuries to the same area. Additionally the thermogram can show the altered thermal patterns and temperatures of these athletes. This is helpful in examining acute and chronic problems as well as changes in the thermal image as a result of previous injuries.

As a screening tool, infrared thermography can aid the medical staff in determining if a region of interest needs further examination prior to participation. As a diagnostic tool thermography can be used to improve injury diagnosis. Further infrared monitoring will help sports medicine personnel to monitor the progression of rehabilitation post surgery and the efficacy of therapeutic modality treatment.

THE USE OF THERMOGRAPHY TO PREDICT SPREAD OF RSD/CRPS

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In a study of twenty patients with RSD/CRPS whose symptoms were Limited to one limb, a complete thermographic study was done from head to plantar feet. In addition, dedicated TOS views were taken irrespective of whether or not the patient had upper body symptoms.

In eighteen of the twenty patients identified and studied, the thermographic study was positive in another part of the body, one in which the patient had no symptoms. In fifteen of these eighteen patients, the disease progressed with the patient developing symptoms in the "predicted" limb in a time frame from several weeks to five months after the thermographic study. This allowed us to recognize symptoms that were clearly related to the disease at their first presentation, thereby initiating treatment in a rapid fashion. By doing so, we were able to get better symptom relief because of the rapidity of administered sympathetic blockade. The long-term benefits of such early recognition and reatment cannot be minimized in the approach to this disorder. Further study is ongoing to verify this limited patient population but the early results are most encouraging.

RSD/CRPS I; VASCULAR ABNORMALITIES, PAIN AND HYPERALGESIA

Srini Govindan,

Wheeling WV.

Patients with painful syndromes of neurological origin may express abnormal cutaneous temperature in the symptomatic part of the body (1)

Deviations of cutaneous thermal emission are conveniently documented by thermography, a technique that sensitively detects and precisely displays temperature patterns of chosen regions of the body surface (2). In the skin where most of the blood is used for thermoregulation and only a small fraction goes through the nutritional capillaries. Blood may enter the subpapillary vascular network through AV Shunts and bypass the nutritional skin capillaries (3). A specific structure of the skin vascular bed is the arterio-venous anatomoses (or) A-V Shunts, through these A-V Shunts the skin blood flow may vary enormously from time to time, mainly depending on the skin temperature (4). Wasner G documented complete functional loss of cutaneous sympathetic vasoconstrictor nerve activity in the early stages of RSD/CRPS I with recovery (5). The origin of this autonomic dysfunction is in the central nervous system. He used 1) Laser Doppler flowmetry for measuring cutaneous blood flow, 2) Infrared thermography for skin temperature and 3) Sympahtetic vasoconstrictor function (phasic induced by deep inspiration and tonic induced by controlled thermoregulation). Baron R studied Capsaicin evoked pain, hyperalgesia and vasodilatation and concluded cutaneous sympathetic vasoconstrction activity does not influence spontaneous pain and mechanical hyperalgesia after Capsaicin induced C- nociceptor sensitization (6)

Laser Doppler and thermography can measure and image skinblood flow. These finding can be correlated clinically with changes in pain and mechanical hyperalgesia in RSD/CRPS I patients.

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COLD STRESS TEST FOR THE DIAGNOSIS OF COLD HYPERSENSITIVITY ON HANDS

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Purpose: The cold hypersensitivity is a subjective symptom and it is very difficult to evaluate the severity. It is possible to detect cold hypersensitivity by measuring the skin temperature on DITI, but there is limitation only using DITI to find the objective grade of the symptom. To set a new objective standard for the diagnosis of cold hypersensitivity, we examined the relationship between the Visual Analogue Scale (VAS) score for the cold hypersensitivity and the change of skin temperature on hands by cold stress test

Method: 23 patients with symptom of cold hypersensitivity were participated as subjects who visited the women medical center of Kangnam Kyung Hee Korean Hospital, Kyung Hee Univ. from May 1, 2002 to August 31, 2002. There were all carefully examined to rule out other disease such as obesity, skin diseases, spinal nerve lesions and external wounds. Thermographic observations for this study were made using DITI. We performed cold stress test three times to compare with the results from thermographic observations by DITI; first, after 15 minutes-resting, second, right after 1 minutes soak in 20? water, the third for last, 10 minutes after the soak. VAS score was chosen to determine the severity of cold hypersensitivity.

Re sult: 1 male and 22 female patients were participated ranging in age from 22.17 to 45.21. There was a significant negative correlation between the recovery rate of finger skin temperature after cold stress test and the VAS score. And there was a significant positive correlation between the difference of finger skin temperature and the back and palm of hands after cold stress test and the VAS score. Conclusion

In cold hypersensitivity patients, the cold stress test combined with DITI could be an accurate method for the objective evaluation of cold hypersensitivity, especially good at deciding the severity by numeric values. Using a more strict criterion, as diagnosing of cold hypersensitivity, and longer follow-up may improve the validity of the results attained in clinical trials.

STANDARDS FOR THERMOGRAPHY DATA COLLECTION AND INTERPRETATION FOR ANIMAL SPECIES

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In most mammalian species the body temperature is normally well controlled by its own metabolic state. The skin temperature is normally lower than that of internal tissues and depends not only on the metabolic state of the animal, but also various factors such as thermal conduction from heat sources within the body's vascular activity, and just beneath the surface heat losses due to evaporation, convection by air currents, or exchange of infrared radiation energy to the surroundings. Heat lost from the body by the exchanges of IR radiation with the surrounding is the basis of thermography. For this to occur, there must be a temperature gradient. Thus, to obtain a reliable and meaningful thermogram having diagnostic value, one should follow well established standards.

First, the environmental factors which interfere with the quality of thermo- graphy should be minimized. The room temperature should be maintained between 21 and 26 degrees C, and room temperature should always be cooler than body temperature and free from air drafts. Thermograms obtained outdoors under conditions of direct air drafts, sunlight, and extreme variations in temperature provide unreliable thermograms in which thermal patterns are altered. Such observations are meaningless. When a person or an animal is brought into a temperature controlled room, it should be equilibrated at least 20 minutes or more, depending on the external temperature from which a subject was brought in.

Other factors affecting the quality of thermograms in various animal species are hair coat, exercise, sweating, body position and angle, body covering, systemic or topical medications, regional and local blocks, sedatives, tranquilizers, and anesthetics, vasoactive drugs, skin lesions such as scars, surgically

altered areas, etc. The value of thermography is its extreme sensitivity to changes in heat and its ability to detect changes. Therefore, it is important to have well documented, normal thermal patterns and gradients in a species prior to making any claims or detecting pathological condition.

THERMOGRAPHY AS A GUIDE IN PAIN MANAGEMENT Part I of II

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The value of Thermography is limited to evaluation of neurovascular dysfunction. It provides indispensable information regarding neuropathic pain due to perivascular micro-circulatory sympathetic dysfunction. Thermography records superficial, and deep temperature changes. The bilateral cervical cord temperature modulation demands careful clinical correlation. Thermography is an objective guide helping the clinician to choose a proper and harmless treatment protocol, especially avoiding unnecessary surgery.

*Introduction***:** This is a study of the role of Thermography as a guide in pain management. The results were compared with the information in medical literature. The anatomical tests such as magnetic resonance imaging (MRI), computed tomography (CT), and physiological tests such as electromyography (EMG) and nerve conduction velocity (NCV) tests have been the main diagnostic tools applied in the management of somesthetic (somatic) pain. The above tests usually are not informative in the diagnosis of neuropathic pain. The neurovascular involvement in neuropathic pain requires tests such as Thermography and Quantitative sudomotor axon reflex test (QSART) that address autonomic (e.g., thermal) changes for a more accurate diagnosis and treatment

*Methods***:** Bales Scientific Thermal Processor and Agema Cameras were used for this study of 3,265 successive patients. A review of our experience with Thermography and its role in pain management was conducted, and compared with the recent medical literature. The study was limited to the role of Thermography in the management of complex chronic pain

Discussion: Sloppy technique, and poor background in basic neurophysiologic training, have contributed to poor utilization and interpretation of thermographic images. For thermography to be accurate and clinically useful, proper technique, standardization, and proper clinical correlation are the minimal requirements. The basic physiology of autonomic thermoreg ulation is outlined in detail to help the clinician to properly understand and interpret the test. The dysfunction of thermal sensory nerves in the wall of arterioles cannot be detected by EMG or NCV and excluding the Thermography test may mislead the clinician to diagnose the condition as “psychogenic” or “functional.” Our results were compatible with the review of current medical literature.

*Results***:**Thermography provides useful clinical information when applied with proper technique. It provides diagnostic and therapeutic information limited to diseases involving autonomic, neurovascular, and neuroinflammatory changes. Conversely, it cannot be expected to help diagnose nerve injuries with no microvascular involvement such as somesthetic nerve injuries. Proper teaching and understanding of thermoregulation helps the clinician to obtain indispensable information from this test.

THERMOGRAPHY AS A GUIDE IN PAIN MANAGEMENT. Part II

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Thermography is a neurophysiological tool providing diagnostic and therapeutic information in patients suffering from neuropathic pain with neurovascular involvement. This information cannot be obtained from anatomical tests (e.g.,MRI or CT).

Methods: Bales Scientific Thermal Processor (Bales Scientific, Walnut Creek, CA)(762 patients) and Agema Cameras (Flir)(2,503 patients) were used for this study of 3,265 successive patients. A review of our experience with Thermography and its role in pain management was conducted, and compared with the recent medical literature. The study was limited to the role of Thermography in the management of complex chronic pain.

Discussion: Thermography is helpful in proper localization of hyperthermic foci due to iatrogenic permanent damage to thermosensory nerves, such as seen after repetitive sympathetic ganglion blocks; or due to sympathectomy or prolotherapy. As the result, the physician stays out of harms way by not causing further permanent damage. In addition, Thermography identifies the spread of Complex regional pain syndrome (CRPS), pointing to the need for treatment of such spread. It helps differentiate migraine from neuropathic occipital neuralgia - two diseases requiring to contrasting treatments.

Results: Thermography has not been proven useful in evaluation of cervical and lumbar radiculopathies, stroke, and transient ischemic attacks. Thermography can differentiate cervicogenic headaches from migraine - each requiring opposite forms of treatment. Thermography is a useful prognosticator for diabetic foot pain, sparing some patients from amputation. Thermography can spare patients from unnecessary carpal tunnel, spinal disc, and TMJ surgeries by identifying the original source of neuropathic pain. If Thermo- graphy shows diffuse hyperthermia in the extremity already treated with repeated sympathetic ganglion blocks (virtual sympathectomy), such patients should be spared from undergoing further ganglion blocks. The hypothermic extremity after sympathectomy proves the futility of this and other ablative treatments such as chemical sympathectomy, or neurolytic blocks.

MEDICAL INFRARED IMAGING– LOOKING BEYOND THE PRIMARY SYMPTOM

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Many patient present to my clinic for IR examination with the primary symptom of Pain. This pain is usually of a Chronic nature. The area (s) of Pain are defined by the patient, with negative findings from X Ray, CT Scan and/or MRI evaluations.

It has been my experience that scanning a ‘region of interest’, as reported by the patient, may result in an incomplete assessment of the pathology causing or contributing to the patients’ condition.

As a result I have adopted the approach of scanning the whole body when a patient presents with long term undiagnosed pain.

All patients are provided with a Full Body study, a minimum of 27 scans. This protocol has enabled me to establish a considerable database of studies showing thermal abnormalities in regions of the body not reported by the patient. In many cases the body appears to prioritise pain awareness by the patient - i.e. more distinct thermal asymmetries/ patterns will be evident in regions of the body not reported as painful. A number of case studies will be presented to illustrate the benefits of such a protocol. A full body study provides additional useful information about the patient, such as:

1.uneven weight bearing

2.compensatory over use of alternate limb

3.areas of pathology not reported by the patient

4.in some cases, tumors not sufficiently advanced enough for detection by other modalities. The patient is thus given the best opportunity to address all factors contributing to their disease state, leading to a more complete health outcome than by addressing the Primary Symptom alone.

NERVE BLOCKS FOR NEUROPATHIC PAIN

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*Introduction:*Sympathetic ganglion blocks are the standard nerve blocks for neuropathic pain. However, these blocks are not consistently successful [1-5]. According to Bonica, in the hands of experts, these blocks are technically successful in no more than 75% of patients [1]. Such blocks usually last for a short period of time (from hours to days). As such, these blocks are more diagnostic than therapeutic.

Methods: Comparative study of the diagnostic and analgesic values of nerve blocks was done. Four groups of 100 patients were studied for the efficacy of sympathetic, epidural, regional (BIER), and plexus blocks. The regional temperature was measured with Bales Scientific Infrared Imaging Thermography.

Results: Sympathetic nerve blocks: These nerve blocks were effective in the first few months post- injury lasting an average of 11 days. The technical success of sympathetic blocks was rated at 72%. The success rate of warming up of the extremity (Fig) and pain relief was reduced by an average of 11???days in 41% of patients. This is in contrast to the other types of blocks lasting more than nine weeks (Table). Epidural blocks containing Depo-Medrol® were successful in 89% of patients. The regional BIER blocks showed an average success rate of 32%. The brachial plexus blocks showed 63% success in regards to analgesia and hyperthermia.

Conclusion: The sympathetic nerve blocks are more diagnostic than therapeutic in nature. Epidural, regional, and plexus blocks containing corticosteroids provide more effective and longer lasting pain relief.

Table Comparison of Nerve Blocks

Type of Nerve Block	Duration of Pain Relief
Sympathetic Ganglion Block	2-11 days
Epidural Steroid Block	5-9 weeks
Regional Bier Block	1-2 weeks
Brachial Plexus Block	2-8 weeks

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THERMOLOGY AS A TOOL IN THE DIFFERENTIAL DIAGNOSIS OF MALIGNANT AND FIBRO-CYSTIC BREAST DISEASE

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There are more than three hundred and fifty thousand (350,000) breast biopsies done during a typical year in the United States. Though the core biopsy technique is less invasive and stereo-tactic methods have improved the ability to sample tissue in question than open excision; biopsy is a major expense to the health care system and traumatic to both breast tissue and women. Approximately eighty percent (80%) of all breast biopsies prove to be benign fibro-cystic disease and thus unnecessary. The high frequency of breast biopsies is the result of a high prevalence of both benign fibro-cystic and malignant disease and dependence on anatomically-based methods of evaluating breast disease.

Our laboratory evaluated the thermal features of a group of fifty (50) randomly selected women that presented newly-discovered breast masses from clinical examination or mammography. Each of these patients had subsequent biopsies with definitive histologic results. We discerned significant differences in what would prove to be benign fibro-cysts from malignant disease in the proximity of these masses based on the thermal features and response of these features to a standardized autonomic challenge. We also characterized a typical evolution in the thermal features of benign fibro-cysts as we monitored these women over time.

UPDATE ON THERMOGRAPHY IN SPORTSMEDICINE

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Thermography has been used in sportsmedicine for many years, especially in Europe and Asia. It is slowly being accepted in the USA as a premier imaging process for athletic injuries, their diagnosis and progress of treatment. This update is a review of what has been reported over the past 10 years and provides suggestions for future utilization. Prevention of sports injury and rapid, safe, return to play are our primary goals, ones which may be advanced through the use of Thermography and should be fostered by members of our Organization.

NEUROGENIC INFLAMMATION IN CHRONIC REGIONAL PAIN SYNDROME.

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In 1920 Lewis hypothesized that several inflammatory symptoms commonly observed in RSD (Reflex Sympathetic Dystrophy) patients result from release of pain producing vaso-

dialator substances at the endings of sensory nerve fibres as a result of excitation of these nerve fibres some where at axonal leve (l). Studies have demonstrated that not only mechanical but also chemical (2) and electrical (3) excitation of sensory nerve fibres somewhere at axonal level may provoke neurogenic inflammation. Sensitization of unmyelinated nociceptive afferents has been hypothesized to play a pivotal role in the induction of CRPS. In addition to their sensory function, nociceptive C-fibers have an efferent neurosecretory role. Upon stimulation they release neuropeptides within their innervation territory, which causes vasodilatation (mainly CGRP) and protein extravasation (mainly Substance P) in redents (neurogenic inflammation), the latter could be prevented by selective neurokinin 1 (NK-1) receptor antagonism (4). Weber's data suggest that either neuropeptides are released from the nociceptive nerve ending in large amounts, their inactivation is im- paired or that there is an enhanced expression or sensitivity of receptors (4).Noxious stimulation of the skin of man leads not only to a flare response (redness of the skin), but also to edema and reduced pain threshold both locally and more widespread. Neuropeptides are considered to be the cardinal mediators of neurogenic inflammation resulting in vasodialator effect on the microvasculature, increased excitability of primary sensory nerve fibres, increased vascular permeability and release of inflammatory mediators like histamine (5).

The sequence of events induced by excitation of sensory nerve fibres is referred to as neurogenic inflammation and includes the triple response:

1)The red reaction due to local dilatation of skin microvessels.

2)The flare, a widespread dilatation of neighbouring arterioles brought about by a local axon reflex and accompanied by hyperalgesia.

3)The wheal ie, local increased permeability of skin microvessels.

In neuropathic patients the alleged release of neuropeptides may be involved not only in vasomotor disturbances but also in altered nociception and edema formation.

CGRP acting via CGRP 1 receptors is the principal transmitter of neurogenic dilatation of arterioles . Whereas SP and neurokinin A (NK A) acting via NK1 receptors mediate the increase in vascular permeability (6). Edema and the increase of skin blood flow found in early stages of CRPS resemble the two major features of neurogenic inflammation (7).

CRPS (Chronic Regional Pain Syndrome) is characterized by a variety of clinical features including spontaneous pain and hyperalgesia. Increased neuropeptide release from peripheral nociceptors has been suggested as a possible pathphysiologic mechanism triggering the combination of trophic changes, edema, vasodilatation and pain. Awarness of neurogenic inflammation can help in the diagnosis, treatment and follow up of the patients with CRPS/neuropathic pain syndromes.

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PRACTICAL CONSIDERATIONS IN EVALUATING THERMAL IMAGES FOR PERIPHERAL SYMPATHETIC NERVE DYSFUNCTION

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In publications about infrared thermography (IRT) as practiced in relation to human medicine, we find many references to the syndrome Reflex Sympathetic Dystrophy or "RSD". Although an identical syndrome has not been clinically recognized in veterinary medicine, we do see thermal patterns that appear to have many similarities to those seen in RSD. This thermal patterning is most commonly associated with Peripheral Sympathetic Nerve Dysfunction or "PSND". Horses are the animal species that are most commonly presented for thermal evaluation, and that may explain why practitioners are most likely to see these thermal patterns in that species. For a thermographer working under field conditions, there are several important considerations in evaluating the thermal images of a horse suspected of have PSND.

The first consideration relates to the physical location and environmental factors associated with that location and subsequently, the images taken there. A second consideration is the patient's physical presentation and history. In addition to environmental and physical factors, one needs to perform a test of the horse's alpha receptor response as previously described by Drs. Purohit and Pascoe.

When all of these factors are considered together, a reasonable assessment of the abnormal thermal patterns, exhibited by an individual horse, can be made. The outcome may be a true PSND or conversely, be found to be primarily associated with other physical and/or environmental factors.