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Infrared Thermal Imaging As A Tool In Pain Management - An 11 Year study, Part I of II

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Summary

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 Infrared thermal imaging (ITI) and Quantitative sudomotor axon reflex test (QSART) that address autonomic (e.g., thermal) changes for a more accurate diagnosis and treatment. This is a study of the role of ITI in the diagnosis and management of pain.

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

Sloppy technique, and poor background in basic neurophysiologic training, have contributed to poor utilization and interpretation of ITI. For the ITI to be accurate and clinically useful, proper technique, standardization, and proper clinical correlation are the minimal requirements. The basic physiology of autonomic thermoregulation is outlined in detail to help the clinician to properly understand and interpret the test. The dysfunction of thermal sensory nerves cannot be detected by EMG or NCV and excluding the ITI test may mislead the clinician to diagnose the condition as “psychogenic” or “functional.

ITI 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

Key Words - CRPS, Headache, Sympathectomy ,Thermography

Infrarotthermographie als Hilfsmittel im Schmerzmanagement - eine 11 Jahres-Studie. 1.Teil

Anatomie orientierte Untersuchungen wie die Magnetresonanzdarstellung (MRI) oder die Computertomographie (CT) und physiologische Tests wie die Elektromyographie (EMG) und die Bestimmung der Nervenleitgeschwindigkeit (NLG) gelten als die wichtigsten diagnostischen Methoden, um den somatischen Schmerz zu beurteilen. Diese Untersuchungen versagen jedoch bei der Beurteilung des neuropathischen Schmerzes. Bedingt durch die neurovaskulären Veränderungen des neuropathischen Schmerzes bedarf der Methoden desr Infrarothermographie und der quantitativen Beurteilung des sudomotorischen Axonreflexes, um die Veränderungen des autonomen Nervensystems zu Zweck einer korrekten Diagnose und Behandlung zu beurteilen. Die vorliegende Untersuchung beschreibt die Rolle der Infrarotthermographie in der Diagnose und dem Management von Schmerzsyndromen.

Infrarotkameras von Bales (Scientific Thermal Processor) und Agema wurden in dieser Studie an 3265 Patienten eingesetzt. Ein Überblick unserer Erfahrungen mit der Infrarrotthermographie und ihrer Rolle im Management von Schmerzsyndromen wird gegeben und mit der aktuellen medizinischen Literatur in Beziehung gesetzt. Dabei war der Einsatz der Infrarotthermographie auf das Management komplexer chronischer Schmerzsyndrome beschränkt.

Mangelnde Technik und unzureichende Kenntnisse der elementaren Grundlagen der Neurophysiologie habe n

zu einer insuffizienten Anwendung und Auswertung von Infrarotthermogrammen beigetragen. Korrekte und standardisierte Durchführung und Korrelation mit den klinischen Befunden sind die minimalen Voraussetzungen, um die Infrarotthermographie verlässlich und mit klinischem Nutzen einzusetzen.Die grundlegende Physiologie der autonom-nervösen Thermoregulation wird im Detail beschrieben, um zu gewährleisten, dass der Kliniker die Thermographie richtig anzuwenden und zu interpretieren weiß. Die Fehlfunktion der thermosensiblen Nerven kann durch EMG und NLG nicht erfasst werden. Wenn die Thermographie in diesen Fällen nicht eingesetzt wird, kann der Kliniker fälschlicherweise zur Diagnose eines "psychogenen" oder "funktionellen" Syndroms gelangen.

Die korrekt durchgeführte Infrarot-Thermographie liefert nützliche klinische Informationen. Allerdings sind die diagnostischen und therapeutischen Aussagen auf Krankenheitsbilder mit autonomen, neuro-vaskulären oder entzündlichen Veränderungen beschränkt. Im umgekehrten Fall, kann nicht erwartet werden, dass die Thermographie bei Nervenverletzungen ohne begleitende Gefäßreaktion zur Diagnose beträgt. Kenntnisse der Thermoregulation erlaubt es dem Kliniker, die unverzichtbare Information aus dieser Untersuchung zu gewinnen.
Schlüsselwörter: CRPS, Kopfschmerz, Sympathektomie ,Thermographie

Introduction

This is a review of our 11-year experience with the application of Infrared thermal imaging (ITI) in 3,265 patients suffering from chronic pain. This study focuses on the application of ITI as a diagnostic and therapeutic guide.

Terminology

The nociceptive pain sensation is divided into two distinct categories: Neuropathic (Table 1) and somesthetic (somatic) pain. The neuropathic pain is associated with thermal (vasomotor) changes. These changes are in response to the afferent noxious impulses of unmyelinated sensory nerves (1). This is in contrast to the common somatic (somesthetic) pain which is usually not accompanied by circulatory dysfunction.

The somesthetic pain is characterized by involvement of afferent somatic (spinothalamic) nerves usually with no circulatory disturbance. The somatic pain has a dermatomal pattern (Fig. 1) in the distribution of nerve roots and nerve trunks. In contrast, the thermatomal distribution (Fig. 1) of neuropathic pain (2,3) follows an arterial distribution such as femoral, carotid or brachial arteries. In pathologic states, hypo- and hyperthermic changes are recorded by ITI which can be quite helpful in the selection of a proper treatment protocol.

The neuropathic pain, by virtue of involving the neurovascular structure, is accompanied by circulatory (Thermal) changes leading to a different type of pain such as causalgia (4), deafferentation and sensitization (5), as well as abnormally evoked pain: e.g., hyperpathic (protopathic) regional pain (6),and allodynic pain evoked by even minimal tactile stimulation (7). These are characteristic pains accompanied by

Table 1,
Diseases; in which neuropathic pain may occur.

Mononeuropathy	Amputation stump pain Causalgia Diabetes mellitus Neuroma Plexus avulsion Postherpetic neuralgia Traumatic Vasculitis
Mononeuropathy multiplex	Diabetes
Polyneuropathy	Alcohol, Nutritional neuropathy Chemotherapy Diabetes Ehrler Danlos Syndrome Fabré disease HIV Hypothyroidism Vitamin deficiencies
Cancer	
Neurosyphilis (Tabes)	
Trigeminal neuralgia	

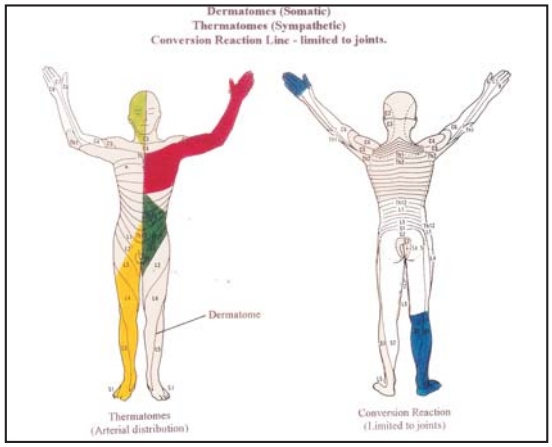


Figure 1
In neuropathic pain the sensory loss shows thermatomal (vascular) distribution in contrast to the dermatomal (radicular) distribution of the somatic pain. Conversely, the malingering sensory loss is limited to the joints.
With permission from Springer-Verlag Publishers (1).

neurovascular dysfunction (8) of any etiology (e.g., post herpetic neuralgia, diabetic mononeuropathy, etc.

The ITI exclusively measures temperature changes of the body. Hence, its diagnostic value is limited to the study of nerve dysfunction with microvascular involvement (neuropathic pain). The thermal regulation is achieved by coordination of multiple anatomic areas of central and peripheral nervous system (PNS). The PNS contribution is modulated by afferent impulses from microscopic small c-fiber thermoreceptors) (9,10,11). Such minute unmyelinated nerves cannot be tested with anatomical tests such as CT and MRI, nor with somatic type of physiological tests such as electromyography (EMG), and nerve conduction velocity (NCV). The NCV cannot study the microcirculatory neuropathic function. It studies the function of the large trunk myelinated nerve fibers which are part of the somatic (e.g., spinothalamic) nervous system (12). In contrast, ITI evaluates sympathetic thermoregulatory function more comprehensively than sweat test. The sweat test e.g., QSART measures the function of a minority (less than 10%) of cholinergic nerves in the sympathetic system.

History

In ancient medicine, physicians were taught to measure temperature by hands. This insensitive and inaccurate method is still applied by physicians with poor knowledge of physiology. Approximately Four decades B.C., wet mud salves were used to detect surface body temperature. Hippocrates advocated the method. By the end of the 16th century, Galileo devised a "thermoscope" as a tool in patient care. John Herschel was the first to perform Thermography by using a prism and a piece of paper soaked with alcohol and impregnated with lamp-black. By the early 1950's, thermal re-c oding was applied by US forces in the Korean war. Dr. Ray Lawson, and later Professor E. F.J. Ring, and others (13-16) reported clinical application of thermography. By 1982, thermal imaging was accepted as a new laboratory test in Japan. At least in 2 states (California and Florida) the worker's compensation courts have accepted the utilization of ITI for the diagnosis of CRPS.

The American Academy of Neurology (AAN) (17) in 1990 reviewed the utilization of Thermal imaging in neurologic practice. It emphasized the importance of proper technique. It found the test not useful for the diagnosis of radiculopathies, entrapment neuropathies, headaches, stroke, and transient cerebral ischemia (17). As discussed in the present paper, the ITI is not useful for diagnosis of transient ischemic attacks, entrapment neuropathy (18), and disc herniation (19), but can contribute information to diagnosis and treatment of neuropathic pain due to neurovascular dysfunction.

The ITI Puzzle

The ITI has been abused, and over -and underused in the past three decades. Improper technology on one hand, and poor understanding of the basic anatomy and physiology of the autonomic nervous system (ANS) has contributed to exclusion of this test, depriving the patient of proper diagnosis and treatment.

The erroneous expectation of a single test to identify the cause of a complex clinical syndrome can lead the physician to deem the test useless. Such a complex syndrome is properly diagnosed by careful history taking and clinical correlation rather than by applying a single test. As an example, MRI of the spine may show an innocuous disc bulging or protrusion unrelated to the patient's pain. Whereas only 28-30% of the patients suffering from chronic back pain are due to disc pathology, over 80% of such patients are diagnosed as disc disease, leading to unnecessary surgery (20,21).

Technical Aspects

The dynamic state of flux of the sympathetic system plays an important role in balancing and compensating the external versus internal fluctuations of body temperature. Accurate recording of this sophisticated temperature regulation requires impeccable technique, reproducible, consistent recording, and a controlled laboratory environment. Unfortunately, the physician rarely enters the laboratory to obtain further, more sensitive, and accurate pictures than the standard technique done by the technician (Fig.2). ITI can provide further information leading to correct diagnosis.

The infrared camera records the infrared electromagnetic spectrum (Table 2). At the short wave boundary (Table 2) the infrared spectrum starts at the visual perception limit of deep red. At the opposite extreme of long wavelength frequency, it borders, and blends with, microwave-radio wavelength. The infrared band is

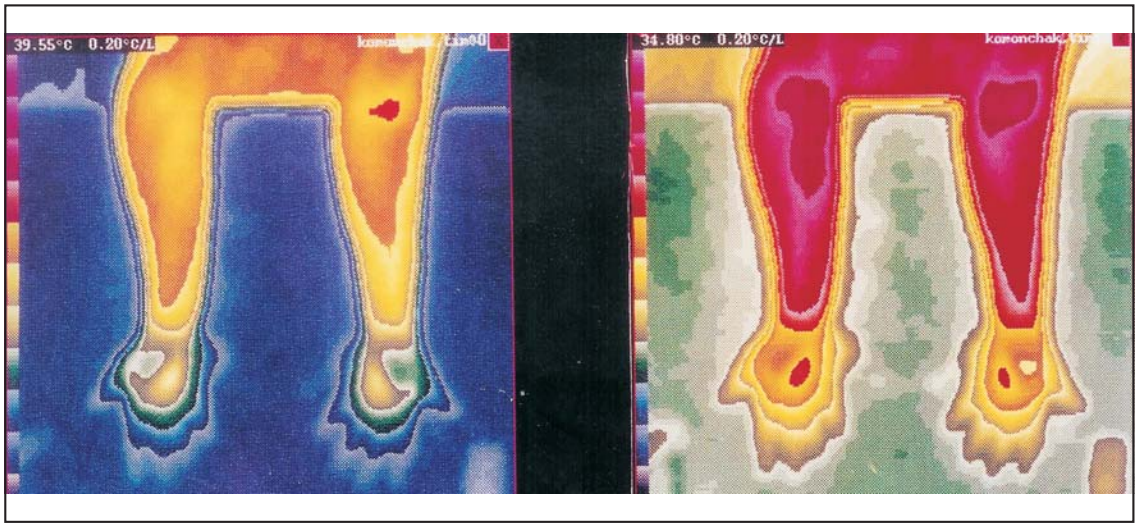


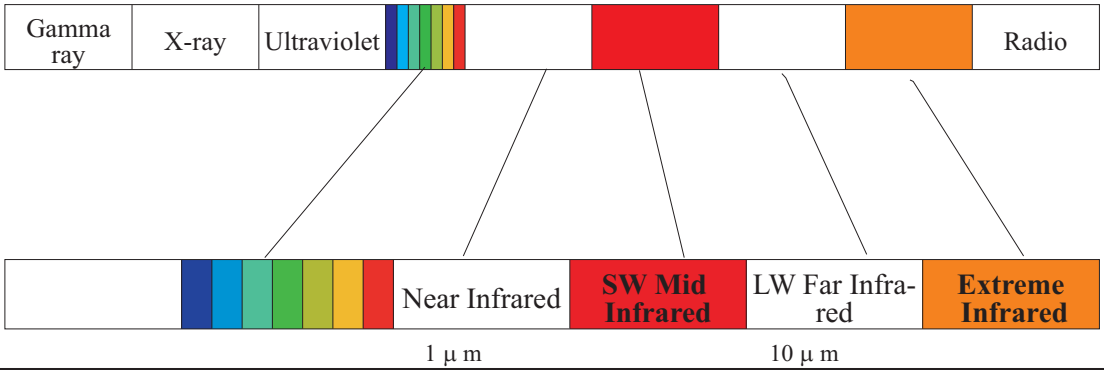
Figure 2

Central hyperthermic areas of entrance and exit in electrical injury. The permanent hyperthermic damage is surrounded by vasoconstrictive hypothermia. Only after increasing the thermal sensitivity (right) the lesions were identified. This Abutton hole@ sign is exclusively seen in electrical injury.

subdivided to "near infrared" (0.75 to 3µm), "middle infrared "(3-6µm), "far infrared" (6-15µm), and "extreme infrared" (15-100µm). The standard ITI units measure the far infrared (FIR) wave length. To accurately record and measure subtle temperature changes requires a " blackbody" box. The "blackbody" is an object capable of absorbing all radiation and equally emitting any wave length (Kirchhoff Law).

The thermal imaging laboratory requires minimum space of 3.5x4.5 meters; Room temperature of 70-72ºF; No shiny (e.g., Linoleum) or smooth plastic floor to avoid heat and light mirror effect; The interior of the laboratory should be infrared absorptive. Walls should be insulated at minium rate of R=19Hr-Ft 2 - ºF/BTU; Room humidity of 50-70 %. The air conditioner should provide laminar down flow ranging no more than 1ºF (1.8 ºC) temperature. The patients are cooled down in a 20-21ºC steady state room for 30 minutes of equilibration without clothing. No prior smoking for at least 90 minutes, no sun bathing lotion, no application of ice packs or heat, no acupuncture, laser therapy, EMG needle test, or transcutaneous electric nerve stimulation (TENS) for at least 48 hours prior to the thermographic testing. The patient should not wear any type of jewelry during the test. A standard sensitivity of 24-34ºC is the usual staring point. Standardization of technique, and consistent reproduction of the results are essential for accuracy of the test. A standardized ambient temperature of

Table 2.
The relationship of electromagnetic spectrum to the infrared band.



21-22º C (70-72ºF), a minimum of 2-3 sets of reproducible measurements in a cool, controlled temperature, no smoking, and no perfumes for at least 1 hour before the test, are the minimal technical requirements (22) to achieve a reliable comparative side to side (delta T) of ± 0.2 - 0.3º C (23). The review of ITI done prior to patients being referred to our clinic have revealed the tendency for inflexible routine baseline temperature measurements, rather than adjusting the sensitivity gauge to achieve a more accurate test (1).

Physiology

The sympathetic nervous system is an integral part of the comprehensive central and peripheral nervous system playing a role in

1. TEMPERATURE REGULATION of the body (skin and viscera) (24-27),

2. CONTROL OF VITAL SIGNS (blood pressure, pulse, and respiration), and

3. MODULATION OF IMMUNE SYSTEM.

The temperature regulation is achieved by modulating heat loss and heat preservation through dermal and sub-dermal circulatory (sympathetic) and sweating (cholinergic) changes. In contrast to the fish, the "warm blooded" animals can only survive in the stable, narrow - range band of the internal environment temperature - milieu interne (28). The dermal and subdermal structures provide a grid style of vertical and horizontal vascular shunting system which protects the body against excess ambient heat by wasting the body heat through vasodilation and sweating. The same system does the opposite in excess ambient cold environment by conserving heat, and by cooling the skin surface. The deep tissue circulation plays a major role in the protection of the internal environment (homeostasis). In cold temperature, skin vasoconstriction increases the deep tissue heat and circulation to prevent core hypothermia. Chronic pathologic sympathetic up- regulation causes the vicious circle of persistent dermal vasoconstriction, and increased deep circulation in bone and muscles, leading to osteopenia and muscle weakness (29).

The sympathetic system modulates the cellular immune function (30), leading to modulation of cellular neurogenic inflammation in pathologic conditions (30-45). In severe and chronic stages of sympathetic dysfunction, neuro-in flammation results in bulbous lesions (33), pelvic inflammatory disease (PID), interstitial cystitis (46), and sterile abscess (47). The regional neuroinflammatory edema leads to impingement of the peripheral nerves mislead the clinician to mistake the disease for conditions such as carpal tunnel (38,48,49), Dupuytren´s contracture (50) (Table 3), thoracic outlet (TOS), tarsal tunnel, and myofascial syndrome (39). The surgical trauma or repetitive trauma due to sympathetic ganglion blocks (Table 3), in turn aggravates the inflammation (12, 40, 51-54), becoming a new source of neuropathic pain and leading to spread of the disease (42,55). ITI can spare the patient from unnecessary surgery (12,36,37). The primary afferent sensory neuron plays a major role in modulation of excitatory, and pro-inflammatory neuropeptides such as substance P (SP) (,43,44,56-66), nitric oxide (NO) (67-87), and calcitonin gene-related peptide (CGRP) (88), as well as inhibitory hormones such as corticotropin-releasing hormone, opioid peptides, such as dynorphin

Table 3
The role of ITI in selection of treatment modalities.

1. Identification of **A**Virtual Sympathectomy@. (Permanent hyperthermia due to damage from repetitive ganglion block needle insertion). ITI spares the patient from further blocks.
2. Alpha-receptor supersensitivity to circulating Nor-ep shows diffuse hypothermia indicating the futility of any other chemical, radiofrequency, or surgical procedures
3. ITI identifies the permanent hyperthermia in the injured extremity. The apex, central part of permanent sympathetic nerve damage is surrounded by hypothermia. Any form of needle insertion, nerve block, or topical Clonidine skin patch application to the damaged nerve area aggravates and enlarges the lesion. The treatments should be applied proximally at epidural and paravertebral levels of spine corresponding to the area of nerve damage.
4. Thermal evidence of neurovascular instability on ITI proves advanced stage of sympathetic dysfunction non-responsive to sympathetic ganglion block or sympathectomy.
5. ITI identifies referred-pain focal hypothermic area. Massage or nerve block in this focus relieves the pain.

Figure 3
Cervical neuropathic pain represented with hypothermia on ITI in the paravertebral area. Gentle pressure exerted over the cervical spine (Left) revealed reactive release of inflammatory chemicals and blushing of the skin in the hypothermic area. Treatment with paravertebral nerve blocks (Right) provides pain relief, and dissemination of irritative substances (SP, NO, etc). Massage therapy after block enhances the recovery.

(59). Usually, in chronic stage, the referred pain such as seen in shoulder-hand syndrome, results in antidromic spread (89) of the inflammatory substances (59) causing secondary involvement of the paravertebral sensory nerves. The sympathetic dysfunction leads to inflammatory response in the extremity, as well as in the epidural and paravertebral regions of spine. ITI helps identify these inflammatory changes. Epidural (90) and paravertebral (91) nerve blocks in these regions help relieve the inflammation (Fig. 3). Such blocks achieve pain relief, as well as anti-inflammatory effect through injection of minute (2.5 to 10 mg) doses of depomedrol® (methylprednisolone) (12,92).

Peripheral and Central regulation of Deep and Surface Temperature

The sympathetic system participates in regulating the core body temperature within a narrow band. The normal blood flow to the skin is 200 ml/mm which is 4% of the cardiac output (93). This output far exceeds the baseline oxygen and nutrient requirements of skin. The rich arteriovenous anastomoses in acral areas of the palm of hands, feet, and axilla, allow a large volume of blood to flow through the skin. This leads to hyperthermia and heat emission. The parallel anatomical structure of large arteries and veins in the extremities allows countercurrent exchange of heat leading to superficial vasoconstriction, and simultaneous shunting of blood from the superficial to the deep venous systems, leading to surface heat preservation (93).

Central Nervous System Thermoregulation

The thermal changes in blood circulation are detected by neurons in the preoptic nuclei of the hypothalamus (94). The thermoreceptors for cold - and warmth sensations in the skin and perivascular areas play an important role in this temperature detection (94). The posterior hypothalamus modulates proper heat-generation or dissipation mechanisms. The inhibition of sympathetic output results in cutaneous vasodilation and heat loss (94). Moreover, the same inhibition results in more cholinergic sweating (by 1/10 of nerve fibres in the efferent

sympathetic nerves). On the opposite extreme, cold exposure stimulates increased sympathetic output from posterior hypothalamus leading to vasoconstriction, and heat conservation (94). The shunting of blood into the deep venous system acts as an insulator in the subcutaneous fat layers between the blood and the cold ambient temperature. The protective effect of subcutaneous fat is important. The obese individuals can maintain a higher internal temperature on cold exposure. They also have chronically cooler skin temperature (95,96). The above multiple factors contribute to maintenance of a constant core temperature of approximately 37º C against a range of external temperature fluctuations - usually between 15º C and 54º C (60º F- 128º F) (97).

ITI Recording of Deep Temperature Changes

Thermal imaging in medicine addresses the thermal variations in superficial and deep structures of the body . Even though the old literature has claimed that ITI studies the surface skin temperature , as claimed by the U.S.Federal Register (98), to a depth of 6 mm. The research conducted by Elam, et al (99) has shown the test to be informative in evaluating deep temperature changes as well. The skin is an almost perfect radiator of the deep heat. This radiator helps prevent hyperthermia and damage to internal organs (specifically the brain). This radiator, with 98% emissive efficiency, allows the deep heat, that is conducted through the tissue and convectet by blood vessels, to radiate and dissipate in the ambient environment (99). This heat radiation is recorded by ITI (Fig. 2). Different methods have been applied to study superficial and deep circulation (e.g., scintigraphic bone scanning, and ITI) (100). The first clinical application of ITI was to record the thermal changes of deep structures such as breast cancer (101-103), and arthritis (104,105). ITI in Paget's disease has shown pathological hyperthermia in deep structure of the sacral-sacroiliac region. The ITI in Paget's disease showed direct correlation with improvement and reversal of bone changes and pain after proper treatment (106). This is another example of the sensitivity of ITI in identifying the deep tissue pathology (99).

Limitations of ITI

The ITI provides accurately measurable information regarding subtle thermal changes (100). The ITI shows any old or new sympathetic nerve damage or dysfunction, thus confusing the examiner and demanding careful and proper clinical correlation. The examiner interprets the old lesion as the main pathology. The confusing results due to multiple old and new life time injuries may mislead the physician to end up losing faith in ITI. Only proper history taking and interpretation can solve such a problem. However, in a double blind study the above example of ITI will be tagged as invalid.

Another source of confusion is spread of the thermal changes to the contralateral extremity - making it difficult to compare the delta T between the two extremities. As the disease becomes chronic and the sympathetic thermal dysfunction becomes bilateral (1,61,107), the ITI shows identical bilateral temperature changes causing difficulty in diagnosis. This is true both in standard ITI, and in cold stress tests (108,109). The bilateral representation of central sympathetic temperature regulation is modulated at the following centers: The first center is at the chain of sympathetic ganglia on each side of spine. These ganglia relay the transmission of pain or thermal impulses horizontally and vertically(21,110) (Fig. 3). This bilateral integration of the impulses at the sympathetic chain level serves the purpose of transmitting the stressful impulses to the rest of the body, and coordinating the sympathetic stress regulation (21). The second center is at the spinal cord level (61) where the temperature modulation is exerted symmetrically and bilaterally with side to side temperature variation (delta-T) of ± 0.2 - 0.3º C (23). This explains the spread of thermal changes to the contra- lateral side (1). The next relay center for neuropathic afferent nerves and temperature regulation is the hypothalamic modulation centers (107). Finally, at the cerebral hemispheric level, the Central autonomic network (CAN) exerts its influence on vasomotor, visceromotor, neuroendocrine, cardiovascular, and pain modulation. The CAN includes the limbic system-specifically the mesial frontal and insular cortex, amygdala, stria terminalis hypothalamus, and nucleus solitarius (111,112).

Significance of Hyperthermic Regions

In early stage of nerve dysfunction, the involved area is hyperthermic due to release of destructive cytokines (21,47). After a few weeks, the hyperthermic area shrinks. In some cases

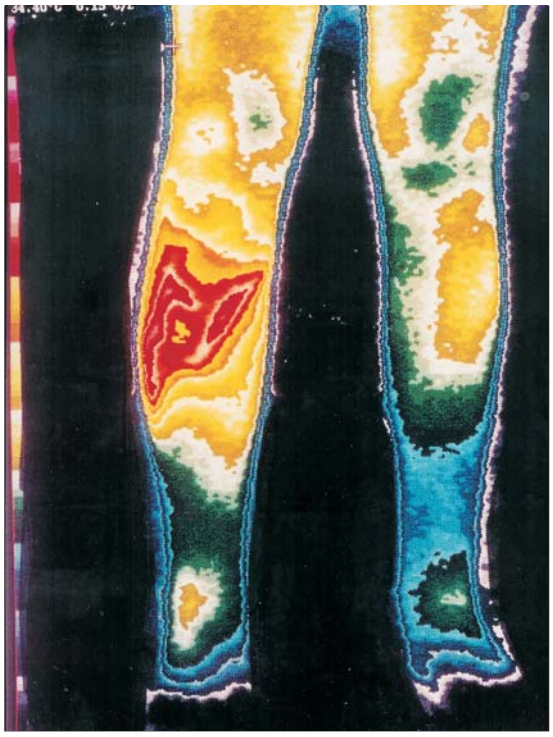


Figure 4
A previously undiagnosed right leg arteriovenous malformation (AVM)over 27mm deep, complicated by CRPS (RSD) . ITI identified the deep lesion and spared the patient from the scheduled sympathectomy. Vascular surgery corrected the condition.

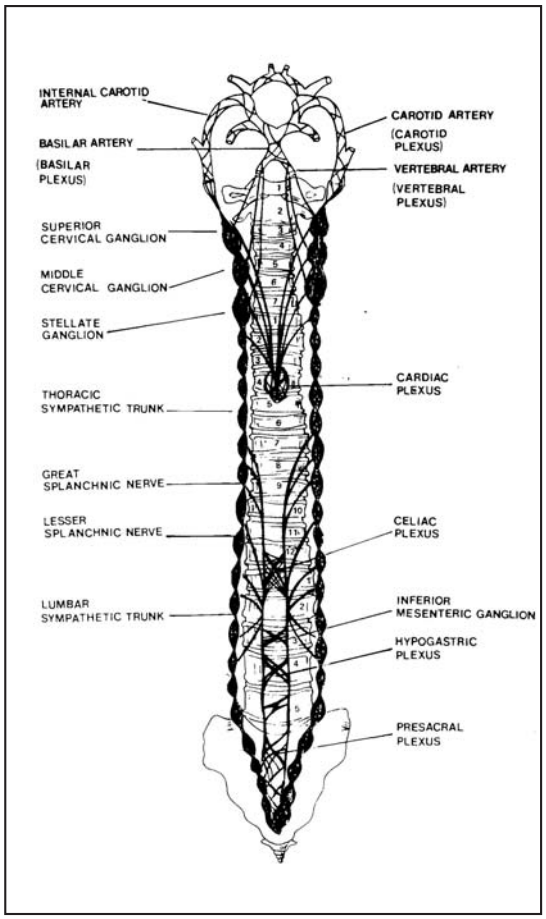


Figure 5
The paravertebral chain of ganglia transmit the neuropathic pain and abnormal sympathetic dysfunction vertically (e.g., from foot to hand and vice versa), and horizontally (from side to side). This explains the remote symptoms and thermal manifestations of CRPS patients.

With permission from Springer-Verlag Publishers (1).

Figure. 6
CRPS nerve damages to right toes after Aneuroma exploration@. The sympathectomy did nothing for the pain. ITI spared the patient from the scheduled chemical sympathectomy. The left foot showed compensatory hypothermia after sympathectomy.

Figure 7
AVirtual sympathectomy@ secondary to repeated stellate ganglion nerve blocks leading to permanent sympathetic nerve damage and hyperthermia (heat leakage) in upper extremities. The ITI spared the patient from further sympathetic nerve blocks.

(47) the hyperthermia persists due to permanent damage to the thermosensory nerve fibers (1) (Fig. 4). This bodes a poor prognosis.

Traditionally, hyperthermic areas recorded on ITI have been ignored due to the universal old and partially true dictum emphasizing the importance of hypothermic foci as the main sign of sympathetic dysfunction. This has resulted in the examiner usually not paying attention to hyperthermic foci which are equally significant. Usually, the hyperthermic areas point to either irreversible damage to the sympathetic system in the traumatized focus, or a referred pain area undergoing a backlog of neural transmission of the antidromic afferent sensory nerve fibers (88) to the spinal cord in the form of algogenic chemicals such as nitric oxide (NO) (67-87,113,114), SP (43,44,56-58,60), CGRP (44,115), and oxidative stress agents (116) (Fig. 5). These algogenic pro-inflammatory chemicals play a major role in the function of immune regulation, and when accumulated in large doses cause movement disorders such as tremor, and pro-inflammatory referred pains such as headaches, neck pain, back pain (12,113). Traumatic procedures such as surgical ex ploration(12), needle insertion in hands or feet for nerve blocks, or EMG needle insertion should not be applied to the damaged hyperthermic area in the extremity which may lead to further deterioration and aggravation of the condition (22,117,118). On the other hand, the above treatment should be applied to the referred pain areas in cervical, thoracic and lumbar regions which have undergone no focal nerve damage but are reflecting the backlog and accumulation of cytokines in the path from the distal extremity nerve damage to the dorsal horn of the spinal cord (88) (Fig. 3). This identification of hyperthermic nerve injury is a major therapeutic contribution of ITI.

Physiologic hyper - and hypothermia are the reflection of the dynamic function of sympathetic system (22) to achieve homeostasis. These changes are the end-results of multiple factors such as hyperthermia due to damage to thermoregulatory sympathetic nervous system (117,118) (Fig. 2). The up-regulation of the sympathetic system leads to vasoconstriction and hypothermia. The down-regulation or damage of this system leads to a dermal hyperthermic focus surrounded by a compensatory hypothermia (1) (Fig. 6).

The referred pain phenomenon may be accompanied by hypo - or hyperthermia in paravertebral regions (Fig.3). This form of hyperthermia is due to accumulation of pro-inflammatory cytokines outlined above. These cytokines play a major role in development of inflammation (42,55), movement disorder (119-122), and immune regulation (44, 59,113). In contrast, in chronic late stages, the hyperthermic area becomes more focal and quite small in size surrounded by compensatory hypothermia of the rest of the region (12). The contralateral normal side also undergoes compensatory hypothermia. The end result is two cold extremities with no statistically significant thermal difference (delta T). This problem can only be solved by proper clinical correlation.

Significance of Hypothermic Regions

Sympathetic dysfunction causes sympathetic up-regulation and regional hypothermia. This phenomenon has been blamed as Alpha-receptor supersensitivity to circulatory norepinephrine (NE) after prolonged denervation(24,25). This phenomenon is usually seen in the sympathectomized limb. The limb, instead of being warm, becomes colder after surgery due to end - organ supersensitivity to alpha receptors (24, 25,123) (Fig. 6). This is a major cause of sympathectomy failure (Fig. 6). ITI identifies this form of hypothermia, sparing the patient from further harmful surgical treatment(12) (Fig. 6). In this regard, ITI points to the futility of sympathectomy. Commonly, as the sympathetic system becomes chronically dysfunctional, the prolonged pathologic vasoconstriction yields to inconsistent tonus of the vasomotor nerves. This leads to the development of neurovascular dysfunction, mottling, and instability (124). This refers to blotching, and fluctuation of skin temperature. ITI identifies this condition more accurately, and spares the patient from sympathectomy and ganglion nerve blocks (Fig. 6) which cannot be expected to help an unstable and failed stage of sympathetic dysfunction (1,12).

The Role of ITI in Pain Management

The proper identification of hyper - and hypothermic areas guides the clinician in management of pain, more accurate diagnosis, and avoidance of further traumatizing the already damaged nerves by avoiding unnecessary surgical procedures (51-53),(Fig. 7), or improper nerve blocks. ITI can identify these areas of nerve dysfunction in paravertebral regions of

the spine (91) in form of hypothermic foci. Epidural nerve blocks (with bupivacaine and depo-medrol) in these regions provide both somatic and sympathetic pain relief (12,21,91). According to Stein (88) the cytokines and inflammatory chemicals are transmitted via spinal nerves to the spinal cord and vice versa, modulating the spinal cord function of nociception. The therapeutic effect of these blocks lasts 8-12 weeks (1,12,21) versus ganglion blocks which last a few hours or days.

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Thermographic evaluation of selected cases of pathology of the venous system in children

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2. Department of Paediatric Surgery, Clinical Hospital, Central Military University School of Medicine, Warsaw, Poland.

3. Crystal Physics and Technology Section, Institute of Applied Physics MUT, Warsaw, Poland.

Summary

Thermal imaging can be used for the documentation of vascular disorders in children. The advantages and restrictions of this technique are discussed and four typical cases with various venous pathologies are presented. In patients with Klippel-Trenaunay's syndrome a close agreement between the existence of angiomas, Doppler ultrasonography, venography and temperature changes was observed. Correlation between Doppler ultrasonography and thermal images were also found in a patient with thrombosis of the femoral vein; and a boy suffering from varicocele. In the fourth case, a poorly functioning haemodialysis fistula was characterized by hypothermia of the arm. Thermal imaging in the described cases was an important supplement to more popular clinical and imaging methods.

Key words: Thermal imaging, Klippel- Trenaunay's syndrome, Doppler ultrasonography, Thrombosis, Varicocele.

Die thermographische Beurteilung ausgewählter Venenerkrankungen bei Kindern

Die Thermographie kann bei Kindern für die Dokumentation von Venererkrankungen eingesetzt werden. Die Vor- und Nachteile dieser Methode werden diskutiert und an 4 typischen Patienten mit unterschiedlichen venösen Erkrankungen dargestellt. Bei einem Patienten mit Klippel-Trenaunay Syndrom fand sich eine gute Übereinstimmung vorhandener Angiome und der Dopplersonographie mit den Temperaturveränderungen. Eine Korrelation zwischen Ultraschalldopplerbefunden und der Thermographie zeigte sich sowohl bei einem Patient mit Thrombose der Femoralvene, als auch bei einem Knaben mit Varikozele. Im vierten Fall war ein schlecht funktionierender Hämodialyse-Shunt durch einer verminderte Wärmeabgabe des Armes charakterisiert. Die Thermographie erwies sich in allen beschriebenen Fällen als wichtige Ergänzung zu den häufiger gebrauchten klinischen und bildgebenden Untersuchungsverfahren.

Schlüsselwörter: Thermographie, Klippel- Trenaunay Syndrome, Doppler-Sonography, Thrombose, Varikozele.

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Introduction

Abnormalities of the venous system can occur in early childhood. In addition to clinical examination, diagnostic imaging methods are useful (5,6). With the exception of Doppler ultrasonography, most methods of imaging venous flow are invasive (11,12).

Thermography has the advantage of being safe and non-invasive compared with venography. However, Doppler ultrasonography may not be useful in searching for changes in small veins. Another technique, plethysmography, has a high percentage of the false positive results. Thermography is used in evaluation of vascular problems e.g. venous thrombosis, varicose veins of the lower limbs, varicocele and arteriovenous fistula patency (10,14).

The maintenance of patency of arteriovenous fistulae is important in haemodialysis patients.

In addition to clinical observation of the fistula, Doppler ultrasonography is used when necessary. Thermographic examination also has the possibility of accurate determination of arteriovenous shunt patency and flow (8).

Some cases are presented illustrating various venous pathologies in which thermography was used in diagnosis and monitoring of the condition.

Materials and methods

The studies were undertaken with a Therma CAM 1000 camera, and the data obtained were processed using Inframetrics' ThermaGRAM 95 software.

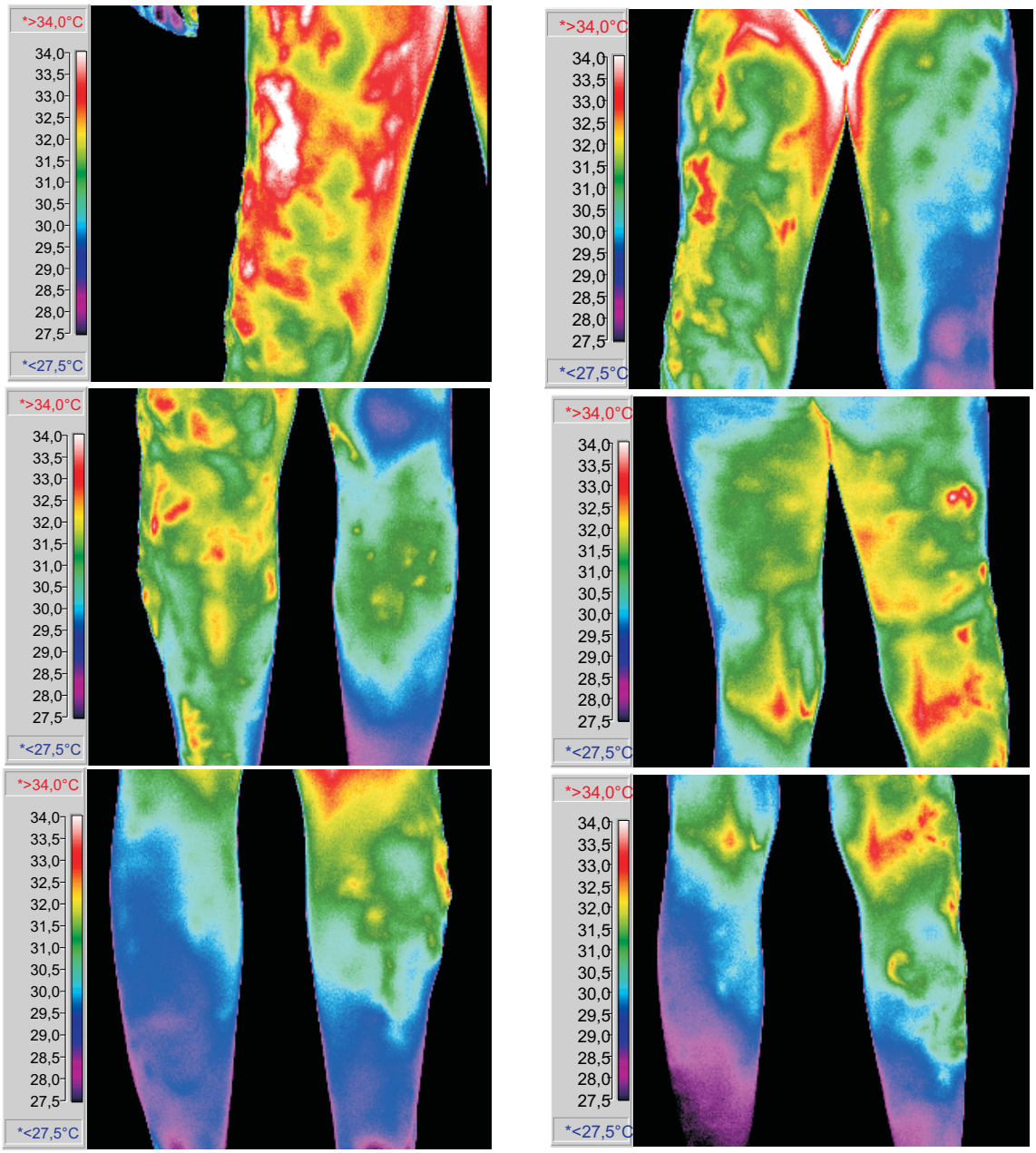
Case 1

A 15-year-old girl attended the Children's Surgery Clinic, Military University School of Medicine with angiomatosis of the right lower

Figure 1
Klippel-Trenaunay Syndrome in a 12 years old girl- angiomatosis syndrome of the lower right extremity

Left: before surgery, temperature gradient 4.5°C

Right: after surgery, temperature gradient 2,5°C



limb (Klippel- Trenaunay's syndrome). Cavernous angiomas of the foot, calf (especially laterally), knee and thigh were assessed. These lesions were gradually getting larger. In the thigh, angiomas present since late1997 were inflamed with pain, fever, muscular contractions and difficulties in walking. The right mid-thigh circumference, measured standing, was 2.5 cm greater than the left mid-thigh. The upper right calf circumference was 3.5 cm greater than the upper left calf. There was 10° flexion deformity at the right knee joint. The right lower limb was 2 cm longer than the left lower limb. Doppler ultrasound examination of the right thigh confirmed an extensive venous angioma involving superficial and deep veins. Flow in these veins was evaluated in the seated and supine positions. There was no evidence of thrombosis. An oscillating blood circulation was observed during the Valsava manouvre and during compression. Blood flow within the angioma was not visualised. Cavernous angiomas were also examined in the foot and on the anterior and lateral surface of the thigh. In the left lower limb the popliteal vein and the long saphenous vein were narrower than the same veins in the left lower limb. The blood flow in the deep veins of the right lower limb was maintained but it was slower than in the lower left limb. There was normal blood flow in the arteries of both lower limbs (Fig 1a, 1b).

On venography, there was a conglomeration of dilated superficial veins. The deep venous system was not visualised, except for a portion of popliteal vein. At surgery very wide (2-2.5cm) thin-walled angiomas were exposed and separated superficial to the fascia, with many connections between them and between the vessels situated subfascially. After the ligation, the angiomas which spread out in the upper calf were resected. Post operatively the wound healed by first intention. Six months later there was no pain or inflammation in the calf.

On post operative Doppler ultrasound there were no angiomas present in the operated area. The visualised blood flow through the popliteal vein and long saphenous vein was faster than before the operation but still slower than on the left side. Thermographic investigation of the right lower limb before the operation showed extensive hyperthermal areas in the right thigh, extending into the right popliteal and calf areas. The hyperthermal areas corresponded with the images of conglomerates of dilated veins on Doppler ultrasound (Fig. 1a). |Post operatively, the areas of increased temperature were significantly smaller (Fig. 1 b). The temperature gradient between the area of abnormal veins and the surrounding tissue was about 4.5°C pre-operatively, however, after the operation the gradient decreased to 2.5°C. Thermographic visualisation strictly correlated with the clinical assessment of the post-operative state.

Case 2

A 12 year old boy was hospitalised at the Clinic of Children's Surgery Military University School of Medicine because of 9 days of fever, pain and oedema of the left thigh. He was visibly limping and, when resting, he kept the left hip joint flexed. There were visible dilated veins

Figure 2
Thermographic investigation in diagnosis of left femoral vein thrombosis.

A - before treatment:
* hyperthermal focus over left femoral vein

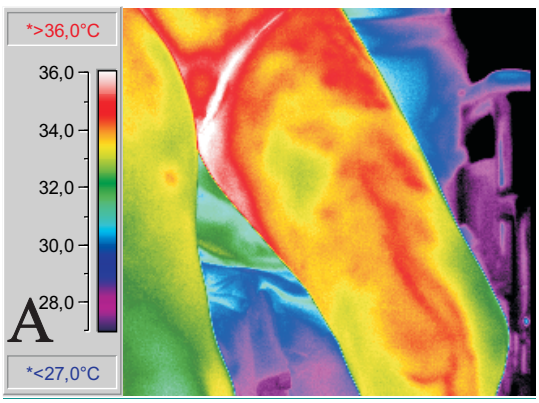
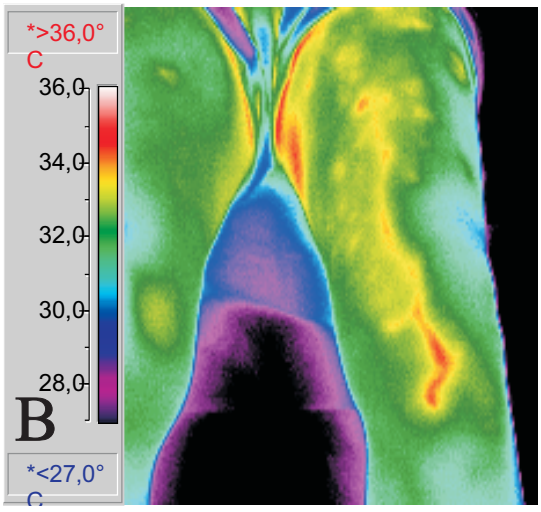


Figure 2 B
After treatment



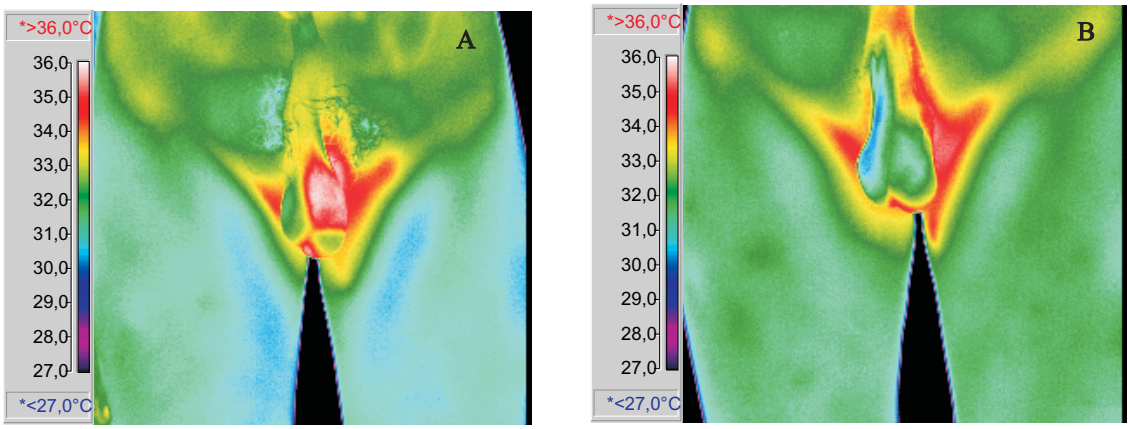
beneath the skin of the left upper thigh, groin and left buttock. Doppler ultrasound of the femoral vein revealed thrombus occluding blood flow. There was also non-occlusive thrombus in the inferior vena cava and left renal vein. Other lower limb veins were patent and arterial flow was normal. Treatment with intravenous antibiotic, fractionated heparin and fibrinolitic medicines (streptase, actylize) was commenced. However the thrombus did not disperse. Long-term anticoagulant therapy was undertaken. The prothrombin level was maintained at 35-45% and the APTT index at 1.70-1.90. Follow-up Doppler ultrasound studies showed partial recanalization of the left long saphenous vein, and disappearance of the thrombus in the left superficial femoral vein, but there was still no flow in the left iliac vein (Fig 2a,b).

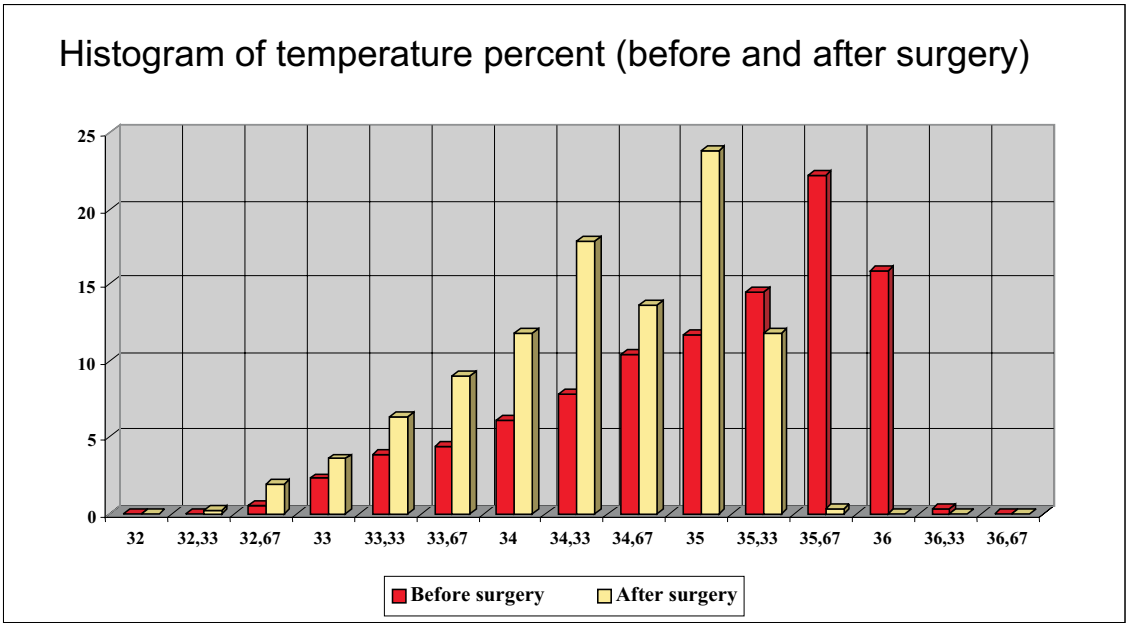
There was correlation between thermographic studies and the Doppler ultrasound images.

Case 3

A 14-year-old boy was hospitalised in the Clinic of Children's Surgery, Military University School of Medicine because of a left varicocele. Doppler ultrasound showed dilated seminal veins (4 mm diameter in the lying position and 6 mm standing), with considerably reduced blood flow. By comparison, on the right side these veins were only1 mm in diameter. The left testis measured about 32 x 14 mm in length while the right testis 38 x 18 mm.

Figure 3
A - before operation B – after operation
C – Histogram of temperature distribution (before and after surgery)





At surgery 7 dilated veins were found, and a 1 cm segment of veins between ligatures was resected. The post operative course was normal. There were no varicoceles on post operative ultrasound.

On pre-operative thermography there was a homogenous area of increased temperature in the region of the left spermatic cord and left groin. The temperature gradient between the hyperthermal focus and the surrounding tissues was 3.5°C (Fig 3a). Post-operatively, the hyperthermal area was smaller (Fig 3b). Assessment of the skin temperature distribution in the scrotum in the pre- and post-operative periods, showed decreased heat emission on the left side post-operatively (Fig 3c).

Case 4

A 41-year old woman with arteriovenous fistulas in both upper limbs was investigated because of feeling cold in right upper limb. Thermographic examination revealed significant hypothermia in the area of the right forearm and palm, caused by serious impairment of blood flow due to shunting through the fistula.

Discussion

In the four presented cases of different types of abnormalities of blood vessels, the thermographic study showed strict correlation with Doppler ultrasonography estimation. In Case 1, thermal imaging also correlated with venography. In Case 2, treated non-operatively, thermography correlated with Doppler ultrasound. Similar observations are quoted by Goluboff (1), who made thermographic investigations of the patients suffering of varicocele. The studies were made before the operation and in the post operative period. The authors showed reduction of the hyper-thermal areas post operatively, as in the present work. A number of papers show the usefulness of the thermal imaging in such case (1, 4, 13). In the thrombo-embolic disease of the blood vessels, Maurer (9) proposes the usage of thermography as the initial screening method for this illness (9). Harding (3) proposes a schedule of examination in thrombo-embolic disease, beginning with thermal imaging (3). In 700 patients he showed the usefulness of thermography in the initial recognition of the thrombo-embolic disease. A positive result of the study is an indication for further, broader diagnostic investigations in thrombo-embolic disease (2). However, a negative result avoids the need for fur-

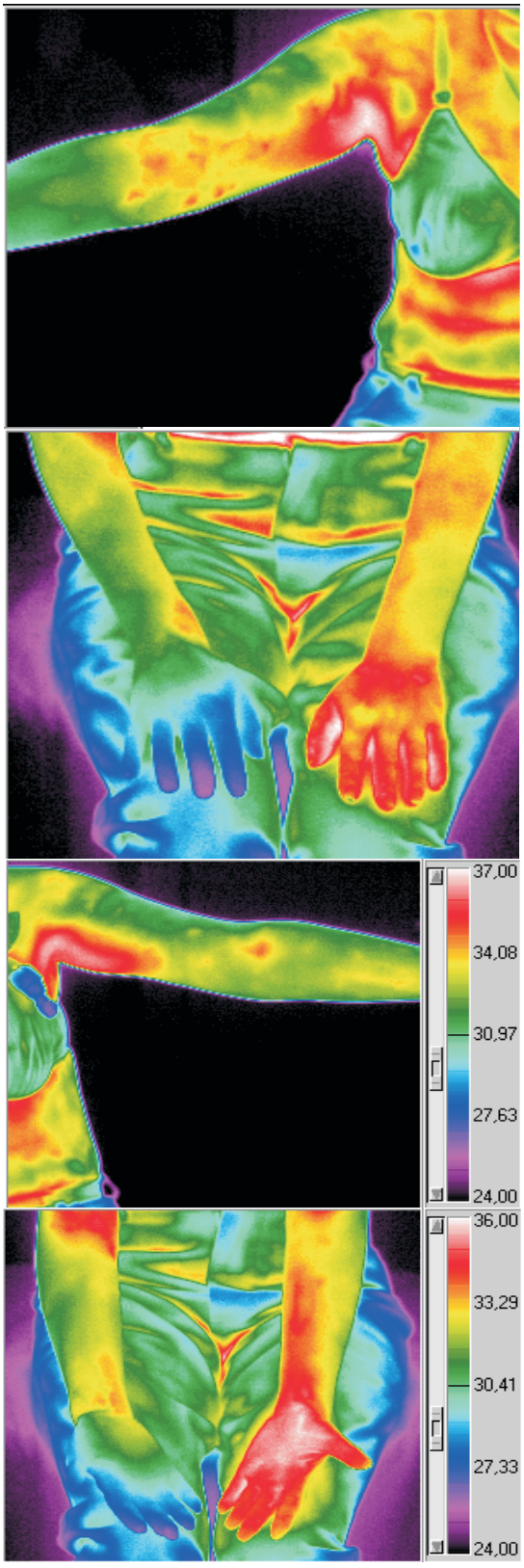


Figure 4
Thermographic image of upper limbs with haemodialysis fistulas. On the right side the hypothermal area, corresponding to circulatory disturbances is clearly visible.

ther investigation. At present, thermography is an accepted diagnostic method in the investigation in studies of the vascular system. Earlier described studies were made using liquid crystal thermography (7). Thermal imaging in the described cases was an important supplement to more popular clinical and imaging methods. It is non-invasive, allowing multiple repeat examinations and comparison of data for general assessment. Thermal imaging is thus a recommended method in the investigation of the circulatory system.

Acknowledgement

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European Association of Thermology
Austrian Society of Thermology
Ludwig Boltzmann Research Institute for Physical Diagnostics

Fifth International Congress of Medical Thermology

Combined with the
14th Thermological Symposium of the Austrian Society of Thermology
and the
Annual Meeting of the German Society of Thermology

Vienna, Austria
May 28-30, 2001
SAS Radisson Palais Hotel

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Governor and Major of Vienna

Prim. Dr. Elisabeth Pittermann
Health Minister of Vienna

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Prof. Dr.R.Purohit(USA)
Prof.Dr.E.F.J.Ring(UK)
Prim. Dr.O.Rathkolb(Austria
Prof.Dr.H.Tauchmannova(Slovakia)

Conference Schedule

Registration: Friday April 27, 2001, 18.00 - 19.00 SAS Hotel
Saturday, April 28, 2001 7.30 -18.00
Sunday, April 29; 2001 8.30-12.00
Monday . Apri 30, 2001 l8.30 -10.00

Friday ; April 27, 2001 19.30 General Assembly of the European Association of Thermology

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OPENING</td><td rowspan="2">8.20-10.20
THERMAL IMAGING
IN ANGIOLOGY I</td><td rowspan="2">8.40-10.30
DIAGNOSIS ASSISTED BY
THERMAL IMAGING I</td></tr>
<tr><td>8.40-10.20
THERMOMETRY AND
THERMAL IMAGING I</td></tr>
<tr><td>10.20-10.40 Coffee break</td><td>10.20-10.40 Coffee break</td><td>10.30-10.50 Coffee break</td></tr>
<tr><td>10.40- 12,00
THERMOMETRY AND
THERMAL IMAGING II</td><td>10.40-12.20
THERMAL IMAGING
IN ANGIOLOGY II</td><td>10.50-11.30
DIAGNOSIS ASSISTED BY
THERMAL IMAGING II</td></tr>
<tr><td>12.00- 13.30 Lunch</td><td>12.20-13.30 Lunch</td><td>11.30-12.00
A FINAL LOOK INTO THE SKY</td></tr>
<tr><td>13.30-15.10
THERMOMETRY AND
THERMAL IMAGING III</td><td>13.30-15.30
BACK PAIN AND
SPINAL DISORDERS</td><td>12.00-12.10
Closing Remarks</td></tr>
<tr><td>15.10-15.30 Coffee break</td><td>15.30-15.50 Coffee break</td><td rowspan="4">14.00 Trip to the Abbey Melk in the Wachau Danube Valley</td></tr>
<tr><td>15.30- 17.30
THERMAL IMAGING IN NEURO-
LOGY AND NEUROSCIENCE</td><td>15.50-16.50
TREATMENT EVALUATION
BY THERMAL IMAGING</td></tr>
<tr><td rowspan="2">17.35-18.15
BREAST THERMOGRAPHY -
A REVIVING ISSUE</td><td>16.50 – 18.30
ROUND TABLE DISCUSSION :
STANDARDS IN MEDICAL
THERMAL IMAGING</td></tr>
<tr><td>20.00 Reception in
the City Hall of Vienna</td></tr>
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SATURDAY, APRIL 28, 2001

7.30-8.30 Registration

8.30 *K.Ammer* Welcome address on behalf of the European Association of Thermology
8.35 *O.Rathkolb* Greeting address from the Ludwig Boltzmann Research Institute for Physical Diagnostics

THERMOMETRY AND THERMAL IMAGING I
Chair: K.Ammer (Austria), F.Ring (U.K.)

8.40- 9.10 Oberhauser G; Pichler L; Urban M, Hruby W. *(Austria)*
Thermometry by magnetic resonance imaging

9.10- 9.40 Wiecek B, Zwolenik S, Danych R *(Poland)*
Thermal wave method and thermography - basis and applications

9-40 - 10.00 Campbell PA., Song C; Frank TG, Cuschieri A. *(United Kingdom)*
Investigating Energised Surgery and Thermally Activated Fixator Deployment using Dynamic Thermography

10.00-10.20 Rave E; Katzir A *(Israel)*
Endoscopic Thermal Imaging using Ordered Bundles of Infrared Transmitting Fibers

10.20-10.40 Coffee break

THERMOMETRY AND THERMAL IMAGING II
Chair: D.Rusch (Germany), I. Benkö (Hungary)

10.40 - 11.00 White P, Howell KJ, Smith RE , CM Black *(United Kingdom)*
Control Factors Affecting the Quality and Reproducibility of Medical Thermal Imaging

11.00 - 11.20 Merla A, Di Donato L, Romani GL. *(Italy)*
Tau Image: A Diagnostic Imaging Technique Based on the Infrared Functional Imaging.

11.20- 11.40 Ring EFJ *(United Kingdom)*
Provocation Tests in Thermal Imaging

11-40-12.00 Kondo K, Mabuchi K, Chinzei T, Nasu Y, Kakuta N, Suzuki T, Saito T, Ishigaki H *(Japan)*
Images of the Spectrum Analysis of the Changes in Skin Temperature and its Application for the Evaluation of Autonomic Nervous Function

12.00-13.30 Lunch

THERMOMETRY AND THERMAL IMAGING III
Chair B.Wiecek (Poland), M Anbar (USA)

13.30-13.50 Berz R *(Germany)*
Measurements of skin temperature in vitro and in vivo comparing contact measurements and infrared systems

13.50-14.10 Benkõ I, Köteles GJ, Németh G *(Hungary)*
Computerized Visualisation of Radiation Induced Thermal Alterations of Human Tissues

14.10-14.30 Forde K, Edwards C, Harding R,. Anstey A *(United Kingdom)*
A Comparison Between Visual and Reflectance Spectrometric Assessment of Erythema and Thermography in the Elucidation of Dose-Response of Skin To Ultraviolet Irradiation in Photo(Chemo)Therapy.

14.30-14.50 Singer D, Aumann C, Schröder M, Benninghoff U *(Germany).*
Prevention of Hypothermia in Preterm Neonates: Benefits of Water-Filtered IR Radiation

14.50-15.10 Purohit RC., Heath AM, Navarre CB, Simpkins SA, Pugh DG, Pascoe DD.*(USA)*
Thermographic Evaluation of Animal Skin Surface Temperature With Or Without Hair Coat

15.10-15.30 Coffee break

THERMAL IMAGING IN NEUROLOGY AND NEUROSCIENCE
Chair: G. Dalla Volta (Italy); H Hooshmand (USA),

15.30-15.45 Brioschi ML, Cimbalista M Jr., Saito RT, Baltar AC, Flor VR *(Brazil)*
Dynamic infrared computerised thermography in the diagnosis of carpal tunnel syndrome

15.45-16.00 Melnizky P, Ammer K *(Austria)*
The thermal image in traumatic lesions of the median nerve

16.00-16.15 Brioschi ML; Cimbalista M Jr, Saito RT; Baltar AC *(Brazil)*
The Use Of Thermal Imaging For The Assessment of Work-Related Injuries.

16.15-16.30 Ammer K, Melnizky P, Kern E. *(Austria)*
Cold fingers after keyboard operation: Relationship with duration of typing

16.30-16.50 Schartelmüller T, Ammer K. Rathkolb O. *(Austria)*
Thermographic Diagnosis of Thoracic Outlet syndrome - a re-evaluation

16.50-17.10 Govindan S *(USA)*
Microcirculation Pathophysiology in Chronic Regional Pain Syndromes

17.10-17.30 Hooshmand H *(USA)*
The Role of Infrared Thermal Imaging in Diagnosis and Management of CRPS.

BREAST THERMOGRAPHY – A REVIVING ISSUE
Chair: K.Mabuchi (Japan)

17.35-17.55 Anbar M, Naumov A, Milescu L, Brown *C (USA)*
Objective Detection of Breast Cancer by DAT – an Update

17.55-18.15 Berz R *(Germany)*
MammoVision™ - Infrared Regulation Imaging has a predictive value for breast health or disease

SUNDAY, APRIL 29, 2001

THERMAL IMAGING IN ANGIOLOGY I
Chair: R.Harding (U.K), T.Maca (Austria)

8.20-8.40 Jung A, Frank-Piskorsaka A, Zuber j, Kalicki B, Murawski P *(Poland)*
Monitoring of vasodilating treatment by thermal imaging

8.40-9.00 Ammer K, Melnizky P, Rathkolb O, Hirschl M *(Austria)*
Reproducibility of Response to the cold water challenge

9.00-9.20 Howell KJ, Cherkas LF, Carter L, Spector TD, Black CM, MacGregor AJ *(United Kingdom)*
Diagnosis Of Primary Raynaud's Phenomenon Using A Portable Radiometer

9.20-9.40 Merla A, Di Donato L, Farina G, Pisarri S, Proietti M, Salsano F, Romani GL *(Italy)*
Infrared Functional Imaging Applied to the Study of Raynaud' s Phenomenon

9.40-10.00 Rasmussen L. K., Mercer J.B. *(Danmark/Norway)*
A Comparison of Skin Temperature Changes in the Hands and Feet of Young and Elderly Subjects Following Local Cooling

10.00 – 10.20 Brioschi ML, Cimbalista M. Jr, Saito RT, Baltar AC, Takahashi L, Falavinha JMM *(Brazil)*
Pre-operative localization of perforating arteries in reconstructive plastic surgery

10.20- 10.40 Coffee break

THERMAL IMAGING IN ANGIOLOGY II
Chair: R. Purohit (USA), J-M Engel (Germany)

10.40-11.00 Brioschi ML, Loures DR, Cimbalista M. Jr, Saito RT,. Baltar AC *(Brazil)*
Thermal computerized coronary angiography for intraoperative evaluation of cardiac perfusion: preliminary experimental study and the first clinical application in Brazil

11.00- 11.20 Siniewicz K, Wiecek B, Baszczynski J *(Poland)*
The use of thermography in children with orthostatic disorders of the cardiovascular system – a new diagnostic method .

11.20-11.40. Brioschi ML, Cimbalista M. Jr., Saito RT, Baltar AC, Contin LA *(Brazil)*
Thermography for the detection varicose veins of the leg

11.40- 12.000 Govindan S *(USA)*
Imaginmg Extracranial Trigeminovascular System in Chronic Pain Syndromes

12.00 – 12.20. Stefanadis C, Toutouzas K, Tsiamis E, Vavuranakis M, Kallikazaros I, Stratos C, Vaina S, Toutouzas P *(Greece)*
Unfavorable outcome after successful percutaneous intervention in patients with increased temperature of culprit atherosclerotic plaques

12.20-13.30 Lunch

BACK PAIN AND SPINAL DISORDERS
Chair: Y-S.Kim (Korea), H.Mayr (Austria)

13.30-13.50 Gabrhel J. Tauchmannova H, Gubzovoa S *(Slovakia)*
Thermal Imaging in Back Pain- A comparative Study

13.50-14.10 Kim Young-Soo; Cho Yong-Eun *(Korea)*
IR Image Standardisation of various Spinal diseases

14.10 –14.30 Mayr H, Ammer K *(Austria)*
Thermography in radiculopathy – a systematic review

14.50-15.10 Kim Young-Soo; Cho Yong-Eun *(Korea)*
Digital Infrared Thermographic Imaging for diagnosis of osteoporotic compression fracture in elderly patients.

15.10-15.30 Koprowski R, Konik H, Wróbel Z (*Poland)*
Computer Analysis of Thermograms From Spinal Deformities In Children

15.30- 15.50 Coffee Break

TREATMENT EVALUATION BY THERMAL IMAGING
Chair: H.Tauchmannova (Slovakia)

15.50-16.10 Jeon Byung Chan *(Korea)*
Outcome Evaluation of Anterior Cervical Sequestrectomy with Digital Infrared Thermographic Imaging

16.10-16.30 Dalla Volta G *(Italy)*
Thermographic evaluation of ozonotherapy for patients with degenerative discopathy

16.30-16.50 Frauendorf H *(Germany)*
Thermographic recording of the acral temperature reaction during different techniques of needle acupuncture

16.50 – 18.30 ROUND TABLE DISCUSSION :
STANDARDS IN MEDICAL THERMAL IMAGING
Participants: F.Ring (UK)
K.Ammer (Austria)
R. Frauenrath (Germany)
M. Anbar (USA)
S.Govindan (USA)

Y-S. Kim (Korea)
K. Mabuchi (Japan)

20.00 Reception in the City Hall of Vienna

MONDAY, APRIL 30, 2001

DIAGnOSIS ASSISTED BY THERMAL IMAGING I
Chair: R. Berz (Germany). A. Jung (Poland)

8.40-9.00 Jung A, Zuber J, Kalicki E, Dadas E, Murawski *(Poland)*
Thermal imaging for the visualisation of the bronchial tree in asthmatic patients - a preliminary study

9.00-9.20 Kim Yong-suk; Lee Kyung-sub *(Korea)*
Correlation between Women Infertility and DITI

9.20-9.40 Lee Kyung-sub, Kim Yong-suk *(Korea)*
An Evaluation of the Sensitivity and Specificity of DITI for the Diagnosis of Cold Hypersensitivity

9.40-10.00 Lee Ye-Chul *(Korea)*
Thermographic findings of acute appendicitis

10.00-10.20 Brioschi ML, Cimbalista M. Jr, Saito RT, Baltar AC, Takahashi L *(Brazil)*
Infrared computerized thermography in varicocele diagnosis

10.20-10.30 Miranda G. Robaina FJ *(Spain)*
Thermography in the Diagnosis of Myofascial Pain Syndrome

10.30-10.50 Coffee break

DIAGNOSIS ASSISTED BY THERMAL IMAGING II
Chair: F. Ring (U.K), Ammer K (Austria)

10.50-11.10 Maca TH, Mlekusch W, Herberg K, Minar E. *(Austria)*
Comparison of the Thermal Footprint With Pedobarography

11.10 - 11.30. Melnizky P, Ammer K, Rathkolb O *(Austria)*
Thermographic findings of the lower extremity in Patients with Type II diabetes

A FINAL LOOK INTO THE SKY

11.30-12.00 Maca T *(Austria)*
Infrared astronomy

12.00-12.10 *F.Ring* Closing remarks

14.00 Trip to the Abbey Melk in the Wachau Danube Valley

5th International Congress of Medical Thermology - Abstracts

THERMOMETRY BY MAGNETIC RESONANCE IMAGING

Oberhauser G; Pichler L; Urban M; Hruby W.

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In the last decade magnetic resonance imaging has shifted from being just an imaging tool to functional imaging. By fast imaging techniques MRI provides almost real time visualisation for interventional procedures. In 1983 the first report of temperature mapping by MRI appeared. Recently much interest has been focused on local hyperthermia using laser, microwave and radiofrequency or focused ultrasound approaches. MRI offers a unique feature for thermal tumor ablation, because the temperature induced changes within tumor tissue and in the surrounding structures can be visualized.

MRI offers several temperature sensitive procedures which could be used for MR Thermometry, such as the T1 Relaxation Time of Water Protons. the Molecular Diffusion Constant of Water and the Water Proton Resonance Frequency. The PRF method seems to be the most promising tool for monitoring interventional hyperthermic procedures. Thermosenistive T1 weighted Gradient echo sequences show a signal loss of thermal treated lesions due to the elongation of T1 Relaxation time in elevated temperature.

Thermal ablation is usually carried out under sedation and local anaesthesia. RF electrodes or laser fibres are inserted into the tumor under ultrasound , CT or MRI guidance. Patients are followed up with contrast enhanced CT or MRI.

Percutaneous ablation techniques have produced promising results, and are becoming a useful tool in the management of focal malignant disease.

In the future MRI may be used for the study of time–variable temperature changes in tissue according to some optimistic predictions in the literature.

THE THERMAL WAVE METHOD AND THERMO GRAPHY - BASIS AND APPLICATIONS

B. Wiecek, S. Zwolenik, R. Danych

Technical University of Lodz , Institute of Electronics , Computer Thermography Group , Poland

This paper presents the mathematical background of the thermal wave method based on heat transfer theory. Lock-in thermography is discussed and also im- pulse dynamic thermography. The selected applications are presented mainly for non-destructive testing, with some perspectives for medicine. Dedicated software for real-time image processing is also described.

INVESTIGATING ENERGISED SURGERY AND THERMALLY ACTIVATED FIXATOR DEPLOYMENT USING DYNAMIC THERMOGRAPHY

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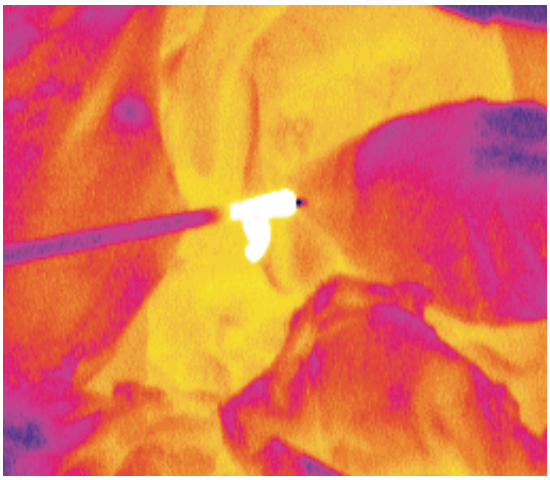
We have been interested in studying two surgically relevant procedures using dynamic thermography. The first area relates to the use of NiTi Shape Memory Alloy (SMA) as a tissue approximation device in minimal access surgery (MAS). The function of such suture-fixators is to replace conventional intracorporeal suturing as this is a difficult and laborious task during minimal access operations because of the kinematic restrictions imposed by the MAS approach. Of critical importance during the thermal activation of the suture-fixator is the dissipation of heat into the surrounding tissue. If tissue temperature becomes excessive. In order to quantitatively monitor heat dissipation processes in real time, we have undertaken thermographic investigations using an infrared imaging camera. Mathematical modelling suggests that the implementation of pulsed ($t < 0.1s$) heating minimises heat loss to the surroundings. Therefore, the specific aim of this study was to determine whether pulsed current heating could affect fixator closure whilst maintaining a safe ($T<45$ C) temperature along the body of the fixator. We present observational evidence confirming this assertion and therefore validating future employment of such devices in MAS procedures.

Our other area involves a study of thermal spread and related collateral damage to tissue during energised procedures, such as electrosurgery and ultrasonic dissection. We present our preliminary findings from a large study on porcine tissue during open surgery. We will show that complex isotherms arise which may be correlated to the level of perfusion in surrounding tissues. Our finding also indi

cates that ultrasonic dissection (at 50MHz) causes temperatures of between 250-300°C at the blades and temperatures of 150-190 at distances up to 10cm from the active site.

(a) Thermal activation of SMA



(b) Thermogram taken during ultrasonic dissection

ENDOSCOPIC THERMAL IMAGING USING ORDERED BUNDLES OF INFRARED TRANSMITTING FIBERS

Eran Rave and Abraham Katzir

Applied Physics Group, School of Physics and Astronomy, Tel Aviv University, Israel

There has been a wide interest in the development of a system that will be able to carry out thermal imaging inside the body. In the visible spectral range, physicians often use flexible fiberoptic endoscope for imaging of internal organs. These endoscopes are based on two bundles of silica glass fibers: a non-ordered bundle is used for illuminating an object inside the body and an ordered bundle for imaging. Flexible bundles, which consist of tens of thousands of individual fibers, each of diameters of few micrometers, have very high resolution. The resolution is stated in the number of lines per mm that can be transmitted through the bundle, and a larger resolution means that the optical quality is higher. A human hair can be observed in through a typical bundle whose resolution is 100 lines per mm. Thermal imaging is carried out in the middle infrared spectral range 3-30 m. The endoscopes mentioned above are totally opaque in this spectral range. We have developed a novel type of crystalline optical fibers that are extruded from single crystals of AgClBr, that are highly transparent in the mid-IR. The fibers are flexible, non-toxic and are not soluble in water. We have recently managed to extrude ordered bundles of fibers. Such a bundle can be used to transmit a thermal image of a warm body. In this case, there is no need to have the non-ordered illumination bundle, because the warm body emits infrared. We have developed rigid bundles of diameters 5-40mm and lengths of 3-6cm. Such bundles consisted of up to 10000 individual fibers and they had a resolution of roughly 10 lines/mm. An image of a human hand was transmitted through such a bundle. We also developed a flexible bundle of diameter 1mm and length up to 2 meters. Such bundles had 30-100 individual elements. In such bundles, the resolution was relatively low (few 1ines/mm) and they cannot yet be used for full image transmission. We are trying now to develop a flexible bundle with a higher number of individual fibers. Such a bundle could be used for endoscopic thermal imaging. This would be extremely useful in many medical disciplines.

CONTROL FACTORS AFFECTING THE QUALITY AND REPRODUCIBILITY OF MEDICAL THERMAL IMAGING

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The confidence one has in a clinical thermal image is dependent upon three factors: adequate patient preparation, reliable instrumentation and appropriate image capture techniques.

Thorough patient preparation is generally well understood within the thermal imaging community. Allowing the patient to acclimatise within a tem perature-controlled environment is essential to minimise the influence of ambient temperature fluctuations, physical exertion and emotional stress. However, camera performance and consistent techniques tend to be less regulated aspects of medical thermography and may have unforeseen effects.

We investigated the performance of a newly acquired uncooled FPA thermal camera using measurements from:

1.a standard black body source under a variety of laboratory conditions

2.human subjects when the imaging protocol was deliberately deviated from the optimum.

These experiments clearly evidence the need for documenting instrument performance and strict control of imaging protocol. Not only did the results demonstrate how such factors as camera stability, environment and viewing angle have on the image quality but also threshold criteria for optimal imaging techniques could be developed. Our findings have been integrated into a clinical risk assessment protocol now used at the Royal Free Hospital and it is suggested that similar assessments be performed to incorporate the technology available for each facility where thermology is performed.

TAU IMAGE: A DIAGNOSTIC IMAGING TECHNIQUE BASED ON THE INFRARED FUNCTIONAL IMAGING

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3 INFM, Sezione de L'Aquila, Italy

A new diagnostic imaging technique based on the Infrared Functional Imaging is described. Using the functional information associated with the local thermoregulatory process, this technique can help to detect and classify the stage of some disorders that alter the normal pattern of the regional thermo -regulatory system. The presence of these altering pathological factors can be revealed by means of an induced thermal stress and by the dynamics of the thermal recovery exhibited by healthy versus pathological area. The recording of the dynamic recovery – by means of digital thermograms characterised by high thermal sensitivity and a very short acquisition time – may provide a new useful imaging tool, especially for the validation and the follow up of specific rehabilitative processes.

PROVOCATION TESTS IN THERMAL IMAGING

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Infrared thermal imaging of the human body skin surface is normally carried out after a standard period of acclimatisation in a temperature-controlled room. Normal temperature patterns are known, from which clinically important abnormalities in temperature can be identified. Dynamic reactions to provocation tests can be useful when there is a possibility of loss of thermal symmetry between the two sides of the body. The effects of some work related injuries on skin temperature may also be made more obvious following such tests.

In general, provocation or stress testing the skin can be made by using one or more of the following: *Chemical, thermal or mechanical.*

1.Chemical and pharmacological skin tests are used in dermatology.[1] These may be applied allergens, or inflammatory mediators such as prostaglandins, 5HT etc. Nicotinic acid compounds in sufficient dose are known to provide local and transient areas of inflammation on the skin under normal conditions. In certain circumstances, this reaction may be inhibited or enhanced, depending on local blood perfusion to the skin and the status of the sympathetic nervous system.

2.*Therma*l tests have been used primarily to quantify the finger and toe temperatures in Raynaud's Phenomenon (2). Immersion of the hands in a water bath at 20°C or colder for a fixed period provides a useful clinical test of recovery which is related to the local perfusion and the sympathetic response. Normal subjects may produce reactive hyperaemia in the fingers, or recover baseline temperatures quite quickly (<10 mins) whereas a vasospastic reaction is marked by delayed recovery in one or more fingers. Exposure to Ultraviolet radiation may also be used to generate local inflammation, and has been used to test solar barrier creams on the skin in- vivo (3)

3.*Mechanical* tests may be based on muscular work, by performing controlled exercises and observing the muscular heat so generated. This may be absent in some cases of pain syndrome or where permanent damage to the nervous or vascular system has occurred. In vibration white finger VWF, which is work related, cold fingers and hands can occur as a result of local damage to the peripheral micro-vascular and nervous systems. Controlled contact with a suitable vibrating surface is a means of provoking a reaction in these patients. Rapid re-warming of the fingers is normal, but delayed localised recovery of skin temperature can be found in VWF.

Examples of the above techniques demonstrate that thermal imaging has a valuable role in assessing the response to provocation tests on the skin. Under standard conditions the tests can be quantitative, thus providing the means for clinical trials of pharmaceutical compounds, and evoking abnormal responses in certain injuries which affect the vascular and local sympathetic nervous systems.

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IMAGES OF THE SPECTRUM ANALYSIS OF THE CHANGES IN SKIN TEMPERATURE AND ITS APPLICATION FOR THE EVALUATION OF AUTONOMIC NERVOUS FUNCTION

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It has been reported that skin blood flow and, consequently, skin temperature exhibit several periodic fluctuations. Although the mechanisms and physiological basis underlying these fluctuations are not well understood, it is thought that the fluctuations originate in the periodic rhythms of the autonomic nervous system. In this study, a program for a far-infrared thermal imaging system was developed. This system is capable of displaying topo grams of the power spectra of an arbitrary frequency range with respect to changes in skin temperature.

Thermographic images were taken using a high-speed (scanning speed: 33 msec/frame) far-infrared thermal camera (Laird 3ME system, Nikon Co., Ltd., Japan) and recorded by a digital video recorder. The thermal data were then transferred to a personal computer and stored in the hard-disk memory.

The change in the skin temperature with respect to time at every pixel was obtained from the time series of the thermograms, and the power spectrum was calculated by means of the FFT method using a personal computer. The amplitude of the power spectrum at an arbitrary frequency range was changed into pseudo-colour at each pixel, and colour images of the amplitude mapping of the power spectrum were obtained.

To evaluate its feasibility, the system was used to analyse the difference in the distribution of the rhythms of skin temperature between healthy subjects and patients with Raynaud's syndrome.Although the numbers of both examined subjects and patients are still too small for conclusive results to be obtained, the present results suggest the possibility that the periodic fluctuations of skin temperature could become a useful tool for the evaluation of autonomic dysfunction or for the preventive diagnosis of neuro-vascular diseases such as Raynaud's syndrome.

COMPARATIVE MEASUREMENTS OF SKIN TEMPERATURES IN VITRO AND IN VIVO WITH CONTACT AND INFRARED SYSTEMS

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The determination of the accurate temperature of the human skin is not an easy task. Contact thermometers (thermistors or thermocouples) change their electrical resistance resp. their voltage with the temperature. They can be exactly calibrated, but the contact with the measured skin area influences the result. The range of influence depends on the contact mass, the pressure and the temperature of the thermometer, and of course the time of contact.

Infrared thermography as a remote measuring method has different problems: emissivity and reflectivity as well as the spectral range of the emitted radiation and the water content of the skin layer play a major role.

Comparing both methods in different applications (contact thermography systems, FPA-IR-Camera, IR-Sensor) leads to different results, in vitro as well as in vivo. The differences are stable and constant and depend on the measured surface. Each method shows reliable and reproducible results. Most applications in medical thermography have a need for a constance of temperature and less for absolute results. As a result, there is no problem when using the same equipment. With different equipment, however, it is necessary to identify the specific deviation of each system and to cross-calibrate them.

COMPUTERIZED VISUALISATION OF RADIATION INDUCED THERMAL ALTERATIONS OF HUMAN TISSUES

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2"Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene, H-1775 Budapest, POB.101.,Hungary;
3"Semmelweis" University, Dept. of Radiotherapy, H-1389 Budapest, POB.112, Hungary.

Thermography / thermogrammetry pertain to the sciences of the analysis of surface temperature fields. The methods of the temperature field analysis have visual and mathematical interpretations.

The different methods of temperature field analysis offer us some typical advantages to open up new properties. As it is known from mathematical analysis a method of higher degree enriches the knowledge of physical phenomena by a new feature, on the other hand the advantages obtained from earlier more simple processes are usually lost. This is the case in the IR-image analysis, where the order of methods, in the increase of the complexity degree, is as follows:

1. General evaluation: measurement of temperature, visualization by isotherms and relief images.
2. Mathematical evaluation: by histogram and distribution of histogram, as well by mathematical filtering.

The applicability (advantages and limitations) of infrared (IR)-images and their scientific value are determined in the medical practice by the type of the phenomenon investigated; consideration of rules of IR-optics during the IR-image-taking; proper selection of ambient parameters. Under opti-

mum conditions, the IR-image will contain all the important information on the thermal character of the examined object or phenomenon.

The evaluation of IR-images, the thermophysical characteristics and interpretation will contribute to the scientific value of IR-images. In actual practice, with IR-image analysis one may choose from three general methods, however, their relative advantages and disadvantages must be decided in the light of the tests undertaken. The first is the traditional phenomenological analysis. Two new methods serve for mathematical evaluation of temperature fields: histographic analysis, i.e. the application of the distribution curve of temperature histogram for process monitoring, and the mathematical filtering of IR-images to reveal the sites of highest temperature or of the largest temperature alterations. This paper presents these practical methods of IR-image analysis in medical diagnosis.

The analogous and digitized **temperature field** gives some general information about the local temperature distribution: the determination of the temperature at specified points of the surface under test (e.g. the centre point of a cross-hair) and comparison between temperature distribution along the horizontal, vertical or optional lines.

In **histograms** which represent temperature fields in digital IR-images, the percentages of pixel numbers with the given temperature are plotted against temperatures occurring within the fields. Temperatures occurring in the selected area may be displayed both graphically and digitally, and the ob tained data lend themselves for further computation. The **distribution curve** (D) of the histogram is the integral of that histogram. By this approach sensitive measurements can be made through the value of D for comparison of different cases (note: median is at D=0.5).

Image filtering is a special and not commonly used method of IR image analysis. The mathematical IR image filtering in general is suitable for detecting some hot spots, thermal faults which are difficult to identify other wise. Image filtering is based on the adequate transformation of the temperature field, i.e. the modification of the temperature values in the pixels of the image.

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A COMPARISON BETWEEN VISUAL AND REFLECTANCE SPECTROMETRIC ASSESSMENT OF ERYTHEMA AND THERMOGRAPHY IN THE ELUCIDATION OF DOSE-RESPONSE OF SKIN TO ULTRAVIOLET IRRADIATION IN PHOTO(CHEMO)THERAPY.

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Photoresponsive dermatoses such as psoriasis and eczema are often treated with ultraviolet therapy, either UV-A (~360nm) with topical or systemic psoralen skin sensitisation (PUVA) or with UV-B (312nm) alone (UVB). Before each course of therapy, the patients' skin is tested for sensitivity by applying to separate small patches of skin an increasing series of 6 (PUVA) or 8 (UVB) UV doses, waiting for delayed erythema to develop, then visually assessing the dose which elicits the first sign of faint erythema (the Minimal Erythema Dose, MED, for UVB or Minimal Phototoxic Dose, MPD, for PUVA). This dose determines the therapeutic dose regimen.

We studied the time course of evolution of erythema and the dose-response of skin in 11 UVB and 5 PUVA patients. We compared visual assessment of redness, single-pigment indices of erythema and melanin pigmentation and measurement of skin surface temperature using the AGA Thermovision 782 thermal camera with Btherm software.

No increase in pigmentation occurred. The erythema meter and visual assessment showed peak erythema occurred 72 hours post-irradiation for PUVA

and UVB. Thermology did not show clear progressive changes in skin temperature. Both visual assessment and erythema meter demonstrated linear dose-responses. Thermology also showed a dose-response curve for group average skin temperature, but large inter-individual variability masked this. Small increases in skin erythema are detectable using the reflectance meter before they are visible.

Although thermology can show a dose-response of skin temperature to UV irradiation, the effects of underlying tissues and of day-to-day variation in individual body temperature cause poor contrast and excessive variability in measured skin surface temperature.

PREVENTION OF HYPOTHERMIA IN PRETERM NEONATES: BENEFITS OF WATER-FILTERED IR RADIATION

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Background: Prevention of hypothermia is crucial for the outcome of pre-term neonates. Hence, they are nursed in humidified incubators or under radiant warmers. However, whereas the former are disturbed by any opening of side doors, the latter are limited by the risks of fluid loss and skin burns. Recently, water-filtered infrared (IR) radiation has become available (Hydrosun) which, due to its modified spectral composition (IR-B and -C bands filtered out in favour of IR-A), promises a better depth effect at lower surface stress. *Aim of the Study:* To test its potential benefits in neonatal care, water-filtered was compared with conventional IR radiation in *physical measurements* and *clinical observations*. *Methods: Physical measurements* were performed on Agar phantoms, adult skin, and meat slices, and focused on the surface-to-core warming ratio and on the evaporation effects of both types of radiation. *Clinical observations* dealt with the effects of additional IR-A radiators in the delivery room and with the use of conventional or IR-A „lamps“ as supplementary sources of heat in incubator care. A variety of thermometric methods, including IR thermography, were used to determine surface and/or core temperatures in the different settings. *Results:* In Agar phantoms, comparable power densities (100 mW/cm²) led to slower surface (T=+7.4 vs. +11.8 °C / 60 min) and faster core warming rates (T=+8.5 vs. +5.1 °C / 60 min) in water-filtered than in conventional IR radiation. Similar differences were found in skin temperatures of adult volunteers (T=+5.6 vs. +7.7 °C / 10 min, n=7, $p<0.01$). Moreover, relative water loss in meat slices amounted to -9.0 under water-filtered in contrast to -12.5 % / 60 min under conventional IR radiation (n=5, $p<0.01$). In the delivery room, additional IR-A radiators exerted a preventive effect on the babies' heat loss during the subsequent intra-hospital transport (T=-0.2 vs. -0.5 °C, n=25/16, $p<0.05$). Finally, in incubator care, the fall in neonatal body temperatures was less pronounced with an IR-A than with a standard IR „lamp“ as a supplementary source of heat (T=-0.4 vs -0.6°C, n=60/62, $p<0.01$). *Conclusion:* In comparison with standard radiant warmers, water-filtered IR radiators result in more efficient core warming at reduced surface overheating. Thus, in pre-term neonates, they allow an appropriate extra heat supply without unacceptable risks of fluid loss or skin burns. Even though the benefits are gradual in healthy babies, they may be fundamental in the very sick and premature neonates.

THERMOGRAPHIC EVALUATION OF ANIMAL SKIN SURFACE TEMPERATURE WITH OR WITHOUT HAIR COAT

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Dept of Clinical Sciences, College of Veterinary Medicine; Dept.of Health and Human Performance; Auburn University, AL; U.S.A.

Infrared themography has been used on various animal species for the last 30 years. During this evaluative procedure, one must consider the influence of thick hair coat (wool, fur, etc.) on imaging. Several studies have been completed in our laboratory to investigate the influence of hair coat. Our research has demonstrated the importance of recognizing both the individual species differences and regional thermal patterns of the animal. Most horses have an even hair coat that allows regional patterns to be obtained without extensive hair clipping. Similarly, most bovine, goats, dogs with thin hair coats can be imaged without clipping. While this hair coat does interfere with the emissivity of the radiant heat, patterns and thermal differences within the patterns remain consistent. In contrast, animal species such as the South American camelids (llamas, alpacas), most cats, sheep and other furry animals would require clipping and/or shearing to obtain meaningful thermograms for diagnostic evaluation. Clipping and/or shearing may create an uneven hair coat surface but additionally can cause skin irritations, rash, hair follicle infections, clip burns that will be revealed in the thermogram. Our recent studies with alpacas have shown that shearing not only provides superior quality of thermogram, but during summer thermal conditions may demonstrate improved thermoregulatory control for the animal. Sheared alpacas have a lower core body temperature during high ambient temperature than did non-sheared alpacas ($p=0.0636$). Thermographic studies of alpaca scrotums revealed cooler surface temperatures in sheared versus non-sheared ($p=0.0529$). In conclusion, thermograph imaging of the animal species should be performed in accordance to animal species, regional areas imaged, and precautions should be taken to minimize the influence of clipping and/or shearing.

DYNAMIC INFRARED COMPUTERIZED THERMOGRAPHY IN THE DIAGNOSIS OF CARPAL TUNNEL SYNDROME

M.L. Brioschi, M. Cimbalista Jr., R.T. Saito, A.C. Baltar, V.R. Flor.

Thermoclinica S/C. SOBRATERM - Brazilian Society of Thermology, Curitiba – Parana – Brazil
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Carpal tunnel syndrome is a disease which occurs mostly in people between 35 and 65 years old. It is a disabling pathology which justifies research to look for the best diagnostic method and evaluation after the treatment. Amongst the many methods used, electroneuromyography has 90% of sensitivity and 60 % of specificity, but it must not be used for evaluationg after surgical treatment because the results of this intervention may not be detected immediately. Another used method is infrared computerised thermography which is based on the fact that neurological changes of carpal tunnel syndrome are related to dysfunction in the thermoregulation of the skin. This method consists of a not invasive procedure with capacity to carry through the accompaniment of the patients and the early diagnosis of this pathology. The authors report cases of carpal tunnel syndrome of different degrees diagnosed with a thermal imager AGEMA 550 (FLIR Corp.). Using the cold stress test it was possible to evaluate the thermoregulation of the hands in real time with the software AGEMA RESEARCH 2.1 (FLIR Co.).

THE THERMAL IMAGE IN TRAUMATIC LESIONS OF THE MEDIAN NERVE

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The thermal images of 2 patients with traumatic lesions of the median nerve are reported.

Patient A: An eleven year old girl suffered from a laceration of the forearm with a complete dissection of the median nerve. About eight weeks after surgery, where the nerve was refixed by perineural stitch and the transverse carpal ligament has been dissected, clinical, neurophysiological and thermographic examinations were performed.

The infrared image showed signs of acral hypothermia of both hands. Only the radial three fingers of the affected side were visible on the thermograms.

Immediately, ten and twenty minutes after the stress test - immersing both hands in 20°C cold water for one minute - the affected fingers were thermographically amputated, whereas the other fingers showed a hyperthermic reaction.

Patient B: A 59 years old male patient presented with clinical signs of a proximal lesion of the median nerve, probably caused by an angiographic transaxillary intervention, 10 weeks previously. The reported thermograms before and after a cold water stress test showed thermal amputation of the second and third radial finger of the affected side, whereas the other fingers presented with hyperthermic recovery.

Conclusion: According to the similar pathology of the median nerve, quite different thermal patterns before and after a stress test could be seen. Common interpretation of partial or complete lesions of autonomic nerve supply cannot be applied in these cases.

THE USE OF THERMAL IMAGING FOR THE ASSESSMENT OF WORK-RELATED INJURIES.

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The diagnosis of the repetitive strain injuries related to work is sometimes difficult. In some cases it is necessary complete the diagnostic procedure with imaging such as echography or magnetic resonance imaging. An increasing number of research publications supports the use of thermal imaging for the assessment of work-related injuries. The infrared computerised thermography is a non-invasive method which detects the results of nervous, vascular and muscular dysfunctions in high resolution images. The authors demonstrate some cases of work-related injuries visualized with a thermal imager AGEMA 550 (FLIR Corp.).

COLD FINGERS AFTER KEYBOARD OPERATION: RELATIONSHIP WITH DURATION OF TYPING

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It has been previously shown, that typewriting can lead to cold finger tips of the keyboard operator. However, the relationship between this phenomenon and the duration of keyboard operation is yet unclear.

The hands and forearms of 15 healthy females, who performed type writing for 5 and 15 minutes, were investigated by thermal imaging. After acclimatization to a room temperature of 24° for 15 minutes, thermal images were taken prior and immediately after typing. The temperature of the forearm, of each single finger tip and metacarpo-phalangeal joint was determined. The findings were statistically analyzed by non parametric tests.

Baseline readings were comparable in both groups. The temperature values after writing were statistically different between type-writing for 5 and for 15 minutes. While the increase of temperature over the forearm was higher after 15 minutes typing, most of the finger tips presented with lower readings than at baseline in this group(T finger tips –0,15 ± 2,27

°K). In contrast, a high percentage of finger tips showed higher temperature values after keyboard operation for 5 minutes (T finger tips 0,8 ± 2,00 °K)., compared to both baseline readings and 15 minutes typing.

In healthy subjects keyboard operation for 5 minutes is followed by an expected increase of temperature of the forearm and fingers. After type writing for 15 minutes, a high percentage of the investigated group presented with cold finger tips despite a increased temperature of the forearm. Obviously the repeated touch of the keyboard results in a vasoconstriction of blood vessels, which counteracts the expected vasodilatation which is necessary to remove the local excess of heat produced by the muscle contraction of the forearm muscles.

MICROCIRCULATION PATHOPHYSIOLOGY IN CHRONIC REGIONAL PAIN SYNDROMES

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Chronic Pain Syndromes, migraine and CRPS/ RSD both have the following similarities:

1) a chronic pain state with associated allodynia and hyper- pathia (1,2,3)

2) regional perfusion abnormalities (4,5)

3) neuropeptide changes, e.g., CGRP (6,7)
4) A-V O^2 difference (8,9) or tissue hypoxia (10,11) and

5) role of AVAs in altering flow independent of metabolism (12,13).

The microcirculatory alterations resulting in regional neuropeptide sensitive perfusion changes can manifest as altered A V O^2 difference (8,9) or as tissue hypoxia (10,11). The release of vasoactive peptides from a remote site can also induce prolonged changes in vasomotion of the AVAs (14).

The role of AVAs in migraine pathophysiology was published by Heyck in 1956 (8).

The mechanism of action of antimgraine drugs have been studied with reference to its effect on AVAs by Johnston and Saxena in 1978 (9) and Spierings and Saxena in 1979 (15). The methodology and clinical implications of imaging microcirculatory vasomotor changes due to AVAs in migraine has been published (16,17). Thermography can image microcirculatory vasomotor changes due to arteriov enous anatamoses (AVAs) and has diagnostic and prognostic significance in chronic pain syndromes like migraine and CRPS/RSD. Drs. Swerdlow and Dalla Volta have focused on its relevance to migraine diagnosis , management and clinical course (18,19). In the diagnosis of CRPS /RSD (20, 21) baseline temperature asymmetry or stress infrared telethermography has been documented to be useful.

During the last few years, there has been increasing evidence that points to the impairment of oxygen metabolism during progression of CRPS, probably as a result of hypoxia and microangiopathic changes (10). Birklein F. et al, documented increase in skin lactate in CRPS patients probably as a result of chronic tissue hypoxia (11). Regional blood flow abnormalities are found regularly in CRPS (5). CGRP and Substance P release could explain vasodilatation and edema and indeed one study found CGRP to be increased in CRPS (18). CGRP (6) also has been documented to be increased in migraine. Deshayes P (22) indicated in order to define the course of vasomotor changes both Thermography and Capillaroscopy could be considered. Thermography demonstrates thermic gradiens in Phase I, hyper or isothermia in Phase II, and hypothermia in Phase III. Capillaroscopy can demonstrate pericapillary edema, venulo-capillary stasis and tortuosities which are only significant by their associations (22). Thermography can image neuropeptide sensitive microcirculation/arteriovenous anastomoses.

Although as a rule capillaries are regarded as being the only communication between arteries and veins, the presence of AVAs in certain organs has long been known. They were first described by Lealis-Lealis in 1707 in the male genital organs. An article by Clark in 1938 and a monograph by Clara in 1939 give excellent reviews of the literature (23).

Blood vessels are distributed profusely immediately beneath the skin. Especially important is a continuous venous plexus that is supplied by inflow of blood from skin capillaries. In most exposed areas of the body-the hands, feet and ears, blood is also supplied to the plexus directly from small arteries to highly muscular ateriovenous anastomoses. The rate of blood flow into the skin venous plexus can vary tremendously - from barely above zero to as great as 30% of the total cardiac output (24).

Popoff in 1934 published the digital vascular system (25). The digital arteriovenous anastomoses of the Sucquet-Hoyer type contains a zone of ateriovenous anastomoses located a little deeper than the web of the subcapillary arteries and veins. He indicated that the arteriovenous anastomoses must be considered as a peculiar peripheral neurovascular anatomic unit of complicated structure and important function.

The Sucquet-Hoyer canal-the entire anastomotic unit includes:
1) Afferent artery;
2) Sucquet-Hoyer canal;
3) Neuroreticular and vascular structures around the Sucquet-Hoyer canal;
4) The outer lamellated collagenous tissue and
5) the primary connecting veins.

He indicated that the entire muscular coat of the Sucquet-Hoyer canal is surrounded by a wide clear zone consisting of delicate collagenous reticulum and containing numerous nonmedullated nerves. Anatomically, arterio- venous anastomoses are div ided into two groups. The first group belongs to the

arteriovenous anastomoses of the Sucquet-Hoyer type. In man, these anastomoses are under control of the vasomotor nerves and their function is to divert rapidly the flow of blood from arteries directly into veins. For this reason, Sucquet chose for these anastomoses the name canaux derivatifs. They regulate both local and general temperature. The arterio-venous anastomoses of the second group are the direct anastomoses between arteries and veins of larger caliber. Thermography observation on rats with experimental neuropathic pain indicate the role of neural impulse activity on microcirculation and arteriovenous anastomoses (26).

Goldfert (27) in 1998 indicated that peripheral blood flow can be regulated by specialized vessel segments the arteriovenous anastomoses. Their wall consists of relatively thick layer of smooth muscle cells and the so-called epithelioid cells. The epithelioid cell is a specialized myogenic cell phenotype expressing nitric oxide synthase. He studied the innervation pattern of the different segments of the arteriovenous anastomoses in the rabbit ear using antisera against neuropeptide Y, tyrosine hydroxylase, CGRP, and substance P, as well as neuron specific enolase, calbindin D and neurotubulin and reported a correlation of the innervation pattern with epithelioid cell type in arteriovenous anastomoses and suggested that the epithelioid cells of the AVAs are controlled by a dense network of neuropeptidergic nerve fibers in functional connection to their paracrine role as a nitric oxide producer.

Molyneux GS (14), et al, studied the structure innervation and location of arteriovenous anastomoses in the equine foot and found that the innervation of the AVAs are more dense than that of the arteries and consisted of adrenergic and peptidergic nerves. Noradrenaline and neuropeptide Y containing nerves were identified as the vasoconstrictor components of the nerve supply and occurred along arteries and formed dense plexuses around AVAs. CGRP, substance P and VIP are vasodilators and were present in single nerve fibers which accompanied arteries and AVAs along the length of the dermal laminae. He suggested that the release of vasoactive peptides from diseased organs at a remote site may induce inappropriate prolonged vasodilatation of the AVAs.

Figueroa JM (28), et al, compared vascular innervation patterns in patients with and without symptoms of chronic rhinitis by immunohistochemical study of the nasal mucosa for the following neuronal markers: protein gene product 9.5 (PGP), CGRP, substance P, C termial peptide of neuropeptide Y (CPON).The following classes of vessels were identified: arteries, sinusoids, veins and arteriovenous anastomoses. Each vessel type had a characteristic innervation pattern, differing in the amount of fibers and their distribution within the adventitial and muscle layers. Rhinitic arteries and AVAs displayed a rich innervation than did nonrhinitic blood vessels.

Isidor Muffson (29) studied the responses of abnormal arterial circulation to various stimuli, i.e., intra-arterial histamine, papaverine, aminophylline, adrenaline, sympathectomy, Etamon and pain by use of radioactive sodium and suggested the possibility that the effect of histamine is mainly on the minute vessels and capillaries while that of sympathetic block is on the arteriovenous anastomoses.

Also literature gives references to AVAs in other organs like stomach, lung, heart and in the pathophysiology of Raynaud's phenomenon (30).

The pathophysiology of dynamic changes in regional perfusion / microcirculation associated with central pain mechanisms, e.g., RSD, CRPS, and migraine, can be better understood by utilizing Thermography to:
1) image neuropeptide sensitive microcirculation /AVAs,
2) evaluate preexisting vasomotor tone (31), and
3) to study their response to vasomotor and pharmacological challages. This will help us to clinically correlate the vasomotor processes that are encountered in migraine and CRPS/RSD.

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THERMOGRAPHIC DIAGNOSIS OF THORACIC OUTLET SYNDROME – A RE-EVALUATION

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Background: After using Infrared Thermography to objectively investigate paresthesias of the fingers of patients suffering from chronic pseudoneurogenic Thoracic Outlet Syndrome (pnTOS) (1), we have modified our standard procedure. This study presents the results of the re-evaluation of thermograms of patients and healthy controls, taken according to the new protocol.

Methods: After 15 minutes to adapt to the room temperature of 24 0,5°C we record thermograms of both hands. The mean temperature of regions of interest, matching the 2nd and 5th finger, is measured in different positions of the arm. Formerly we took thermo-grams of the standing patient
a) in 90° *abduction* of the upper arm, 90° flexion of the elbow, palm pointing towards the camera,
b) after *hyperabduction* test, that is positioned as before with the head turned as much as possible to the investigated side,
c) after the *fist maneuver*, that is a series of 30 times closing and opening the fist and finally
d) after a modified *Adson's test* with the arm hanging freely, the head turned as much as possible towards the contralateral side.
The fist maneuver was removed from the protocol and an image of the hands with the patient sitting, with his forearms lying *at rest* on an even surface, the palms pointing upwards, was added. The "new protocol" now consists of
A) one image *at rest*,
B) *abduction* (like a),
C) after *hyperabduction* (same as b) and finally
D) *Adson's test*.

Results: Infrared Thermograms of the hands of 34 patients and 12 healthy volunteers were recorded using a NEC San-ei thermo tracer according to the new protocol. In addition to the established method of calculating the difference of the temperatures of the 2nd and 5th finger of one hand in one thermal image, we also calculated thermal gradients for the 2nd and 5th finger respectively as follows: rest position (A) minus hyperabduction (C), rest position (A) minus Adson's test (D) and finally abduction (B) minus hyperabduction (C). Sensitivity and specificity of the results of the calculation of gradients are compared to the results of the difference between 2nd and 5th finger.

Discussion: In former studies the fist maneuver (2) never proved to be really helpful, so it was excluded from the standard procedure. Furthermore, we had to face the disappointing fact of a low specificity of

this quite sensitive diagnostic tool. The new protocol did not really change this phenomenon. Only exclusion of patients suffering from generally cold fingers (<30°C in *rest position*) increased the specificity. Of the different gradients we calculated, only "abduction minus hyperabduction" showed significant difference between patients and healthy controls. The normal values for these gradients still have to be defined. However, the new protocol needs only seven instead of eight images, and provides a picture of the hands in a position which is accepted as not being stressful for the peripheral circulation.

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THE ROLE OF ITI IN DIAGNOSIS AND MANAGEMENT OF COMPLEX REGIONAL PAIN SYNDROME (CRPS)

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Background: The clinical application of ITI in diagnosis of Complex regional pain syndrome (CRPS) has been controversial. One factor is lack of proper clinical correlation with test results.

Aim of Study: To evaluate the role of ITI in diagnosis and management of CRPS, and to correlate the thermal imaging with the patient=s clinical picture.

Methods: ITI was performed to accurately localize areas of nerve damage or dysfunction in 824 patients clinically diagnosed as CRPS by utilizing the four minimal criteria of:

1. Allodynic, hyperpathic, or causalgic pain;
2. Vasomotor and somatomotor disturbances, flexor spasm, or tremor;
3.neuroinflammation; and
4. Limbic system dysfunction in form of insomnia, agitation, depression, and poor memory (1,2).

A Bales Scientific Infrared Thermal Processor and an Agema (Flir) Infrared Thermal Processor were utilized in this study. The patients were cooled down in a 20-211C steady state room for 30 minutes of equilibration without clothing. No prior smoking for 90 minutes. A standard sensitivity of 24-341C was done. If the areas were not properly visualized, the physician would adjust the sensitivity accordingly. Two identically reproducible images recorded on laser disc were required.

Results: ITI is instrumental in early diagnosis of Complex Regional Pain Syndrome (CRPS) (3), leading to a higher therapeutic success, and higher chance of recovery (4-7). ITI is mainly helpful to obtain information regarding the nature and extent of the disease, guiding the clinician to proper management of CRPS (4). ITI provides a comprehensive picture of the entire body temperature, leading to a more accurate diagnosis of CRPS (8). Asymmetrical atrophy and edema can be identified on ITI . In acute stage, the epicenter of the damaged area is usually hyperthermic(4,9). After a few weeks, the hyperthermic area shrinks. In some cases (9) the hyperthermia persists due to permanent damage to sympathetic nerve fibers (10). This points to a poor prognosis. The hypothermic area surrounding the hyperthermic epicenter of the damaged nerve reflects up-regulation and supersensitivity of sensory nerves to norepinephrine (11-14).

ITI provides clues to differentiate CRPS from fibromyalgia. In fibromyalgia there is no temperature asymmetry between the extremities, no deviation from normal t, no focal temperature differences, no blotching (neurovascular instability), no edema, or atrophy.

ITI spares the patients from additional surgical damage to the hyperthermic traumatic focus of nerve damage of the original lesion with a surgical procedure or nerve block (

Conclusion: ITI is essential in providing the "big picture" of the body, more accurately focalizing areas of nerve damage, hence preventing further iat rogenic trauma of needle insertion, or surgery. Bone scan (25-55% accuracy) (15,16), EMG, NCV, CT or MRI cannot provide such indispensable information obtained by ITI.

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OBJECTIVE DETECTION OF BREAST CANCER BY DAT – AN UPDATE

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The feasibility of breast cancer detection using dynamic computerized infrared imaging has been demonstrated in a preliminary clinical study of 100 patients including 34 cases of pathologically established breast cancer and 66 with benign breast lesions found by pathology. Several alternative parameters and combinations of these have been tested for their effectiveness in separating cancerous breasts from benign ones. Also the separation between DCIS and invasive cancer in breasts has been explored. This report, which updates the findings published in this journal in 1999 on a much smaller number of cases and with less elaborate analysis, confirms the adequacy of DAT as an objective test method that can detect cancer in human breasts with a >98% sensitivity and >98% specificity.

MAMMOVISION™ - APPLIED INFRARED REGULATION IMAGING WITH PREDICTIVE VALUE FOR BREAST HEALTH AND DISEASES

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MammoVision™ is the resultant step using the **Infrared Regulation Imaging (IRI)** method (ReguVision™) for senology and breast health. The advanced technology of FPA cameras increases the possibilities not only for detecting but also for preventing breast cancer. Conventional regulation thermography using only few recordings on every breast is not sufficient. On the other hand, simple thermal imaging without a standardised regulation test may miss important information.

Combining both the regulation test and the detailed infrared imaging leads to a very productive result. Each breast is subdivided into 25 areas of interest. The average temperature, the min-max range, and the standard deviation can be plotted in a graphic display similar to conventional regulation thermography. By this means MammoVision™ provides much more than just a survey. In addition to the thermal pattern of each breast before and after cooling (6 images), MammoVision™ creates a graphic printout showing T_0 (black rows), T_1 (red rows) and delta-T in all 50 areas of interest.

MONITORING OF VASODILATING TREATMENT BY THERMAL IMAGING

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The results of treatment in patients with peripheral ischaemia of lower limbs are frequently difficult to assess objectively. The aim of our study was to determine usefulness of thermal imaging for monitoring the treatment with vasodilator drugs.

Material and Methods: 25 patients (54 - 68 years old, 19 females and 6 males) were examined before and after drug treatment. The studies were performed with an Inframetrics ThermaCAM SC-1000 camera. The following quantitative parameters of the thermogram have been measured in all patients: maximum, minimum, and mean temperature of regions of interest on the lower limbs.

Results: In all patients asymmetric or symmetric hypothermia of lower limbs was found at the first investigation. After treatment for 6 weeks with vasodilator drugs in 15/25 (64%) patients presented with clinical improvement. In these patients the mean temperature after treatment was higher by 0,7"C to 4,2°C than baseline readings, and correlated with clinical symptoms. In patients without clinical improvement the mean temperature was about 3,2°C lower than the temperature before treatment.

Conclusion: Thermal imaging is a useful and none invasive method for monitoring of vasodilation treatment.

REPRODUCIBILITY OF THE RESPONSE TO THE COLD WATER CHALLENGE

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Cold water challenge is a well accepted provocation test for the thermographically assisted diagnosis of Raynauds´s phenomenon. However, data on

the reproducibility of this procedure are not available.

At an interval of one week thermal images of both hands were taken before and after a cold stress test in 5 healthy subjects, suffering occasionally from cold fingers. In addition, 10 patients, with Raynaud`s phenomenon who received a placebo laser treatment, were investigated twice at in interval of 3 weeks. The temperature gradient from finger tips to the metacarpus was determined of each finger prior, 10 and 20 minutes after the cold water challenge. The reproducibility for absolute temperature readings, temperature gradient and the incidence of normal or pathological gradients was assessed by calculating the Pearson correlation, interquartile distance and Cohen´s kappa.

We conclude from this study that absolute temperature readings are only moderately reproducible. However, the qualitative assessment of normal or pathological temperature gradients shows a high degree of precision. Diagnosis of Raynaud´s phenomenon based on thermal gradients after cold challenge is highly reproducible and may have sufficient respionsiveness to be used as outcome measurement in clinical trials for patients suffering from Raynaud´s phenomenon.

DIAGNOSIS OF PRIMARY RAYNAUD'S PHENOMENON USING A PORTABLE RADIOMETER

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Objective: Cold challenge is of value in characterising Raynaud's Phenomenon (RP) in a clinical setting. However, its place in identifying cases of RP in the population is not known. In this study we assessed responses to cold challenge in a population sample of subjects with RP and in controls. The performance of individual temperature measurements in the classification of RP was examined.

Methods: The study focused on 429 positive individuals with RP and 153 normal subjects identified in a population-based twin study. RP was classified according to standard clinical criteria. All underwent cold challenge. Digital temperature measurements were taken using a Cyclops 330S Portable Radiometer –

(i) prior to immersion in water at 15^0C for 60 seconds (baseline);
(ii) immediately after immersion (drop); and
(iii) at 10 minutes following immersion (rewarm).
A logistic discrimination analysis was performed to identify which of these three thermographic variables best predicted RP.

Results: The reported prevalence of RP symptoms in the twin population was 11%. In the discriminant analysis, only baseline skin temperature contributed significantly towards prediction of RP. Using a 26^oC cut-off, RP status was predicted correctly in 69% of subjects (sensitivity: 34%; specificity 90%; positive predictive value 67%; and negative predictive value: 70%).

Conclusion: Baseline skin temperature predicts the occurrence of RP in subjects drawn from the general population and thus may be of value in supplementing existing criteria for the classification of the disease. However, the cold challenge test itself provides no additional information and is of limited value outside the clinical setting.

INFRARED FUNCTIONAL IMAGING APPLIED TO THE STUDY OF RAYNAUD' S PHENOMENON

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A non- invasive, innovative approach to the study of Raynaud's Phenomenon is proposed. In this pilot study, a simultaneous assessment of the thermal properties of all five fingers of both hands of a group of patients with respect of a control group was obtained using infrared functional imaging (IRFI). This new approach to digital vascular disease highlighted a quite different behaviour between patients with Primary Raynaud's Phenomenon (PRP) and those with early diagnosed Systemic Sclerosis (Ssc). The method is based on the use of high-resolution telethermography imaging and provides identification of objective parameters from the re-warming curves of fingertip immediately after a 2 min cold stress. The evaluation of the area under the time-temperature curve, namely the temperature integral INT, provides a figure particularly effective in describing the thermal properties of the fingertip, and which is also associated with the finger thermal efficiency. In particular, this figure is directly related to:

i) the total amount of heat exchanged between the fingertip and the environment during re-warming and,
ii) the fingertip thermophysical features.

18 healthy volunteers (Norm), 14 Secondary Scleroderma (SSc) and 8 Primary Raynaud's Phenomenon (PRP) patients were studied subsequently to clinical evaluation and nailfold capillaroscopy. A very high specificity in distinguishing the diseases was observed. This new method, compared with

other existing techniques, seems to be an objective and exact tool to discriminate between PRP and RP secondary to Ssc.

A COMPARISON OF SKIN TEMPERATURE CHANGES IN THE HANDS AND FEET OF YOUNG AND ELDERLY SUBJECTS FOLLOWING LOCAL COOLING

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Background: An important component in the regulation of body temperature is skin blood flow, especially in peripheral sites such as hands and feet. Any impairment of vasomotor control in these skin areas can, in addition to causing tissue damage, compromise thermoregulation and may, under certain circumstances, be detrimental for health. While pathophysiological related changes in the control of skin blood circulation (usually reduced blood flow) are often clearly discernible, natural age related changes in the healthy elderly are less well documented and opinions vary concerning the degree and pattern of these changes.

Aim of Study: The aim of this study was to design a reliable, repeatable and, non-invasive experimental method for examining how peripheral circulation in the extremities (hands and feet) is affected by a short period of local cold exposure and which can be easily applied to both young and elderly subjects.

Methods: The experiments, which took place in a climatic chamber under thermoneutral ambient conditions (T_a 26 -28°C), were carried out in 12 young male (mean age 25 years) and 8 elderly female and 4 elderly male (mean age 77 years) healthy volunteer subjects. During the experiments, the lightly clothed subject sat in a comfortable stool while resting either their hands or their feet (palm/sole down) on a thin grid made of nylon netting. Following a 30 minute control period to establish base line values (a generally vasodilated state with particular emphasis on the presence of thermal symmetry between the left & right sides of the body) the right hand or the left foot was immersed for a period of 2 minutes in 10°C water (a thin plastic bag was worn during the immersion period to avoid skin wetting). Throughout the experiments measurements of surface temperatures (infra-red thermal imagery and thermocouples) and skin blood flow (laser Doppler flowmetry) were made at multiple skin sites. Blood pressure and heart rate were also measured. Calculations were made of the time taken for skin temperatures in the 'cold' hand or foot to regain 80% of the cold induced drop in temperature (recovery time).

Results: None of the subjects found the experiments to be discomforting.

The main findings were:
1) Under thermoneutral ambient conditions skin temperatures on the hands and feet were lower in the elderly than in the young subjects.
2). Under thermoneutral ambient conditions skin temperatures on the feet were always lower than on the hands in both the young and elderly subjects.
3) Recovery time after cooling was always longer in the elderly subjects, both for hands and for the feet.
4) In both young and elderly subjects recovery time was always shorter for the hands than for the feet.

Conclusions: The results clearly indicate that the peripheral responses to local cooling differ in the hands and feet and, in addition are altered with increasing age. The sensitivity of the method indicates that it may be a suitable model for the early detection of blood flow disturbances associated with peripheral arterial disease.

THERMAL COMPUTERIZED CORONARY ANGIOGRAPHY FOR INTRAOPERATIVE EVALUATION OF CARDIAC PERFUSION: PRELIMINARY EXPERIMENTAL STUDY AND THE FIRST CLINICAL APPLICATION IN BRAZIL

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The great technological development of the last decades in the world, has improved the intraoperative control of surgical techniques. Specifically in cardiac surgery, one of the most recent and modern techniques is thermal computerized coronary angiography (TCCA). TCCA is a non invasive method, without physical contact, without contrast media, and without harm to the patient, which has high sensitivity and offers instantaneous anatomical evaluation. In cases of coronary occlusion, a frequently used solution is the re-perfusion by mammary or saphenous bypass. An inadequate or insufficient anastomosis can result in new surgery or even a fatal stroke in the post-operative phase. The results expected with this method are increased success rates of surgery, and by improving the surgical procedures by this technique a significant reduction of re-interventions and deaths. Studies of MOHR (1989) and FALK (1995) using TCCA, have established two findings: the presence of 5% of defects in the anastomosis and the necessity of intra-operative change of the surgical procedure in 16% of the cases. The objective of this preliminarily study was to verify the viability of TCCA in the evaluation of the coronary perfusion in dogs. Proven the efficiency without any harms, the method was intraoperatively applied in a patient before and after the arterial re-vascularization with arterial (IMA) and venous grafts (SV) using a thermal imager AGEMA 550 (FLIR Corp.). The differences of temperature to $0{,}1^{o}$ C, map the passage of the warm blood against the cooler myocardial wall, and provide successful evaluation of the anastomosis and the irrigation of the cardiac muscle.

THE USE OF THERMOGRAPHY IN CHILDREN WITH ORTHOSTATIC DISORDERS OF THE CARDIOVASCULAR SYSTEM – A NEW DIAGNOSTIC METHOD

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Vasomotoric functional disorders in the resistory and venous blood vessels are vital in patho- mechanism of orthostatic disorders in children. They are caused by regulation disorders of the autonomic system. Clinical symptoms such as fainting as a result of decreased blood flow in the common carotic artery and brain vessels are sometimes observed .

The orthostatic test is one of the most important methods for detecting these disorders .

The aim of the paper was to evaluate thermal imaging for diagnosis of cardiovascular disorders located in the upper part of the body in children, particulary in the head, which may cause thermal changes in the skin caused by disturbance of the peripheral microcirculation .

30 children with orthostatic disorders were included in the study, a control group was also included with healthy children .

The new generation Inframetrics 760 thermographic camera was used for the analysis. The study showed the accuracy of thermography as a new , non - invasive method of examining the blood vessels system for the diagnosis of orthostatic disorders in children.

THERMOGRAPHY FOR THE DETECTION OF VARICOSE VEINS OF THE LEG

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The location of perforating incompetent varicose leg veins, is still difficult with any single diagnostic method. One solution to overcome this, may be the combination of two different techniques using the advantages of both. Thermography is used to detect sites of elevated temperature, indicating an retrograde stream of hot blood from deep veins to the surface via incompetent veins. In combination with duplex ultrasonography, thermal imaging it is a pain free method. As it is not invasive, the diagnostic procedure is less uncomfortable for the patient. A high diagnostic accuracy of the combination of thermography with duplex u/s examination, reduces the examination time significantly.

The authors show varicose veins diagnosed with a thermal imager AGEMA 550 (FLIR Corp.). Applying the Trendelenburg maneuver, incompetent veins of the legs were evaluated in real time using the software AGEMA RESEARCH 2.1(FLIR Corp).

IMAGING EXTRACRANIAL TRIGEMINOVASCULAR SYSTEM IN CHRONIC PAIN SYNDROMES

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The trigeminovascular system has been implicated in chronic pain syndromes eg., migraine (1) and CRPS/RSD (2). Elevated levels of CGRP of trigeminal origin was seen in the external jugular blood of migraine patients. Drummond and Finch detected asymmetry of the forehead temperature in the trigeminal distribution before sympathetic blockade in 8 of the 9 patients with RSD, suggesting that autonomic disturbances in this condition may influence cervical sympathetic outflow. The release of vasoactive peptides from a remote site can induce prolonged changes in vasomotion of the AVAs (3).

Both conditions have microcirculatory disturbances of regional distribution (4,5). Thermography can image dynamic changes in the microcirculation ie., AVAs in the trigeminal and regional distribution. Committee for the Protection of Human Subjects approved Methodology for using dynamic thermography to image ie., microcirculation/AVAs under the regional control of the ophthalmic division of the trigeminovascular system (ie.,extracranial CBF) has been published both for vasoconstrictor and vasodialator stress (6). Extracranial CBF measurement requires a protocol involving changing rather than static conditions such as superimposed cerebrovascular/vasomotor and pharmacological challenges in determining changes in regional flow to understand control processes that may occur in response to dynamic conditions. The alteration in extracranial CBF depends on pre-existing vasomotor tone of the individual (7), i.e., the primary vasoactive response and the biological limit of vasomotion, i.e., the magnitude of vasoconstriction and vasodilatation. Extracranial CBF imaging allows us to visualize functioning AVAs in real-time and monitor neuropeptide sensitive changes in microcirculation. Normal vasomotor response is either vasoconstriction or vasodilatation. When altered or paradoxical vasomotion is seen, it is probably due to AVAs and can be seen in response to:

1) biological nonthermal vasomotor stimuli, i.e., induced hyperoxia or induced hypercarbia;
2) pharmacological, ie., vasoactive drugs: beta blockers, calcium blockers or triptans or due to
3) changes in the baseline vasomotor tone.

In migraine and CRPS/RSD there is evidence of decreased A-V O2 difference and tissue hypoxia. In migraine extracranial AV shunting has been documented by decreased A-V O 2 difference in the side of the migraine headache (8,9). Different vaso- active properties of the extracranial vascular receptors (10,11,12) may have a role in its capacity to alter extracranial flow independent of the metabolism. During the last few years, there has been increasing evidence that points to the impairment of oxygen metabolism during progression of CRPS, probably as a result of hypoxia and microangio-

pathic changes (13). Birklein et al (14), documented increase in skin lactate in CRPS patients probably as a result of chronic tissue hypoxia. Further study by imaging the trigeminovascular dysfunction in patients with chronic pain, e.g., migraine and CRPS can help us to understand the pathophysiology of microcirculation and AVAs with neuropeptide sensitive regional perfusion changes.

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UNFAVORABLE OUTCOME AFTER SUCCESSFUL PERCUTANEOUS INTERVENTION IN PATIENTS WITH INCREASED TEMPERATURE OF CULPRIT ATHEROSCLEROTIC PLAQUES

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Background. Previous studies have shown increased temperature in human atherosclerotic plaques. However, the prognostic significance of atherosclerotic plaque temperature in patients undergoing successful percutaneous intervention is unknown.

Methods. We prospectively investigated the relation between temperature difference (t) between the atherosclerotic plaque and the healthy vessel wall and event-free survival among 86 patients with coronary artery disease undergoing successful percutaneous intervention. Temperature was measured by a thermography catheter (previously validated). The study population consisted of patients with effort angina (34.5%), unstable angina (34.5%) and acute myocardial infarction (30%).

Results. t was increased progressively from effort angina to acute myocardial infarction (0.132 0.18°C in effort angina, 0.637 0.26°C in unstable angina, 0.942 0.58°C in acute myocardial infarction). The median clinical follow-up period was 17.88 7.16 months. t was greater in patients with adverse cardiac events compared to patients without events (t: 0.939 0.49°C; 95% C.I [intervals 0.72– 1.14] vs 0.428 0.42°C; 95% C.I.[0.33–0.52], P<0.0001).

Conclusion: Increased local temperature in atherosclerotic plaques is a strong predictor for an unfavorable clinical outcome in patients with coronary artery disease undergoing percutaneous interventions.

PRE-OPERATIVE LOCALIZATION OF PERFORATING ARTERIES IN RECONSTRUCTIVE PLASTIC SURGERY

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Perforating arteries have a great importance in plastic surgery, mainly in performing viable fascio-cutaneous and musculo-cutaneous grafts, because the may prevent avascular necrosis after surgical procedure. In the attempt to locate them, many diagnostic methods have been employed: magnetic resonance imaging, echography, colour Doppler, thermography evaluation of perforating arteries (TEPA), angiography and combinations of the two methods. The TEPA is a non-invasive method of great accuracy when used on the trunk and also on the extremities, and is well accepted by patients. It can be optimized when combined with the colour Doppler. The colour Doppler has limitations due to the incapacity to create images. In contrast, echography, already accepted in daily routine, is a fast and cheap method compared to other diagnostic methods. The arteriography capable to supply two and three-dimensional images, must be reserved for special cases because it is invasive and involves ionising radiation. The authors present a study which compares the echography with the infrared computerized thermography in the accurate localization of the perforating arteries.

THERMAL IMAGING IN BACK PAIN - A COMPARATIVE STUDY

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Objective: Investigating differences in thermal images of patients with both acute and chronic back pain, and comparison of these images with thermograms of the same area in healthy subjects.

Methods: We examined 272 patients, athletes and non-athletes, with acute and chronic back pain and compared their thermal images with thermograms of 75 healthy people. Hot and cold spots as well as paravertebral thermal asymmetries were observed using thermographic measurement. Mean age of both groups was similar (25 yrs) with slightly more males in the group of patients compared to equal presence of both sexes in the control group.

Results: Non significant differences were found between the group with acute back pain (both atletes and non-athletes) in comparison with the group of chronic back pain (both athletes and non-athletes). Differences were observed between the group of chronic back pain of athletes and non-athletes, where local hyper/hypo changes were significantly more frequent in athletes ($p<0,000$) while temperature asymmetry was more frequently observed in non-athletes ($p<0,001$). Differences were detected also between the control group and the groups of both acute and chronic back pain in athletes. In the control group more local changes without painful manifestations were observed. In the patients, more temperature asymmetry in the SI area were found. In general, the most thermo-pathological local findings were observed in the cervical and thoracic area. Temperature asymmetry of hands were detected in 10,6 % of the control group.

Conclusion: The back area in subjects with and without symptoms is a very difficult task for differentiation and interpretation of thermographic findings. Our study draws attention to the fact, that temperature asymmetries reflect more severe pathological findings than local changes.

IR IMAGE STANDARDISATION OF VARIOUS SPINAL DISEASES

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Common spinal disorders are degenerative spinal disease, spinal cord tumor, spinal injury, spinal malformations, etc. Such patients suffer from various kinds of pain and discomfort. IR Imaging can detect pain caused by various spinal disorders with high sensitivity and specificity. To achieve this, stand ardisation of the imaging procedure is very important.

Since 1990 Digital Infrared Thermographic Imaging (DITI) has been used in various spinal disorders and a standardised imaging procedure was established for various spinal diseases.

By analysis of IR images of healthy subjects and patients with disk herniation, the cervical and lumbar thermatomes of the spinal nerve roots were investigated and abnormal temperature differences in the arm and the leg in spinal disorders determined. The subjective level of pain was correlated with the thermal image. We analysed the thermograms of 55 healthy subjects and the preoperative thermograms of 217 patients with unilateral disk herniation at a single lumbar level to determine the lumbosacral thermatomes. Temperature was measured in 78 sectors of each thermogram. The T-test was used to compare thermatomal temperature readings between healthy subjects and patients with single level radiculopathies. The distribution of the thermatomes for the roots l3,L4,L5 and S1 was mapped.

Thermograms of 50 healthy subjects and the preoperative thermograms of 115 patients with unilateral disk herniation at a single lumbar level were used to determine the cervical thermatomes. Temperature was measured in 110 sectors of each thermogram. The T-test was used to compare thermatomal temperature readings between healthy subjects and patients with single level radiculopathies. Based on this results, the distribution of the thermatoms for the roots l3,L4,L5 and S1 was mapped.

These studies provided a sufficient number of data to calculate the normal temperature distribution of the neck, the arms, the low back and the legs and established the 95% confidence interval of the minimal temperature difference in each sector. For the correlation of subjective pain and temperature differences, we analysed the intensity of pain, the duration of symptoms, the degree of disk herniation and the side to-side temperature difference of the legs in patients with lumbar disk herniation. A high correlation was between severe pain, high degree of disk protrusion, recently onset of symptoms and increased side-to-side temperature difference of the legs.

In conclusion, IR thermography is a very useful method for the diagnosis and patient management, both prior and post surgery. Standardisation of IR imaging has confirmed the effectiveness and diagnostic accuracy in various spinal disorders.

COMPUTER ASSISTED INFRA RED IMAGING FOR THE DIAGNOSIS OF LUMBOSACRAL RADICULOPATHY

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Aim of the study: Thermography is not an established method for the assessment of radiculopathy. A review by Hoffman et al (1) from 1991 concluded, that thermal imaging should be used for research only and not in clinical routine. This statement was based on the evaluation of 28 papers selected from a total of 81 references. As no paper published after 1990 and only 2 papers reporting computerised infra red imaging were included in

the references, an update of this review seems useful.

Method: The journal "Thermology International" publishes a literature review every year, which searches the database Medline for publications about thermography. An additional hand search was performed in thermographic publications such as "Thermology International", proceedings and other thermographic journals. Papers were included, if there were clearly reported patients with signs or symptoms of radiculopathy (not just back pain). A description of the thermographic method and quantitative data of thermographic findings were also required for inclusion.

Results: Only 3 publications met our inclusion criteria. The paper of McCulloch et al. (3), ranked top in methodology, and found thermography to be invalid. A clear description of the study, 2 blinded observers, a sufficient number of well defined patients and healthy controls are the strengths of this particular study. However, the description of the applied method for performing and interpretation of thermal images was insufficient. The chosen room temperature of 20-22°C which might have been too low for the identification of hypothermic areas. The evaluation of thermal images was based on the criterium that at least 25% of a dermatome present with hypothermia of 1°C compared to the contralateral side. This method of interpretation might have been feasible for contact thermography, but does not meet the requirements for modern quantitative infrared imaging.

The paper of Takahashi et al (4) showed that the thermal deficit detected by infrared imaging is a additional symptom in patients with radiculoapathy . Hypothermic areas did not correlate with sensory dermatomes and only slightly with the underlying muscles of the hypothermic area. The diagnostic sensitivity (22.9-36.,1%) and the positive predictive value (25.2-37.0%) was low for both, muscular symptoms such as tenderness or weakness, and for spontaneous pain and sensory loss. In contrast, high specificity (78.8-81.7%), high negative predictive values (68.5-86.2%) and a high diagnostic accuracy were obtained. The authors conclude, that thermal imaging is a valid tool for the *exclusion* of non organic complaints.

Only the paper Kim & Cho found thermography of high value for the diagnosis of lumbosacral radiculopathies. However, this study has several methodological flaws. Although a high number of patients was reported, healthy control subjects were not described. The clinical symptoms were also not described, therefore on the basis of this paper, the reliability of the thermographic diagnostic criteria used in this study remains unproven.

Conclusion: There is still a lack of evidence for the value of thermal imaging as a diagnostic method in lumbosacral radiculopathies. However, the reviewed publications have added new aspects to the thermal symptoms of this impairment. Thermal changes in radiculopathy need to be studied further with respect to the quality (hyperthermia verso hypothermia), the topographic distribution (in dermatomes, in thermatomes, spot patterns) and pathogenesis (sensory, motor, autonomic) of temperature findings and an optimal protocol of investigation (room temperature, location and number of region of interests, temperature difference etc) must be included. The new protocol and the results must be finally tested in a rigorous and scientific way.

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DIGITAL INFRARED THERMOGRAPHIC IMAGING FOR DIAGNOSIS OF OSTEOPOROTIC COMPRESSION FRACTURE IN ELDERLY PATIENTS

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With the improvement of social and economical conditions, the quality of life in elderly subjects has become of great concern. Elderly patients may have multiple combined diseases such as degenerative disc disease, degenerative osteoarthritis, rheumatic diseases etc. They complain of generalized aches of the body in multiple locations. Recent changes in the spine such as osteoporotic compression fractures can be neglected without concern. But osteoporotic compression fractures are common in elderly and may cause a severe pain at the compression site. Some patients have already developed unknown osteoporotic compression deformities at multiple levels. It is very important to detect the pain by compression fracture and differentiate the recent from old asymptomatic compression fractures in the management of osteoporotic patients.

We analysed the pre- and post surgery performed IR images of 78 patients with osteoporotic compression fractures. The diagnostic sensitivity and specificity of DITI was studied with a specific focus on the ability to differentiate between recent fractures and pre-existing vertebral compression. The thermographic patterns in patients with acute pain by a recent fracture were also analyzed. Vertebroplasty with resin was performed in all patients as treatment for their recent osteoporotic

compression fracture. After surgery, IR images were recorded in all patients.

The thermographic pattern can be classified as localized hyperthermia (57%), bandlike bilateral hyper- thermia (29%), diffuse hyperthermia (14%), Among them, localized hyperthermia and bandlike bilateral hyperthermia corrrelated well with the compression level. In multiple compression fracture the hyperthcrmia was localized at the most recent fracture level. Therefore, DITI may be is very useful to differentiate recent and pre-existing vertebral compression. The thermal change(T) was higher in the acute and more severe pain group.

After vertebroplasty, the localized pain was much improved in all cases and postoperative thermography also showed a marked reduction of hyperthermia .

In conclusion, IR imaging can detect thc painful osteoporotic compression fracture with high sensitivity(94%) and it can differentiale acute symptomatic compression from old asymptomatic lesions. the postoperative clinical result correlated well with the thermal imaging.

Digital Infrared Thermographic Imaging is useful for diagnosis and management of osteoporotic compression fractures in elderly paticnts.

COMPUTER ANALYSIS OF THERMOGRAMS FROM SPINAL DEFORMITIES IN CHILDREN

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Introduction: Vertebral column deformities occur in 3 % of the children and teenagers population and are a serious diagnostic, therapeutic and economic problem. Commonly used diagnostic methods are based on X-rays which may be harmful to patients health. Photogramometric methods although harmless are not precise enough. Independently of scoliosis etiology, an imbalance of the paravertebral muscles tension can be observed in every case. It causes metabolic changes of muscle tissue which lead to changes of the working muscle temperature [1, 2, 3, 7, 14]. We attempted to create a new diagnostic method for vertebral column deformities based on thermographic measurements in the para- vertebral region. The analysis of the obtained images requires sophisticated computer processing which makes the method highly precise and objective.

Measurements: Groups of 200 healthy and 100 dieseased subjectss in the age between 10 to 17 years old from counties in Poland as such Zakopane, Cieszyn, Wroclaw, Mikolów were examined. Images were obtained with the thermographic camera type AGEMA 470 with optical resolution 140 x 140 pixels at a room temperature of 21 $\pm$0,5°C. The subjects undressed to the waist, spent 20 minutes in the waiting-room before examination. Air stream convection in the examining room was restricted and the influence of all heat sources was eliminated. The camera was placed on the stand in the distance about 2 m from a patient. Patients stood undressed with their back to the camera, upper limbs were abducted and the pants were lowered to the half of the nates. Spinous processes of vertebra C7 (cervical) and L5 (lumbar) were marked on the back of each patient.

*Image processing:*Based on theoretical conditions relating to temperature distribution in paravertebral regions and their relationship with spinal column curvatures one may suppose that the temperature is higher on the concave side of the scoliosis. According to this and to work analysing mechanical instruments, a relationship between the degree of scoliosis and the differences in temperature distributions on both side of vertebral column may be expected [4, 6, 8, 9, 10].

It is necessary to average temperature distributions on the left and right side of the vertebral column in a certain region and to calculate temperature change along the vertical axis. For this analysis X-ray and thermographic images must be related.

For image processing Matlab pack was used together with its tools:
Real Time Workshop- real time connection to external hardware;
Image Processing
Neural Network- training the network to intentify the vertebral column position on the X-ray image.

X-ray picture processing: The following operations were performed on the roentgenogram using a scanner type PFU DL2400 pro

Image acquisition

Histogram alignment

Low-pass filtration

Vertebral column shape detection

The last operation of spinal curvemarking is realised using feed-forward backpropagation network [11, 12, 13]. This network had been trained earlier and was used here in ready-made form.

Thermogram processing: Image from the camera is transferred to the PC with floppy disk or video connection. Initially image format *.img or *.ana is introduced to Matlab environment and converted to the matrix form which elements are temperature values assigned to single pixels. On such image following operations are performed completely automatically:

Filling the background with patient average temp. value- it enables the usage of entire colour map.

Image binarization with lower threshold

Object gravity centre calculation

Marks location on patient back
Identificationof the spinal curve on the thermogram as a black line

Average value calculation from paravertebral regions on both side of the defined spinal curve

Programme description: Complete image processing and verification of the data were performed using the author's program written in Matlab which main window is shown in figure 1.
The presented program enables :

Edition of image recorded with AGEMA camera 470 and 590

Basic image processing e.g.- fragment cutting, filtration or changing colour palette.

Marking the spinal curve manually or automatically based on X-ray pictures

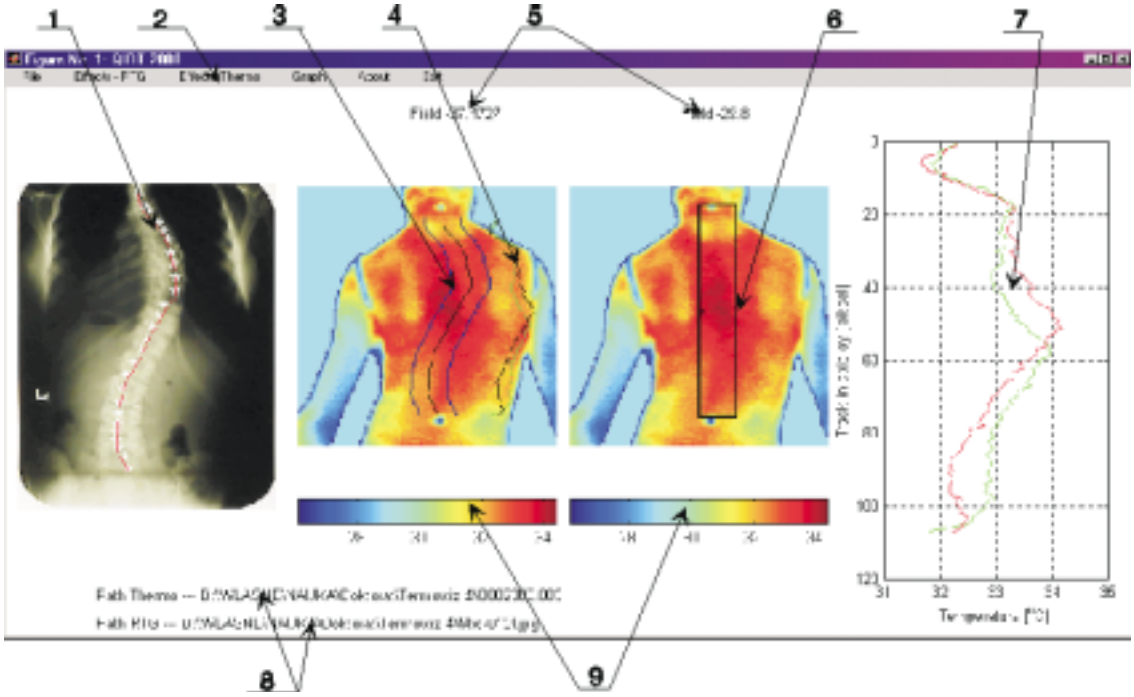

Figure 1
2. Program main menu: 1) marked spinal curve 2) menu for saving, opening and processing images, 3) spinal curve with lines limiting analysed pixels to average values, 4) and 7) average values diagram of analysed region on the left and right side, 5) area value under the difference of curve 7, 6) automatically marked range of spinal curve, 8) access paths to images, 9) colour palette "jet" type in which images were shown.

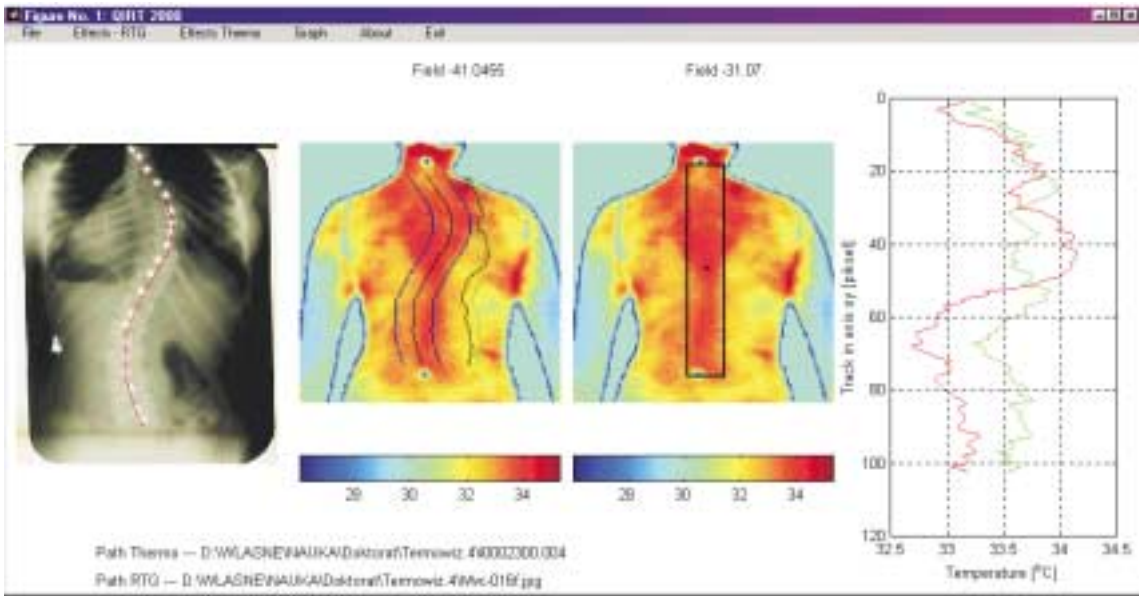

Figure 2. Evaluation of a typical patient with scoliosis

Placing of the spinal curve on thermogram manually when there are no markers or automatically when they are present

Marking the spinal curve when no X-ray is available.

Calculation and drawing average temperature value on both side of vertebral column which is an average value of n pixels for each horizontal line on both side of marked regions.

Calculation of area value under the curve which is the difference previously calculated average values

Saving of the calculations and processed images

Marking ofthe spinal curve is completely automatically possible, when sequences of images are analysed. In such case it is necessary to give the range of analysed pictures and to place markers on the patient´s body for thermal imaging.

Clinical conclusions: A typical scoliosis with temperature distribution analysis is shown in figure 2.

The crossing of both average temperature lines which occurs always in the apex of the scoliosis is very characteristic (green colour- right side, red one- left side). Another significant findings is the difference of temperature on both side of the vertebral column, which is always higher on the concave side of the scoliosis.

Analysis errors: Error in average temperature values calculation is the result of finite optical resolution of the image (140 x 140 pixels), temperature resolution of the camera (0,1 ^{o}C) and inaccuracy in spinal curve marking. Based on this and on analysis presented in [5] total error of average temperature. values calculations can be estimated on 10% level.

Summary: The advantages of the presented system are

Non-invasive assessment of scoliosis at early stage

Automatic evaluation of images

Possibility of storing data to archives

Grant No 4PO 5D 06715

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OUTCOME EVALUATION OF ANTERIOR CERVICAL SEQUESTRECTOMY WITH DIGITAL INFRARED THERMOGRAPHIC IMAGING

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Background: Anterior cervical discectomy without fusion has been shown to be an effective alternative to microsurgery for the treatment of cervical disc herniation. This can be accomplished with the anterior cervical foraminotomy procedure that ws refined by Jho in 1996, but the literature contains no report of anterior sequestrectomy for sequestered disc herniation patients with acute, intractable cervicobrachial pain. This prospective study was designed to evaluate 6-months results in symptomatic cervical disc herniation patients treated by anterior cervical sequestrectomy.

Methods: Between June 1998 and May 2000, 60 patients underwent anterior cervical sequestrectomy for cervical disc herniations. In June 1998 the senior author began a prospective study of all patients who were scheduled for anterior cervical sequestrectomy presenting with intractable cervico- brachial pain, confirmed by computerized tomography (CT) and/or magnetic resonance imaging (MRI): Digital infrared thermographic Imaging (DITI) was performed in all patients prior to re surgery, and 6 weeks and 6 month post surgery.

Results: The male/female ratio was 42:18. The mean age was 38.2 years. The clinical success rate was 92,4% at 6 weeks and 95,35 at 6 months (difference statistically not significant). The thermographic success rate was 89,3% at 6 weeks and 91,4% at 6 months (difference statistically not significant). No significant difference was observed between clinical and thermographic rating at any follow-up point.

Conclusion: We suggest that clinical and thermographic improvement after anterior cervical sequestr-

ectomy can be maintained for 6 months after surgery. DITI seems to be useful method for follow-up as it show a high corellation with the clinical outcome.

EFFECTIVENESS OF OXYGEN-OZONE THERAPY IN THE TREATMENT OF RADICULOPATHY CAUSED BY DISK HERNIATIONS

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The infra red thermography method is able to detect the infrared rays emitted by the source to be explored and transform them into a visible image. The image detected is displayed through a colour range, from yellow to green, based on different thermal gradients, where yellow corresponds to maximum infrared emission, that is to say heat, and green to minimum emission. It is therefore possible to obtain a thermal map of the body cutaneous surface, which is symmetrical in a healthy subject, when compared in the two sides of the body, and reproducible over time. Thermal map variation are related to the vascular tone of the cutaneous microcirculation which is mainly regulated by the activity of the Autonomic Nervous System (ANS). In a lesser way it is also influenced by the systemic vasoconstricting action of Adrenaline, Vasopressin and by the indirect action of Aldosterone. Any pathology which is able to alter the ANS control, both in central and peripheral sites, can alter the cutaneous thermal picture. In particular, the radicular compression determined by a disc hernia in the lumbosacral site entails irritation of the orthosympathetic nervous system which accompanies the motor sensitive root, determining a vasoconstriction in cutaneous microcirculation (cold image) relating to radicular innervation. A neurolytic block of the vegetative fibres, on the other hand, will produce a "hot" image due to the predominant vasodilating activity of the parasympathetic nervous system. The purpose of our study is to search for a direct correspondence between the thermographic, neuroradiologic and clinical pictures found in patients affected by lumbar disc hernia before and after the analgesic treatment with Ozonetherapy.

Our study included the evaluation of 25 patients diagnosed with lumbar sciatica form radicular compression due to lumbar disc hernia. The patients were subject to thermography of the lower limbs before and after the analgesic treatment with Ozonetheraphy. Before the treatment, all the patients had shown an asymmetrical thermal pattern of the lower limbs consisting of: hypothermia (0.5°C greater than the counter-lateral limb) in the cutaneous zone involved in the radicular innervation affected, and hypothermia in the lumbo-sacral area corresponding to the relevant discal space detected with the resonance imaging. Such patients were subject to Oxygen-Ozonetherapy treatment (10 biweekly sessions) with bilateral paravertebral infiltration of 12 cc of O2/O3 mixture at 20 mcg/mL. At the end of the treatment, the 25 patients were clinically re-evaluated by means of thermography and NMR of the lumbo-sacral radix. A strict correlation was thus detected between the clinical resolution, shown by the neuroradiologic picture (with a favourable outcome for 19 patients) and the disappearance of the thermal asymmetry detected by thermography. In the case of the 6 patients for whom only a partial benefit was shown after Ozone- therapy in both the clinical and neuroradiologic pictures following , only a partial reduction of cutaneous hypothermia was also shown by thermography

THERMOGRAPHIC RECORDING OF THE ACRAL TEMPERATURE REACTION (ATR) DURING DIFFERENT TECHNIQUES OF NEEDLE ACUPUNCTURE

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The Acral Temperature Reaction (ATR) was described in the literature as an alteration of the temperature of the skin surface , which was determined by contact thermometry in single spots. Compared to contact thermometry, quantitative infrared thermography provides a means of mapping absolute temperatures and to investigate temperature distribution on the surface of the body. The acral temperature reaction was determined by infrared thermography quantitatively in a prospective, randomized single blinded study, by mapping the acren of the hands. Needle acupuncture was performed in 8 volunteers on the left arm at the acupuncture point Large Intestine 11 or at a placepo point: Each point was treated nine times. Temperature readings from regions of interest located on the acren of the hands were statistically analysed according to an independent sample design. Significant differences were found between real and placebo acupuncture with respect to the amplitude of the acral temperature reaction. Only the cooling effect was significantly more increased after the sedating needle technique than after placebo treatment, but in contrast, cooling and temperature recovery was significantly more enhanced after tonizising acupuncture than after placebo.

The change of the skin temperature was significantly different during the total time of observation. Tonizising acupuncture is followed by vasodilation and higher temperature in the finger tips caused by increased blood flow. The sedating technique leads to vasoconstriction with decreased blood flow and cold finger tips. Finally , the limitations of the study are discussed with respect to study design, which anticipates the special framework for acupuncture research.

THERMAL IMAGING FOR VISUALISATION OF THE BRONCHIAL TREE IN ASTHMATIC PATIENTS – A PRELIMINARY STUDY

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The increasing frequency of asthma bronchitis creates certain difficulties in patients treatment. This report documents the usefulness of the thermal imaging in visualisation of the bronchial tree.

Material and Method: Four asthmatic children, aged 8-12 years (2 males and 2 females) were investigated during acute bronchospasm. Thermal imaging was performed before using broncho-dilating inhalant drugs (Pulmicort in aerosol), next after 3 inhalations, following after 1 min. and 2 min. inhalant therapy. Inhalant therapy was conducted under spirometry control. Follow up with thermal imaging was performed in the same patients after clinical improvement. For thermal imaging a Inframetrics ThermaCAM SC-1 000 camera was used.

Results: In the first phase of examination the mean temperature of the region of interest was 35,8'C and visualisation of the bronchial tree was poor. In the second phase of the registration after successful treatment the mean temperature was lower: 350C with an improved thermal pattern of the bronchial tree. The thermal imaging results correlated with clinical improvement.

CORRELATION BETWEEN INFERTILITY IN WOMEN AND DITI

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Causes of infertility include a wide range of physical, as well as emotional factors. In Oriental medicine, women's infertility is believed to be caused by the deficiency of the Chung and Ren vessel. Then the Kidney Qi is collapsed and cold. Many infertile women complain of cold hypersensitivity and / or body coldness, especially on the lower abdomen, back and knee. The aim of this study is to examine the interrelationship between infertility and body surface temperature.

The 25 infertile women were allocated as infertility group and 25 fertile women (experienced delivery or pregnancy), as a control group at the Kang- nam Korean Hospital, KyungHee University, Seoul, Korea, from April to December 2000. Thermographic observations for this study were made using the Dorex DITI on 3 different areas of cold hypersensitivity: lower abdomen, back and knee.

All data were coded for computer analysis and significances were tested by the Mann-Whitney Test.

The mean T for abdomen cold hypersensitivity was 0.25 ± 1.77° in the control group and 1.00 ± 0.39° in the infertility group. The mean T for back cold hypersensitivity was 1.75 ±.40° in the control group and 1.21 ±0.58°, in the infertility group. The mean T for knee cold hypersensitivity was 0.65 ± 0.70° on control group and 1.32± 0,58° in the, infertility group.

It was revealed that the cold hypersensitivity on the lower abdomen, back and knee are significantly related to the infertile women. These results do not conflict with the view of Oriental medicine.

According to the above results, it is concluded that the body surface temperature, cold hypersensitivity and/or body coldness, have a great effect on women's infertility.

AN EVALUATION OF THE SENSITIVITY AND SPECIFICITY OF DITI FOR THE DIAGNOSIS OF COLD HYPERSENSITIVITY

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Cold hypersensitivity is considered as excessive sensitivity of each body part, particularly limbs and low backs, to cold even in a temperature that a human body does not feel cold. This investigation was performed to evaluate the diagnostic value of DITI for the diagnosis of cold hypersensitivity.

A total of 100 patients participated in this study. The 50 females with cold hypersensitivity were allocated as an experimental group and 50 females without cold hypersensitivity, as a control group at the Kang- nam Korean Hospital, KyungHee University, Seoul, Korea, from June 2000 to November 2000.

Thermographic observations for this study were made using a Dorex DITI. Thermographic measurements were performed on the other two areas (palm-upper arm and back of hand-upper arm) for the diagnosis of cold hypersensitivity on hands and were performed on the other two areas (anterior thigh-top of foot and posterior thigh-heel) for the diagnosis of cold hypersensitivity on the feet. As thermal deviations associated with cold hypersensitivity on the hands were at least 0.3^0C higher, the sensitivity was 94.0% and the specificity 90.0%. As thermal deviations associated with cold hypersensitivity on foot were at least 2.0° higher, the sensitivity was 94.0% and the specificity 76.0%.

The results of this investigation suggest that thermal deviations, observed on upper arm and hand and on thigh and foot, are associated with cold hypersensitivity on hand and foot, respectively.

THERMOGRAPHIC FINDINGS OF ACUTE APPENDICITIS

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Purpose: The pain characteristics of acute appendicitis are complex.The painful site is migrating from the epigastrium, periumblicus to McBurney's point. The time of pain localization is about 4 to 6 hours. Typical McBurney's point pain is only 55% and atypical pain is 45%. These characteristics result in delayed diagnosis of appendicitis. We studied thermography of acute appendicitis with several patients in order to evaluate the temperature change around the McBurney's point, and to evaluate the possibility of early detection of acute appendicitis .

Materials & Methods: 12 patients were analysed. They came to the emergency room of the hospital with highly suspect appendicitis and were treated by surgery. These patients were given blood sampling, abdominal radiography and thermography before operation. We analysed the preoperative thermography and evaluated the temperature around the Mc Burney's point, periumbilical areas, epigastric areas and their contralateral areas.

Results: In 11 patients appendicitis was confirmed by surgery. One patient was treated conservatively with suspicion of another medical disease. 9 patients had a high temperature on the McBurney's point and 2 patient showed high temperatures on the right side of entire abdomen. One was confirmed with perforated appendicitis with peritonitis and another was confirmed with retrocecal upward directed long appendix.

Conclusion: Thermographic examination for appendicitis can be a supportive diagnostic tool for pain localization.

INFRARED COMPUTERIZED THERMOGRAPHY IN VARICOCELE DIAGNOSIS.

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Varicocele is frequent in males and it can cause dysfunction such as decreased spermatozoids concentration in the seminal liquid and an increased number of malformations during spermatogenesis. In many cases, it implies infertility. Many diagnostic methods have been studied in the attempt to substitute the current gold standard: venography; since this is an invasive method. Amongst other diagnostic approachesd, computerized infrared thermography evaluation is a non invasive method with a diagnostic sensitivity of 98.3% and a specificity of 100%, which was considered in 1985 by the World Health Organization as the best diagnostic method for varicocele. The authors report cases of varicoceles of different degrees, evaluated with a thermal imager AGEMA550 (FLIR Corp.) and compared with ultrasonic evaluation.

THERMOGRAPHY IN THE DIAGNOSIS OF MYOFASCIAL PAIN SYNDROME

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Background : In the upper back hot spots may appear, that occasionally correspond with painful areas that have been previously drawn by the patient on a picture. Some authors stated that these areas are trigger points (TrP) of the Myofascial Pain Syndrome (MPS), whereas others argued that thesesare arteriovenous shunts without clinical significance. Previous researchers have thermographically defined a TrP as a discrete area showing a thermal increase over the circumambient or contralateral areas of greater than 0.6º-1ºC. The aim of the study is to analyze ,in our group of patients , the incidence and importance of these hot spots.

Methods: We reviewed all the thermography results performed during the period 1997-2000. A total number of 326 patients were studied. From these patients were recalled, where hot spots, with a thermal asymmetry of at least 0.5ºC, compared with the same area in the opposite site had been found. All the patients accepted the previous general conditions for the procedure, and stood up 20 minutes, undressed in our laboratory, where a surrounding temperature of 21ºC was present. An Agema 900 Thermovision was used. In order to minimize possible artefacts, alcohol spray was used to cool down the skin of the back. At the end of the thermography examination (TH) the patients were examinaed , and all the possible trigger points were palpated. We only considered a real trigger point if a twitching response was elicited and , if radiated pain and a taut band of muscle or fascia was found when palpated.

Results : Under the described conditions, we found 72 patients and 87 hot spots. Their localization were: 33.3% middle trapezius, 20.68% rhomboideus muscle, 17.24% infraspinatus muscle, 14.9% lower trapezius. Medium thermal asymmetry was 0.65ºC. The 15.27% of the patients presented hot spot without pain in the palpation (positive false). The 63.8% of the patients suffered a car accident. Of these , 41.6% suffered a whiplash injury. Mean time from the accident and the TH was 26.58 weeks. No clinical significance was detected between asymptomatic versus symptomatic groups in the mean temperature, age, and type of accident.

Conclusions : Many patients with chronic pain after traffic or labour related accidents present painful areas in the upper back that manifest with hot spot s which can be detected by TH. Are these area trigger

points of the MPS ? In our group of patients many of them could be considered as MPS. Further double blind studies and control groups are necessary to investigate these hot spots and their relationship with MPS.

COMPARISON OF THE THERMAL FOOTPRINT WITH PEDOBAROGRAPHY

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Introduction: Recently we described the basic concept of documenting a thermal footprint. Early detection of anomalies of the feet may prevent irreversible changes of the pedal skeleton or the planta pedis.

Aim of the Study: To compare findings of infra red imaging of the feet with the corresponding information gained by pedobarography.

*Patients and Method*s: 10 healthy individuals have been screened by infrared pedal thermography with respect to their thermal image of the foot sole in a sitting position. Furthermore the results from the pedal thermometry and the thermal footprint after 1 minute barefoot standing have been investigated and compared with the precise pressure measurements evaluated by pedobarography under standardised room climate conditions. Passive (standing still for 1 minute) and active (20 meters walking distance) foot pressure measurements have been performed.

Results: The thermal image of the foot can be easily opposed to the shape resulting from pedobarography presenting with a high degree of correspondence. Furthermore greater areas or complete footsteps with preponderance in pressure are closely correlated to the thermal image. However, the detailed pedo- barographic pressure pattern cannot be directly compared with the thermal imprint of the foot.

Conclusions: The thermal image of man's footprint delivers additional or complementary information despite a high degree of concordance with pedobarography.

THERMOGRAPHIC FINDINGS OF THE LOWER EXTREMITY IN PATIENTS WITH TYPE II DIABETES

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An increase of the skin temperature of feet was repeatedly reported in patients with diabetes. This means that the normal temperature gradient from the knee to the toes was inverted and the forefoot on the same temperature level as the knee or above the knee temperature. However, the reason for this phenomenon is still unclear.

76 patients (30 male, 47 female) who had type 2 diabetes longer than 5 years, were investigated. A physical examination of their feet was performed including measuring range of motion of the ankle joint, recording of the leg axis and the foot arches, toe deformities, skin changes, occurrence of varicosed veins, neurological examination. Nerve conduction tests were performed for both peroneal and sural nerves. Thermal images were taken from both legs in the anterior view, the foot from an anterior view and the soles.

The thermal findings are as follws: An inverted temperature gradient was found in 36 patients on the right leg (mean of pathological gradient: -0.59 ± 0.70°K versus –1.96 ± 0.62°K) in 39 patients on the left leg (-0.62 ± 0.9°K versus –2.13 ± 0,12 °K). The temperature readings of the sole (pathological gradient right side: 31.9 ± 1.1 versus 30.1 ± 1.0; pathological gradient left side: 32.1 ± 1.1 versus 30.1 ± 1.1) and the forefoot differed between patients with a normal and a pathological temperature gradient from the knee to the toes significantly.

No significant correlation were found between pathological temperature gradient, loss of sensibility. pathological nerve conduction tests or the most recent concentration of HbA1c. A very week correlation was detected between normal temperature gradient and lack of clinical signs for varicosed veins. Toe deformities and skin scarring were not related to hot spots on the sole.

We confirm that about half of type 2 diabetes patients present with a disturbed temperature gradient of the leg, but no clear cause for this phenomenon was detected.

INFRARED ASTRONOMY

Thomas Maca, MD.

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Introduction: Apart from medical or industrial applications of thermal imaging on earth, extraterrestrial sources of infrared radiation have markedly increased our understanding of electromagnetic information in the infra red range.

Aims: To provide an overview of the last two decades in infrared astronomy.

Discussion: A reasonable amount of infrared radiation from outer space may be gained in high altitudes via especially equipped aeroplanes and balloons. But it was the IRAS (Infrared Astronomical Satellite), launched in 1983, which for the first time allowed astronomers to gather data of the infrared sky at 12, 25, 60 and 100 microns without the interference of earth's atmosphere. It succeeded in delivering a 95% sky survey and detecting 300.000 infra red sources. Hundreds of publications followed which broadened our understanding but also called for more detailed images. In 1995 the ISO (Infrared Space Observatory) followed again with a Ritchey- Chretien telescope in a helium cooled cryostat. But this time the sensitivity and resolution with the 4 main instruments (Isocam, Isophot, SWS and LWS-spectrometer) served to cover

nearly the whole range of the sky's infrared spectrum. First results described the giant gas planets atmosphere and their moons. The Zodiacal light and Comet Hale-Bopp's flyby have been furthermore studied. The coolest regions in space, places of star birth and deep sky images add up to many new insights. During the last months, new results delineate a possible way of understanding the origins of life by the detection of hot abundant water together with organic molecules in space

Summary: The study of the infrared sky has fundamentally enriched our understanding far beyond technical accuracy in temperature measurements.

Index of Authors

News in Thermology

Thermal Physiology Laboratory opened at the University of Glamorgan

The UK Thermography Association (UKTA) meeting was held at the University of Glamorgan to mark the opening of the Thermal Physiology Laboratories in the School of Computing on 14 March, 2001.

The new Thermal Physiology Laboratory will be used for physiological investigations by measuring and interpreting changes to the skin temperature. The environmentally controlled laboratory will provide a waiting area and changing rooms for patients. There will be an adjacent computing laboratory for the storage and processing of images and for the accommodation of visiting researchers

About 50 people participated in the symposium, which was dedicated to the progress in infrared imaging Technology. The first lecture was by Prof. Francis Ring, University of Glamorgan, who reported the progress in infrared imaging for medicine, followed by Prof Bryan Jones, University of Glamorgan, who reported on Setting up the Thermal Physiology Laboratory. This part of the meeting was completed by Dr. Peter Plassmann, University of Glamorgan speaking on developments in software for capturing, storing and processing infrared images. This first part of the programme showed clearly the background and goals of this new focus of the University of Glamorgan for intensified research in temperature measurements and thermal physiology.

After lunch the participants had the opportunity to visit the new Thermal Imaging Laboratories and to see the available facilities.

The afternoon session started with lectures by Prof. Wiecek, Technical University of Lodz, Poland, who gave an overview on basis and advanced applications of dynamic thermography, which is now frequently used for non destructive material testing. Possible application of these methods in medicine were also discussed.

In his second talk Prof Wiecek showed new Direct X based software, which can easily implemented in Windows 98 or Windows NT. This system is optimised for real-time processing of thermal images and provides full metrological data, specially for fast non-standard visualisation and/or for lock-in thermography. Dr R Delpak, University of Glamorgan, completed this session on industrial thermography with a paper entitled Innovative method of fabric distress assessment in cementitious materials.

After tea , the session on Medical Applications of Infrared Imaging reported applications in dermatology, Raynaud`s phenomenon and chiropractic. Chris Edwards investigated thermal imaging for quantification of skin erythema after ultraviolet irradiation in comparison to visual and reflectance spectrometric assessment. Thermology did not show clear progressive changes in skin temperature. Thermal imaging also showed a dose-response curve for group average skin temperature, but large inter-individual variability masked this.

Two papers reported the use of portable radiometry to assess Raynaud's phenomenon. Both speakers, Kevin Howell and John Melhuish, arrived at similar conclusions: the use of a hand held infrared temperature scanner provides comparable results to thermal imaging for the assessment of Raynaud's phenomenon. This could allow for the use of hand held infrared temperature scanners in Outpatient Clinic or General Practitioner settings.

A. I. Heusch, University of Glamorgan, expressed the keen interest of the chiropractic profession in thermal imaging. The non-invasive methodology associated with Infra-red imaging of patients has been used by the American chiropractic profession for many years. There is a recognised need for standardisation of methodology with respect to the use by chiropractors and correlation of image profile with spinal dysfunction.

12th International Conference on Thermal Engineering and Thermogrammetry (THERMO)

from the 13th to 15th of June, 2001
in the OSSKI Center (Törley Palace)
Budapest, XXII. (Budafok), Anna u. 5.

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About The Conference

Since 1977 a successful series of Symposia has been organised by our Society every year. At the beginning these events were named "Symposium on Thermogrammetry" after a newly developed branch of thermal mapping methods which played a significant role in the program. As the scope of the symposia widened in 1982 they received the new name "Symposium on thermo-technical measurements".

Due to the broad and increasing interest shown by the international thermal engineering and physician communities, in 1987 it was already organised as the International Conference on Thermal Engineering and Thermogrammetry (THERMO). This conference is a series of biennial meetings. The Conference is intended to be an event worthy of the attention of all engineers, scientists, physicians and researchers who are involved in the solution of thermal or energy related problems, as well as in the applications of thermal imaging.

Objectives

The developments of measurement theory and technologies help the energy- conscious design of thermal engineering equipment and processes as well as the better understanding of thermal phenomena in living organisms.

The Conference will cover topics both the field of theory and application including new measurement concepts; transducer technique; thermal mapping; contact, optical and IR imaging; biomedical and biotechnological applications; thermal informatics, automatic methods and sys tems for industrial energy management and process control; heat loss detection and analysis; heat and mass transfer; utilization of alternative energy; thermophysical properties as well as the common practice of thermal engineering.

This Conference will provide the latest information on the above topics together with a good opportunity for personal discussions among experts in the fields of energy conservation, control of energy release and loss, protection of human environment, medical and veterinary applications, remote control through infrared sensors.

Technical Issues

The language of conference and abstracts is English. Together with oral presentation of papers a poster session will be organized. The preliminary programme includes more than 50 papers from 18 countries (Canada, Croatia, Czech Republic, France, Germany, Hungary, India, Iran, Italy, Japan, Poland, Portugal, Romania, Russia, Slovakia, Turkey, Ukraine, USA).

The duration of each presentation will be limited to 15 minutes and additional time for discussion will also be provided. The English translation of lectures not read in English

should be submitted at the registration desk on the spot. LCD projector and computer with Windows OS for Microsoft Power Point format presentations is available. (Please note that using your own computer is not allowed.)

Those intending to attend the conference are kindly invited to send a registration form to the address listed later, under the heading 'INFORMATION'.

Scientific Sessions

Three days of oral presentation and poster-workshops are organized whose topics will cover the following fields:

- Thermophysical properties
- Heat and mass transfer
- Combustion
- Thermal measurements and defectometry
- Infrared imagery and analysis
- Thermodynamics
- Environment and buildings
- Environmental aspects of energy use
- Practice of thermal engineering
- Modelling and software
- Medicine and biology.

Beside the plenary sessions the Organizing Committee will seek the possibility of ensuring appropriate time and other facilities for small-group discussions among people of special interest.

Exhibition

During the conference an exhibition of scientific and industrial instrumentation will be held in the conference hall. Exhibitors from the field of temperature measurement and control, thermal properties, IR-imaging, anemometry, industrial energy control, heat loss detection equipment etc. are welcome. Registration to the exhibition is open until 31st May, 2001.

Venue

The conference is hosted by the OSSKI Center (Törley Palace, Budapest, XXII. (Budafok), Anna u. 5.) located in the vicinity of the famous Budafok wine cellars.

Information

Application Forms and abstracts should be sent to:
Dr.Imre BENKÕ, MATE Secretariat,
House of Technology, III.318.,
H-1372 Budapest, POB. 451., Hungary.
Fax: +361-353-1406 Phone: +361-332-9571.
E-mail: mate@mtesz.hu

For any further information please contact the following address:

Dr.Imre BENKÕ
Budapest University of Technology and Economics (BME), Department of Energy (DoE),
H-1111 Budapest, Mûegyetem rkp. 7. D.208.,
Hungary. Office phone: +361-463-2183.
DoE Phone/fax: +361-463-3273 or -463-3272.
BME Fax: +361-463-1110
E-mail: benko@eta.enrg.bme.hu

Annual Meeting of the AAT

The American Academy of Thermology Meeting which will be held at Auburn University on June 22-24, 2000. The programme organizers received contributions from various fields of application of thermal imaging including Thermal Physiology, Pharmacology, Neurology / Neuroscience, Vascular diseases; Orthopedics, Breast, Forensics, Technical/Equipment Applied Thermography, Veterinary Medicine Clinical Medicine/Surgery, Other Pathologies (RSD, diabetes, wound healing).

For further information

Contact: Pam Helmke
College of Veterinary Medicine
105 Greene Hall
Auburn, AL U.S.A. 36849-5228

Phone: 01-334-844-3699
Toll free: 01-800-483-8633
Fax: 01-334-844-3697
Email:Pam Helmke(chambpj@vetmed.auburn.edu)

Scientific Director: David Pascoe
Department of Health and Human Performance
2050 Memorial Coliseum
Auburn, AL 36849
Phone: 01-334-844-1479
Fax: 01-334-844-4025
Email: pascodd@auburn.edu

Announcement for the Guenter Bergmann Award 2001

The Guenter Bergmann Award is announced for the second time according to the conditions of the award

The Award will be given in a 2 years cycle for outstanding work in the field of clinical application or clinical research of thermal imaging. Pa-

pers in German or English from around Europe are welcomed.

Manuscripts should meet the standard of scientific papers and be consistent with the instructions for authors of the journal "Thermology international". A thesis will not be accepted. Members of the committee of the German Society of Thermology are not eligible for the Award.

The award winning paper will be published in the "Thermology international". Other submitted papers will be also sent the journal "Thermology international" for possible publication.

The Award Committee will consist of

A committee member of the GermanSociety of Thermology

A member of the Bergmann family

A known personality as chairman of the committee.

The jury is allowed to consult external experts for reviewing papers. Deadline for submission (original manuscript and 2 copies) is **August 31, 2001**. Address for submissions is

The President of the German Society of Thermology

Dr Joachim-Michael Engel M.D.

marked PERSONAL

Rheumaklinik Bad Liebenwerda

Dresdener Straße 9

D-04924 Bad Liebenwerda,

Germany

Veranstaltungen (MEETINGS)

13.-15. June 2001

12th International Conference on Thermal Engineering and Thermogrammetry (THERMO)
in the OSSKI Center (Törley Palace),
Budapest XXII (Budafok) Anna u.5.

Conference Organizer:

Branch of Thermal Engineering and Thermogrammetry
Hungarian Society of Thermology at MATE
European Association of Thermology
International Center for Heat and Mass Transfer

Information
Dr.Irme BENKÖ,
Technical University of Budapest (BME),
Department of Energy (DoE)
H-1111 Budapest, Müegyetem rkp. 7.
D.208., Hungary,
office phone. +361-463-2183.
BME Fax: +361-463-1110,
DoE Phonelfax: +361-463-3273 or -463-3272.
E-rnail:benko@eta.enrg.bme.hu
or mate@mtesz.hu

19.-21.June 2001

8th International Symposium on Temperature and Thermal Measurements in Industry and Science (TEMPMEKO 2001)
in Berlin, Germany

Organized by Physikalisch-Technische Bundesanstalt (PTB) und VDI-VDE-Gesellschaft Mess- und Automatisierungstechnik (GMA)

Topics: Instrumentation and Methods
Fundamental Aspects and Standards
Traceability and Dissemination
Sensors
Applications in Thermometry and Humidity

Information: VDI/VDE-GMA
Tempmeko 2001
Graf-Recke-Straße 84
D-40239 Düsseldorf
Phone:+49-2116214-215 Fax:+49-2116214-161

E-mail:tempmeko@vdi.de
Internet: http://www.vdi.de/gma/tempmeko.htm

22.-24. June 2001
American Academy of Thermology
Annual Conference, Auburn University, Alabama, U.S.A

Topics for presentation or poster session:

Thermal Physiology, Pharmacological, Neurology/ Neuroscience, Vascular, Orthopedics, Breast,
Forensics, Technical/Equipment,
Applied Thermography, Veterinary Medicine,
Clinical Medicine/Surgery, Pain, other Pathologies (RSD, diabetes, wound healing, etc.)

Registration Fee (US dollars) :
* After April 1, 2001 add $25

Members $250
Non-Members $300
Residents, Nurses, Technicians $150

Teaching Courses and **thermography certifications** will be available at the conference

For more information contact:

Ms. Pam Helmke,
Conference Coordinator
College of Veterinary Medicine, 05 Greene Hall,
Auburn University, AL U.S.A 36849-5528

Phone (334) 844- 3699; (800) 483-8633
Fax (334) 844-3697;
Email chambpj@vetmed.auburn.edu

David Pascoe,
Scientific Director;Dept. of Health & Human Performance; 2050 Memorial Coliseum
Auburn University, AL U.S.A 36849,
Phone (334) 844-1479;
Fax: (334) 844-4025;
Email pascodd@auburn.edu

THERMAL IMAGING IN MEDICINE

To be held at

The Thermal Physiology Laboratory

In the School of Computing

In the University of Glamorgan

3 -5 July, 2001.

The aims of the course are

1. To provide an understanding of the imaging of skin temperature;
2. To demonstrate the application of standard techniques to assess physiological and pathological conditions;
3. To understand and apply image processing and analysis techniques.

The course will cover

*Principles of infrared imaging

*Technological developments

*Environmental conditions for quantifiable imaging

*Thermal physiology

*The conduct and interpretation of provocation tests.

Presenters:

Prof E F J Ring (Glamorgan)
Dr K Ammer (Vienna)
Dr J R Harding (Gwent)
Prof B F Jones (Glamorgan)

Course fee: £250 including Notes, book and CDROM.

A one day symposium on

PROGRESS IN MEDICAL THERMOLOGY

will follow the short course on

Friday, 6 July, 2001,

at the University ofGlamorgan

If you would like to present a paper, please send a title and abstract to

Prof Bryan Jones at the address below.

Registration fee
(including refreshments) £ 25

Accommodation available in the Halls of Residence.

To: Prof BF Jones,

School of Computing, University of Glamorgan, Pontypridd, CF37 1DL, UK,

Tel:+44(0)1443 482730

E-mail: bfjones@glam.ac.uk

Please send me further details of the

Short course YES/NO

One day symposium YES/NO

Proposed title of symposium presentation:

NAME

ADDRESS

E-mail

29.-30.September 2001

4th Congress of the Polish Society of Thermology in Zakopane

Information:
Prof.Dr.A.Jung

Pediatric and Nephrology Clinic,
Central Clinical Hospital, Military University,
School of Medicine. Szaserow 128 str
00-909 Warsaw-60, PL

Tel/fax +48 22 6817236
email: ajung@cskwam.mil.pl

March 1 - 2, 2002

The 8th International Conference on Infrared Thermal Imaging

TAMPA, FLORIDA U.S.A.

Sponsored by ASI Inc.

Conference Times:

Friday, March 1, 2002 - 9:00 a.m. - 5:00 p.m.
Saturday, March 2, 2002 - 9:00 a.m. -1:00 p.m.

Location: Tampa, Florida

Hotels: Hyatt Regency, Marriott Airport Hotel, Radisson, Wyndham Westshore, Sheraton Suites, Hampton Inn Westshore.

*Airpor*t: Tampa International Airport

REGISTRATION INFORMATION

Get registration form at
http://www.thermology.com/conference8.htm

Print the registration form and send via Regular Mail with Conference Fee

Fee: $195 per person - if registered by January 1, 2002 - space is limited

Payable to: Ashwin Systems International Inc. P.O. Box 1014, Dunedin, FL 34697 U.S.A. - 727/785-5844

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☐ Polish Society of Thermology
☐ Deutsche Gesellschaft für Thermographie

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Payment should be sent (without any charges for the European Association of Thermology) to the following bank account:Bank Austria, Vienna, Austria, bank number:20151, account number: 965023054

Dr. Kurt Ammer
Österreichische Gesellschaft für Thermologie

Hernalser Hauptstr.209/14
A-1170 Wien
Österreich

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