PRE-CONFERENCE ACTIVITIES

Thursday, June 7, 2007	**Memorial Coliseum**

(Thursday schedule is for auxiliary groups only.)

9 a.m.-4 p.m.	**AUBURN-GLAMORGAN WORKSHOP**	**Coliseum, Rm. 1081**
9.00am- 9.30	Historical Introduction	F.Ring
9.30-10.15	IR Detectors and cameras	R.Thomas
10.15- 10.30	Questions/discussion/coffee	
10.30- 11.00	Quality Assurance in Thermography	P.Plassmann
11.00- 12.00	Principles of thermal physiology	K.Ammer
30 minute lunch break		
12.30- 13.00	Film, Hot and cold "Living Body"	F.Ring
13.00- 13.30	Standard protocols for thermography	F.Ring
13.30- 14.15	Causes of human temp. increase & decrease	K.Ammer
15 minute break		
14.30- 15.00	Provocation tests	F.Ring
15.00- 15.30	Image processing principles	P.Plassmann
15.30- 16.00	Educational resources	K.Ammer

4 p.m. CHIROPRACTOR SOCIETY MEETING — **Coliseum, Rm. 1082**

4-6 p.m. AMERICAN ACADEMY OF THERMOLOGY BOARD MEETING, Blair Suite, AU Hotel & Conference Center

INTERNATIONAL AND AMERICAN ACADEMY OF THERMOLOGY MEETING

*Asterisk denotes student presentations)

Friday, June 8, 2007 — College of Veterinary Medicine

7:45-9 a.m.	Transportation from AU Hotel to College of Veterinary Medicine (CVM)	
8-9 a.m.	**REGISTRATION/CHECK-IN**	**Overton/Goodwin Center**

Continental Breakfast

8 a.m.-5 p.m. **Exhibitors and Posters** — **Overton/Goodwin Center**

9 a.m.-12:20 p.m. **WORKER'S COMPENSATION**
Chairs: Woody McDaniel, Tim Conwell

9-10 a.m.	Tim Conwell: *Current Colorado Division of Worker's Compensation Guidelines for CRPS and Reimbursement for Diagnostic Testing*
10-10:20 a.m.	Florin: *Thermographic Monitoring of Physiological Changes in Patients with Chronic Regional Pain Syndrome (CRPS)*
10:20-10:40 a.m.	Haber: *The Use of Thermographic Movies as Real Time Monitoring*
10:40-11 a.m.	**BREAK**

11-11:20 a.m.	Moon & McDaniel: *A Proposed Standard for the Evaluation of Lumbral/Sacral Radiculopathy in the General Population using Digital Infrared Imaging*
11:20-11:40 a.m.	Conwell: *Current Pathophysiological Concepts in Complex Regional Pain Syndrome*
11:40-12:20 p.m.	Worker's Compensation Panel Discussion
12:30-1:30 p.m.	**LUNCH** (provided)

TUTORIAL

1:30-2:30 p.m	Mercer: *Dynamic Infrared Imaging and Blood Flow*

2:30-3:10 p.m. **BREAST SESSION**
Chair: Phil Hoekstra

2:30-2:50 p.m.	Hobbins: *Evaluation of Breast Health—35 years Experience with Monitoring Blood Flow*
2:50-3:10 p.m.	Crawford (Saputo): *Beyond Mammography*
3:10-3:30 p.m.	Hoekstra: *Autonomic Pattern Recognition Applied to Thermal Imaging for Large-Scale Breast Cancer Detection*
3:30- 3:50 p.m.	**BREAK**

3:50-5:10 p.m. **CLINICAL TRACT**
Chair: Kurt Ammer

3:50-4:10 p.m.	Ring: *Pandemic? Thermography Screening for Fever Screening of Airport Passengers*
4:10-4:30 p.m.	Harding: *Sniffing Out Raynaud's Syndrome*
4:30- 4:50 p.m.	Ammer: *Influence of Imaging and Object Conditions on Temperature Readings from Medical Infrared Images*
4:50-5:10 p.m.	Lyon &Orlove: *A Brief History of 25 years (or more) of Infrared Imaging Radiometers*
	Poster: Foster*: *Deviations in Normal Dermatome Patterns: A Collection of Three Studies*
	Poster: Kyung-Sub Lee: *The Effects of Acupuncture in Patients with Cold Hypersensitivity Using the Cold Stress Test*
5:10-5:30 p.m.	Transportation from CVM to AU Hotel
5:30-7 p.m.	**CONFERENCE SOCIAL** Blair Suite, AU Hotel

Saturday, June 9, 2007 — College of Veterinary Medicine

8:15-9 a.m.	Transportation from AU Hotel to CVM	
8:30-9 a.m.	**REGISTRATION/CHECK-IN** *Continental Breakfast*	**Overton/Goodwin Center**

8:30 a.m.-5 p.m. **Exhibitors and Posters** **Overton/Goodwin Center**

9:00-10 a.m. **EQUIPMENT/STANDARDS**
Chair: Francis Ring

9-9:20 a.m.	Vardasca*: *Thermal Symmetry on Extremities of Normal Subjects*
9:20-9:40 a.m.	Fisher*: *Equilibration Period Following Exposure to Hot or Cold Conditions when Using Infrared Thermography*
9:40-10 a.m.	Plassmann: *Performance Testing of Thermal Imaging Systems in Medicine*

10-10:20 a.m. **BREAK**

10:20-11:00 a.m. **VETERINARY MEDICINE**
Chair: TBA

10:20-10:40 a.m. Ryan: *Ocular Thermal Imaging as a Measure of Febrile Responses in Foals to Endotoxin Challenge Testing*

10:40-11 a.m. Rashmir-Raven: *Early Detection of Hyperelastosis Cutis/Herda Lesions in Horse Using Digital Infrared Thermography*

Poster- Nienaber*: *Thermal Windows in Seals and Sea Lions: Non-Invasive Indicators of Health?*

11:30-12:30 p.m. **LUNCH** (provided)

12:30-1:30 p.m. **PHYSICAL THERAPY/ATHLETIC TRAINING**
Chair: David Pascoe

12:30-12:50 p.m. Demmick: *Use of IR Thermography in Determining Spatial Heat Distribution of Varying Ultrasound Treatment Techniques*

12:50-1:10 p.m. MacNunn*: *Cryogenics Changes in Differing Ice Treatments*

1:10-1:30 p.m. Daisy*: *A Thermographic Comparison of Cold Therapy Devices on Surface Skin Temperature*

Poster- Hoyt: *Relationship between Digital Infrared Thermal Imaging Determined Knee Temperatures and Knee Pain in Distance Runners during a 3-Month Cross Country Season*

Poster- St Onge: *Tissue Compression at the Ischial Tuberosity and the Middle Posterior Thigh: Impact on Nerve Function, Blood Flow, and Tissue Oxygenation*

1:30-3:10 p.m. **BRAZILIAN THERMOGRAPHIC SOCIETY**
Chair: Dr. R.K. Vyas

1:30- 1:50 p.m. Brioschi: *Application of a New Radiological IR Imaging Technique. MRI with IR 3D Fusion and 3D Stereoscopic Printing*

1:50-2:10 p.m. Brioschi: *High Sensitive IR Images Report. New System of Musculoskeletal Injuries Description*

:10-2:30 p.m. Brioschi: *Infrared Expertise: From Diagnosis to Treatments. Infrared Imaging of Far-Infrared Radiation in Different Types of Applications.*

2:30-2:50 p.m. **BREAK**

2:50- 3:10 p.m. Brioschi: *Surgical Infrared Imaging Applications: Directions for the Future*

TUTORIAL

3:10- 4 p.m. Govindan: *Role of Mast Cells in Chronic Regional Pain Syndromes*

4-5 p.m. **SPECIAL INTEREST GROUPS (SIGs)**

*Time will be provided for those interested in meeting as infrared specialty groups.
(Neuromuscular, Veterinary, Clinical, Breast, Physical Therapy/Athletic Training, Physiology, Workers Comp, etc.)

5-5:30 p.m. Transportation from CVM to AU Hotel

6:30-9:30 p.m. **BANQUET** AU Hotel & Conference Center Ballroom

OUTLINE OF THE AUBURN-GLAMORGAN WORKSHOP

HISTORICAL INTRODUCTION

Francis Ring

The historical link between changes from the normal process of thermoregulation and disease is well documented. Even so it was the development of the thermometer that ultimately replaced the medical art of detecting fever by touching the patient. Galileo's simple thermoscope indicated the temperature of the water, but as an open system it was influenced by atmospheric pressure. Once this was realised and the tube was sealed, the glass thermometer became the standard instrument for measuring temperature to the present day. In medicine, a dramatic change in approach to temperature measurement of sick patients followed the thesis of a German physician Dr Carl Wunderlich. He systematically recorded the temperature of his patients at regular times throughout the day, and charted their progress. His main work sets out some forty different statements about the value of temperature measurement in medicine, the proof of fever by elevated temperatures, indication of worsening or improvement, and ultimately the decrease of temperature leading to death and post-mortem cooling. For 200 years, temperature charts have been a familiar record of hospitalised patients throughout the world. Of special, significance was his concept of the maximum or clinical thermometer, optimised to a narrow temperature range for clinical indication of fever.

The original mercury thermometers are now replaced by coloured fluid, for safety reasons. Electrical sensors, particularly thermocouples have been used in contact temperature sensors. Thermistors are not generally as rapid in response, but well suited to continuous monitoring have their place, especially in intensive care medicine.

Radiometric temperature detection of the naturally emitting infrared radiation has been a more recent development. In clinical medicine, simple radiometers are now used for aural temperature, and in some countries are replacing glass contact thermometers, mainly because they are considered to a lower risk for infection. The current interest in mass fever screening in airports etc. is based on thermal imaging, but verified by clinical thermometry to relate to core temperature.

Infrared thermal imaging systems have reached a significantly higher level of performance since 2000. Focal plane array detectors with high spatial and thermal resolution are available, at a relatively lower cost than in previous years. Criteria for their use in medical imaging have been described, and optimal conditions for a physiological recording of temperature should be a part of any thermal imaging routine. Most modern cameras claim to be fully in service within 10-15 minutes from start-up. This may not be valid for all cameras, and some will require much longer before they reach full radiometric specification. Furthermore the time to reach this required stability can change over time. It is therefore important that the user of each camera system is fully aware of the minimum time required before any images of the patient are made. Image capture requires as much standardisation as possible to ensure the ultimate repeatability of the images. Software can be used to help in the precise location of the target and of the regions of interest used for measurement. Improved resolution, stability and accuracy of temperature measurement are significant technical advances. However, critical technique and understanding of thermal physiology are also necessary to obtain clinical benefits from thermal imaging. The new interest in fever screening raises important challenges for the future.

IR DETECTORS AND CAMERAS

Rod Thomas

The use of Infrared Technology has developed significantly in recent years from the very cumbersome, sometimes unreliable, often liquid nitrogen cooled and extremely expensive infrared cameras prevalent in the later part of the twentieth century. Infrared detector technology has developed to an extent where repeatability, reliability and accuracy are now synonymous with modern systems.

Currently there is a proliferation of Infrared Cameras available worldwide representing a number of differing applications and challenges in choosing the appropriate camera . Examples of applications are wide and include predictive machine condition monitoring , which directly impacts on the efficiency of British Industry to the use of infrared thermography to improve efficacy during laser therapy on human tissue.

Optimum IR camera specification is an important consideration especially when adopting quantitative thermography. Examples of key specifications are discussed.

Higher specification infrared cameras are emerging and able to satisfy the requirements of medical practice. These systems have high levels of thermal and spatial resolution ideal for diagnostic purposes. There currently remain one or two challenges regarding spatial uniformity and geometric distortion but these are already subject to experimentation and testing There are a growing number of medical examples of such work in Europe most notably at the University of Glamorgan in the UK.

An important aspect of any infrared programme is training (Snell, 2005). The success often pivots on training and that it is recognised, relevant and most importantly imparts the necessary skills for qualitative and quantitative thermography

QUALITY ASSURANCE IN THERMOGRAPHY

Peter Plassmann

Standardisation is important for reliable use of infrared thermal imaging in medicine. Infrared camera systems are now of higher performance with improved reliability, which can lead the operator to assume that the system is continually giving optimal performance. This, however, is not the case.

We propose a series of simple experiments based on inexpensive and easy to acquire materials, which a thermographer can use under normal clinical conditions to monitor the performance of thermal imaging equipment in order to maintain confidence in the measurements made. The 5 tests proposed here are not intended to replace those performed by manufacturers or calibration laboratories, but can provide valuable information on both short and long-term camera performance. The proposed tests identify: a) offset drift after switching on, b) long-term offset drift, c) offset variation over the observed temperature range, d) image non-uniformity and e) the thermal 'flooding' effect.

Measurement results based on the above experiments will be presented which demonstrate that cameras may drift over several degrees centigrade in less than 2 hours after switching on. We will also show that imaging equipment can produce a varying amount of measurement error (up to 1.5 degrees centigrade), which depends on the temperature range observed. Results also show that equipment may be prone to non-linear errors (in the region of 1 degrees C), which are caused by deficiencies of the optical system and will manifest themselves if the equipment is not calibrated regularly.

Although the proposed tests will identify errors if present, due to the simplicity of the materials used, the tests are only of limited use for the quantification of these errors. We therefore present experimental results obtained using a new 3-point calibration blackbody source currently under development by the UK's National Physical Laboratory (NPL) specifically for use in medicine. The source exploits the stability of the melting/freezing point of certain chemicals which makes it extremely stable and when in use does not require a power source, cables or electronic stabilisation circuits. This source, once commercially available, will provide a highly reliable and practical tool not only for the quality control of thermal imaging equipment but by virtue of its inherent precision it will also enable cross-calibration for multi-centre trials.

PRINCIPLES OF THERMAL PHYSIOLOGY

Kurt Ammer

Thermal physiology describes all body functions related to thermal energy given to or removed from a living body. The most important physiological system in this context is temperature regulation, which keeps the temperature of the inside of the body on a constant level. This is achieved by changing the temperature in the outside of the body varying the superficial blood flow and heat production or activation of additional cooling mechanisms such as evaporation of sweat on the skin surface. The human body uses sympathetic nerve fibres for information spread related to temperature regulation. However, temperature regulation is only one function of the autonomic nerve system. Its main function is the non-voluntary control of smooth muscle fibres.

Strong interactions exist between temperature regulation and the cardiovascular system, also with fluid and energy control Heat generated by contraction of striated muscle fibres is the most important internal heat source of the body. Understanding the mechanisms of heat exchange of the body with the environment is essential for correct interpretation of temperature patterns on the body's surface. Any disturbance of the heat balance of the body is followed by temperature regulation, which keeps the deep body temperature close to the set point. Exhausting the regulation capacity of the system leads to a new set-point i. e. either increase (hyperthermia) or decrease (hypothermia) of the core temperature. The mean skin temperature and the core temperature jointly determine the regulation process. Skin temperature is the result of the heat storage of the body and the thermal environment. The law of physics for heat transfer provides the means of predicting the mean skin temperature under defined conditions.

Various mechanisms unrelated to temperature regulation may affect the diameter of superficial skin vessels, resulting in different levels of skin temperature. Temperatures on the surface can only be correctly interpreted if the condition of the thermal environment is known. It is not true to assume that the surface temperature is synonymous with perfusion or that blood flow is exactly the same as surface temperature. However, very specific responses of vessel control do occur in certain thermal conditions.

Temperature regulation under working conditions is of practical importance to man, especially for research into safety procedures in extreme temperature conditions. The balance between protection against either heat or cold and gross endogenous heat production can be a very difficult challenge. In such a situation interactions of temperature regulation with the cardiovascular system and fluid balance become significant.

Many physiological functions are related with the thermal phenomenon, but not all are the result of temperature regulation. Basic knowledge of thermal physiology is necessary for the correct interpretation of human body temperature measurements.

STANDARD PROTOCOLS FOR THERMOGRAPHY

Francis .Ring

Despite the availability of infrared thermal imaging for medical investigation for 50 years, there is a notable lack of reference data for normal subjects. Human body temperature is known to be self regulating (homeothermic) and to remain within narrow range of temperatures in a healthy subject. Inflammation, reduced blood perfusion and a number of defined clinical conditions can affect skin temperature to a significant degree. Nevertheless, to use thermal imaging to study body surface temperature, strict protocols must be followed; to obtain the thermal sensitivity required for measuring the changes in the limited thermal range. Thermal imaging equipment has increased thermal and spatial resolution, now attainable at lower cost than in the past. Even with the improved technical performance, there are a number of pitfalls to be avoided in order to obtain reproducible and reliable thermal data from medical thermography.

Eight stages for potential errors or artefacts have been identified.

1.Patient information and preparation for examination.

2. IR Camera systems and calibration.
3. Patient positioning & Image Capture.
4. Thermal image analysis.
5. Image storage.
6. Elec-tronic image exchange (radiometric)
7. Image presentation.
8. Information on protocols and learning resources.

The critical factors in a thermal imaging protocol begin with the patient. Prior information to and from the patient is needed. To register any possible effects of drugs, physiotherapy or surgery on body temperature, the patient is always asked to rest in a cubicle, with the examination areas unclothed for a minimum of 10 minutes at a defined ambient temperature.

The equipment must be of proven stability and accuracy, with the IR camera mounted on a parallax free stand. The examination room must be at a controlled temperature, usually from 20°C (used for inflammatory studies) t0 24°C (used for vasomotor studies). Standard views of each required area of the body are essential, and the angle between camera and patient should be around 90° whenever possible.

Standard distances are also advised, since resolution (thermal and spatial) are usually decreased as scanning distance increases. Image analysis must also be standardized. Regionsof interest are frequently chosen on subjective parameters,which have been shown to be irreproducible even by the same investigator on the same image with repeated analysis. A protocol for defined regions of interest based on anatomical limits is the only sure way to minimize inter operator variation.

Finally, reporting the images requires al relevant data on the temperature range and level of the camera setting, the location of regions of interest and their data, and the conditions under which the ex amination was carried out. Failure in any of these parameters can lead to sizable errors, and misinterpretation of the findings.

Examples will be given of false results in thermal imaging from failure of the investigator to understand the essential factors for the patient examination. Inadequate camera settings, or unproven stability after starting the camera have been found to significantly alter the final image. Errors resulting from subjective sizing and placement of regions of interest also show significant variations, all of which can be avoided. The importance of standardized reporting is evident when comparisons over time are required.

In medical-legal issues, each image must be clearly identified, and shown to be taken under comparable conditions. No less a standard is required for normal clinical work with this technique. Knowledge of the normal patterns, and causes of hyperthermia or hypothermia are also important to both the technician and the physician using this technique.

CAUSES OF HUMAN TEMPERATURE INCREASE & DECREASE

Kurt .Ammer

Thermal imaging is a technique capable to map the temperature distribution on the human skin. In healthy subjects skin temperature is highly symmetrically distributed related to a symmetry axis situated in the median plane of the human body. In the extremities, higher temperatures are normally seen at the proximal end of the limb than on the tips of fingers or toes. Any disturbance of these normal temperature pattern may be detected either as hyperthermic or hypothermic area.

Hyperthermic areas within medical thermal images may be caused by inflammation, increased blood flow, growing tumor, heat generation due to muscle contraction or artefacts due to the environment. Examples will include inflammatory joint disease such as rheumatoid and osteoarthritis, inflammation of tendon insertions and tendon sheets and bursitis. In Paget´s disease of bone hyperthermic areas have been related to increased blood flow within the affected bone.

Skin inflammation caused by herpes infection, skin rash due to virus infection, irradiation induced dermatitis will be presented. Varicose veins and deep venous thrombosis are related to hyperthermic changes. A diffuse hyperthermia on the diabetic feet may be caused by neuropathia, an intensive local hyperthermia was related to underlying osteomyelitis.

Malignant tumors of the female breast or of the skin such as melanomas can be visualised in thermal images as hyperthermic areas. These "hot spots" might be caused by an increased angio-genesis.

Recently performed muscular work, muscle spasms and tender points in fibromyalgia patients are characterized by increased skin temperature. Artefacts due the environment such as heating by infrared radiation, conductive heat therapy or skin contact with other hot surfaces can result in hyperthermic areas on the body surface.

Hypothermic skin changes may be caused by decreased blood flow, loss of muscle contraction, sympathetic hyperactivity induced by partial nerve lesion, lymphedema or artefacts due to the environment. Typical findings from patients with obstructive angiopathy . Raynaud`s phenomenon, motor deficit due plexus paresis, poliomyelitis, herpes zoster, radiculopathy, peroneal palsy and decreased range of motion induced by arthritis or arthodesis will be presented . The thermographic changes of common nerve entrapment syndromes such as carpal tunnel syndrome, thoracic outlet syndrome and ulnar nerve entrapment will be discussed. Cases of reflex dystrophy, thermal images from patients suffering from lymphedema and some artefacts causing hyperthermic changes of the skin temperature will close this lecture.

PROVOCATION TESTS

Francis Ring

Infrared thermal imaging of the human body skin surface is normally carried out after a standard period of acclimatisation in a temperature-controlled room. A number of normal temperature patterns have been identified. Clinical abnormalities in temperature can be identified. Once the normal pattern is established. 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 either *Chemical, thermal or mechanica challenges*.

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 20^0C or colder for a fixed period e.g.1 minute, 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 should recover baseline temperatures quite quickly (<10 mins) 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 may occur as a result of local damage to the peripheral micro-vascular and nervous systems. Controlled contact with a suitable vibrating surface is one 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 fingers affected by 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.

IMAGE PROCESSING PRINCIPLES

Peter Plassmann

Over recent years practitioners of medical thermography have recognised the need for introducing standards into the various processes of image acquisition, analysis and data exchange. Commercially available thermal imaging software, however, is generally designed with industrial applications in mind and as such often more a hindrance than a help in achieving this goal.

A set of 24 standard "masks"is proposed which can be superimposed onto live thermal camera images in order to aid the precise positioning of subjects in pre-defined standard views. Embedded in the description of each mask are codes and descriptions which simplify searching and indexing of acquired images in data bases.

Images captured in such a way have a number of advantages: they can be readily compared with other images and lend themselves to semi-automated analysis such as a cold-stress-test. Morphing techniques can be used to create an average image of body region of interest and such average images me be used for reference and comparison with images recently captured.

Examples of standardised image capture and semi-automated analysis produced by the CTHERM software package are presented. The author has developed data file conversion tools so that images captured and analysis data produced by CTHERM can imported into the ImageThermabase package (and vice versa). Copnversion tools for AGEMA CATS-Images and images recorded with the software package IRIS from NEC-Thermotracers are also available. It is planned to incorporate conversion tools for further packages, to enable and simplify consultation and data exchange within the medical thermology community.

EDUCATIONAL RESOURCES

Kurt Ammer

Knowledge of thermal imaging is necessary Rehabilitation medicine (in Austria part of the postgraduate training for Physical Medicine and Rehabilitation), Human Physiology, Occupational Medicine and optional in Rheumatology, Dermatology, Orthopaedics, Neurology, Neurosurgery. In 1993, the European Association of Thermology (EAT) organized in cooperation with the Austrian Society of Thermology a course on medical thermography with lecturers from around Europe, Francis Ring and myself conducted a three days course on thermal imaging in Sao Paolo in 1999, which triggered the foundation of a Brazilian Society of thermology. The University of Glamorgan offers since 2001 a regular training course on medical thermal imaging. Thermology Societies all around the world provide training and certification for technicians and physicians (for example the AAT), organize meetings and conferences and publish journals.

The International College of Thermology was founded in 1987 and links the three continental associations, namely the American Academy of Thermology, European Association of Thermology, and Asian-Pacific Association of Thermology. The president and the International Congress of Thermology used to change for a one year period from Asia to Europe, from Europe to America and from America to Asia. The cycle of international Thermology-Conferences started 1989 in Georgetown, Washington DC, went then to Ghent, Belgium, Matsomoto, Japan, Ft.Lauderdale, Florida, Vienna, Austria and Seoul, South Korea and is now 2007 in Auburn. The EAT started with European Congresses in 1974 in Amsterdam and had the last European Conference last year in Zakopane, Poland. National conferences on thermology were regularly organized in Japan, Korea, USA, Austria, Germany, Hungary, Poland, United Kingdom.

Scientific journals related to temperature are manifold, but only some were dedicated to medical thermology. Acta thermographica and Thermology had ceased publication years ago, Biomedical Thermology publishes now only in Japanese, the German ThermoMed has problems to appear regularly. Thermology international is at the moment the only journal which publishes 4issues/ year with thermological papers in medicine and biology. A number of books are related to thermal imaging in medicine, the latest is a spin off of the chapter on infrared imaging in the handbook of biomedical engineering.

ABSTRACTS OF THE INTERNATIONAL AND AMERICAN ACADEMY OF THERMOLOGY MEETING

CURRENT PATHOPHYSIOLOGICAL CONCEPTS IN COMPLEX REGIONAL PAIN SYNDROME

Conwell, Timothy D.

Colorado Infrared Imaging Center, 1221 South Clarkson, Suite 308, Denver, CO 80210, E-mai: tdconwell@MSN.com

Current concepts regarding the role of the autonomic nervous system and its relationship to nociceptive C-fiber afferents in CRPS I are reviewed. In the normal milieu, sympathetic efferents and sensory afferents are not conjoined. Current investigation suggests that the functional and perhaps structural interaction between the sensory afferent and sympathetic efferent fibers in both the periphery and possibly centrally play a significant role in CRPS I. A review of the literature that elucidates this current understanding will be presented along with putative IR signature images.

THERMOGRAPHIC MONITORING OF PHYSIOLOGICAL CHANGES IN PATIENTS WITH CHRONIC REGIONAL PAIN SYNDROME (CRPS)

Robert E. Florin, M.D. and Constance Haber, D.C.

Sponsored by PhotoMed Technologies, Inc.

Thermal imaging of skin temperature is used to study regional abnormalities in blood flow associated with the autonomic abnormalities seen in patients with neuropathic pain.

We will illustrate the utility of thermal imaging in CRPS patients as a diagnostic adjunct, to monitor thermal changes during therapy, and to provide objective measures of physiological changes following therapy.

Twelve chronic CRPS patients were studied using thermography during therapy with modulated visible light applied to the skin at sites remote from the affected parts. Regional skin temperatures of distal extremities were recorded from infrared thermal images during each session of therapy. Changes in temperature were used as a measure of changes in regional perfusion during and following light therapy.

The average maximum change in skin temperature of the monitored extremities in CRPS patients was 4.3^{0}C relative to the pre-treatment temperature. In normal subjects, the average maximum change was only 1.3^{0}C. All 12 CRPS patients changed 2.0^{0}C or more at least twice during the course of light therapy sessions. In the same period, 75% reported much improvement in their pain intensity, lasting a month in seven cases and up to a year in four cases.

THE USE OF THERMOGRAPHIC MOVIES AS REAL-TIME MONITORINGT

Constance Haber, D.C. and Robert E. Florin, M.D.

Sponsored by PhotoMed Technologies, Inc.

Breakthrough technology permitting automated computer management of thermal movies during therapeutic intervention has revolutionized the modern thermal imaging laboratory.

The tasks which required extended physician involvement in order to produce scientifically valid data have been able to be markedly reduced and in many instances eliminated with specific computer programming. Documents required tovalidate thermal equilibration, laboratory conditions, quantification of response to therapeutic intervention, daily chart notes, outcomes assessments and billing can be produced before the patient reaches the front desk. The laboratory can now operate in a more efficient and cost effective manner. Instead of the physician having to spend hours drawing circles, creating tables and working after hours to produce necessary data and reports the required data is produced effortlessly and almost instantly. The factors which made comparison of data between patient visits difficult have been eliminated.

Patient compliance to treatment recommendations and insurance reimbursement are markedly improved when thermal images document improvement with the therapeutic intervention chosen by the physician while creating valid and irrefutable data.

Rather than enter the controversial arena of establishing a medical diagnosis based on thermal imaging, gathering and presenting real-time scientific data of the patient's physiological response to treatment has added a new arena to the thermal imaging laboratory.

We have chosen to report on data that has been collected and analyzed from twelve (12) chronic CRPS patients commencing October 2005, whose condition had previously been recalcitrant to management. The graphic physiological demonstrations have added a much needed and easily understood acceptance of the treatment offered.

Thermography provides an objective measure of physiological changes in the regional perfusion of affected limbs in CRPS patients during light therapy. Thermography is useful as a confirmatory diagnostic test of changes in skin temperature and blood flow in patients with CRPS treated with light and is characteristic of the sympathetic abnormalities seen in CRPS. During therapy, it provides a means of monitoring the effectiveness of the applied light and allows for termination of therapy in the event of excessive warming of the region. Outcomes assessment is facilitated by providing objective measures of the degree and patterns of thermal changes that correlate with beneficial reductions in pain.

A PROPOSED STANDARD FOR THE EVALUATION OF LUMBAR/SACRAL RADICULOPATHY IN THE GENERAL POPULATION USING DIGITAL INFRARED IMAGING.

Moon, R.T.Y., McDaniel, J.W.

Corporate Health Systems of Alabama, Inc., Birmingham, Alabama

A study was conducted on a worker's compensation patient population to ascertain the viability of utilizing Digital Infrared Imaging (DII) to diagnose lumbar/sacral radiculopathy. The purpose of this exercise was to evaluate an imaging protocol that was developed in-house and based on dermatonal mapping of regions of the low back and lower extremities. This protocol was developed due to the lack of established protocols in the literature.

Patients were selected for the study between October 2005 and May 2006 only if they presented with pain complaints in the low back region and the insurance carrier approved reimbursement for the test. Radiation of the pain into the lower extremities was not a requirement for patient inclusion. The "proof" of the appropriateness of DII for this pain complaint was the correlation of the infrared findings with other anatomical and/or physiological studies. In ninety-three percent (93%) of the patients who tested positive with DII, the findings correlated with other tests.

Conclusion: The protocol developed for evaluation of radiculopathy has high correlation with other, more expensive, testing procedures such as MRI, CT Myleogram, Bone Scan, NVC and EMG. The sharing of evaluation protocols developed by users of DII systems will promote more standardized testing, overall correlation of diagnostics, improved patient outcomes, and the acceptance of DII testing by insurers.

DYNAMIC THERMOGRAPHY

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Infrared thermography or infrared thermal imaging is based on analysis of skin surface temperatures as a reflection of normal or abnormal human physiology using specialized IR-cameras. In a fraction of a second, a large area of the human body can be imaged to an accuracy of less than 0.1°C. In general, skin surface temperature is proportional to local blood flow. However, it is difficult to obtain adequate information on the dynamics of perfusion physiology with static thermographic images. With dynamic infrared thermography it is possible to better evaluate skin perfusion (1). The technique of dynamic infrared thermography (DIRT) is based on the relationship between dermal perfusion and the rate of change of skin surface temperature following the application of a transient local thermal challenges (2,3,4). Rapid physiological changes can be readily registered with the new generation of infrared cameras. The information can be easily analysed using infrared camera that employ, for example, fire-wire technology. This new development allows real time analysis of images (i.e. image sequencing rather than just still pictures). Having access to this technology provides an enormous advantage in the use of IR-thermography. This is especially important since being able to follow dynamic changes in skin temperature opens up a whole new field of possibilities for this technique. For example, it is very usual to use provocation tests (responses to heating and cooling) in both research and clinical situations. Examples of the use of Dynamic Thermography will be presented in both research and routine clinical situations

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EVALUATION OF BREAST HEALTH-35 YEARS EXPERIENCE WITH MONITORING BLOOD FLOW

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Physiology of the breast by infrared imaging of the breast is a skin organ which is unique in that its function and growth which is best monitored by its blood flow.

The Symposium on Biomechanical Engineering of the skin in 1983 determined that thermography was an accurate measure, if not the most accurate! Dr. Atisumi, Professor of Cardiac Surgery and first heart transplant, stated likewise and devised a formula for blood flow. Since 1972, all conditions of the breast have been studied with thermograms from Harvard to John Hopkins and University of Southern California to Austria, England, France, Italy, Japan, Korea, and Asia.

The breast presents changes in blood flow in 1.0 growth, 2) injury, 3) pregnancy, 4) endocinre manipulation, 5) mastopathy, 6) infection, 7) neoplasia, and 8) ingestion of drugs.

Thermography is the greates help in endocrine management of 1) PMS, 2) monioting birth control, 3) monitoring fibrocystic consition, 4) early detection of in angiogenesis in neoplasia, 5) most accurate prognosis of survival, 6) effects of chemotherapy, and7) early diagnosis of inflammatory carcinoma.

Thermography provides major physiological information to be interwoven with ultrasound, x-ray, and MRI with gadolinium contrast. Thermography is the most important exam on declaring the health and function of the breast. This is an important medical observation.

BEYOND MAMMOGRAPHY

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The most devastating loss of life from breast cancer occurs between the ages of 30 to 50. Fortunately, women today have more options available to them to help in the detection of breast cancer than in the past decades. Unfortunately, education and awareness of these options and their effectiveness in detecting breast cancer at different stages on life are woefully deficient.

This presentation explores the latest finding on the effectiveness and shortcomings of various detection methods used by the mainstream medical community, including mammography, clinical breast exams, ultrasound, and to a lesser extent, magnetic resonance imaging (MRI's) and PET scans. This presentation will also explore the highly advanced but much maligned detection tool for breast cancer- breast thermography. Breast thermography, which involves using a heat sensing scanner to detect variations in the temperature of breast tissue, has been around since the 19060's. However, early infrared scanners were not very sensitive and were insufficiently tested before being put into clinical practice, resulting in misdiagnosed cases. Modern day breast thermography boasts vastly improved technology and more extensive scientific clinical research. In fact, reference data from major peer review journals and research on more than 300,000 women who have been tested using this technology. Combined with successes in detecting breast cancer with greater accuracy that other methods, the technology is slowly gaining ground among more progressive practicioners. This "Beyond Mammography" review concludes that breast thermography needs to be embraced more widely by the medical community and awareness by women. Not only has it demonstrated a higher degree of success in identifying women with breast cancer under the age of 55 in comparison to other technologies, but is also an effective adjunt to clinical breast exams and mammography for women over 55. Finally, it provides a non-invasive and safe detection method, and if introduced at age 25, provides a benchmark that future scans can be compared with for greater detection accuracy.

AUTOMATIC PATTERN RECOGNITION APPLIED TO THERMAL IMAGING FOR LARGE-SCALE BREAST CANCER DETECTION

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Malignant breast tumors have characteristic thermal signatures that comport to Hippocrates' cardinal sign of Calor and were empirically recognized since the earliest electronic images. Basic science has revealed the underlying physiologic mechanisms for these thermal signatures and a quantitative and objective method has been developed to improve the reliability of thermal imaging as a diagnostic modality for detection. Intelligent Computation (IC) is now applied to extend the diagnostic parameters, increase reliability and enable large-scale application. Particularly we are applying IC to evaluate the variability of true-positive and false-positive cues by using specialized proprietary neural network (Dynamic Perception) architecture for the analysis of 2000 patients pre-screened for breast malignancies. Moreover, we are applying the technique to a sample data set of 2000 patients screened for breast malignancy with good infrared features but unreliable response to the infrared analysis due to imperfect techniques by the human operators. Finally, the same architecture is being evaluated in ongoing research on breast cancer screening in a hospital environment. Preliminary results are presented and discussed also in relationship with other more classical techniques.

PANDEMIC? THERMOGRAPHY FOR FEVER SCREENING OF AIRPORT PASSENGERS

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The SARS outbreak in S.E.Asia in 2002/3 prompted several local health authorities to assemble a number of thermal imaging systems for installation at airport terminals. Not all the cameras used were of proven radiometric standards, and the manner in which they were employed was highly variable. On the premise that facial temperatures in excess of 38^{0}C were classified as fever, a number of subjects were sent for clinical examination before being cleared for travel. The International Standards Organisation ISO has appointed a working group to prepare a new version of the SPRING documents for International use, defining a screening thermograph. IEC TC/SC62D – ISO/TC121/SC3, *Clinical thermometers, writing group on thermography for human temperature screening*. This group has now met on four occasions since December 2005, and has a document that is moving into its final stages later in 2007. The outcomes of the ISO committee, the definitions involved, and the preliminary results from febrile and non febrile subjects will be presented. Some practical work is being undertaken on fever detection in children in Warsaw where the author has access to some of the latest thermal imaging technology in a paediatric clinic. The aim is to investigate the relationship between facial, auxiliary and aural temperatures in normal and febrile children between 1 year and 16 years of age. To date some 95 children have been examined. Results to date indicate that the inner canthi of the eye are reliable targets for temperature measurement, and when this area is over 38^{o}C, other thermometric measurements confirm the presence of fever. It is anticipated that the standard and advice documents arising from this work, may well lead to a further standard for clinical thermography.

SNIFFING OUT RAYNAUD'S PHENOMENON

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Infra-Red Imaging is the accepted gold standard test for confirming or excluding Raynaud's Phenomenon, and is one of the most widely performed investigations in medical thermology. It can help differentiate between primary Raynaud's Disease and Raynaud's Phenomenon associated with connective tissue disorders such as systemic lupus erythematosis (SLE), scleroderma, Sjogren's syndrome and rheumatoid arthritis etc. A fresh approach to the investigation of Raynaud's Phenomenon will be described and discussed.

INFLUENCE OF IMAGING AND OBJECT CONDITIONS ON TEMPERATURE READINGS FROM MEDICAL INFRARED IMAGES

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Several circumstances influence the accuracy and precision of temperature readings from thermal images: the object imaged, the camera systems, standards, imager calibration and image analysis affects both accuracy and precision, but object position, image capture, information protocols and resources have only an impact on the repeatability of measurements. The Medical Imaging Research Group at the University of Glamorgan investigated the influence of imaging and object conditions on temperature readings from thermal images.

Ring & Dicks showed differences of older and newer thermal imagers in spatial and temperature resolution and Plassman et al. reported a set of 5 tests to control for equipment related measurement errors.

In 2001, the Glamorgan protocol established a series of standardized positions of the body for image capture. Repeatability was proven for most of these body positions. The Glamorgan protocol created also a complete standard for the definition of regions of interest in thermal images based on anatomical limits. Both variations in body position during image recording and variations of shape and size of measurement areas affect the precision of temperature measurements.

The reproducibility of temperature measurement from thermal images was shown. The biggest variation of temperature readings can be detected when the same body region is imaged from a different angle of view. The measurement error may be as much as 1 degree C. A similar, but minor error occurs in slight variations of body position or different size or shape of measurement areas. However, variation of the room temperature in repeated image recordings have a higher impact on the temperature readings than variation in the size of measurement areas

The results indicated that following strictly standard procedures for camera calibration, image capture, subject preparing, body positioning and image analysis reduces errors and increases both accuracy and precisions of temperature measurements.

A BRIEF HISTORY OF 25 YEARS (OR MORE) OF INFRARED IMAGING RADIOMETERS

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Modern thermal imaging radiometers are infrared systems usually endowed with some means of making surface temperature measurements of objects, as well as providing an image. These devices have evolved considerably over the past few decades, and are continuing to do so at an accelerating rate. Changes are not confined to merely camera size and user interface, but also include critical parameters, such as sensitivity, accuracy, dynamic range, spectral response, capture rates, storage media, and numerous other features, options, and accessories

Familiarity with this changing technology is much more than an academic topic. A misunderstanding or false assumption concerning system differences, could lead to misinterpretation of data, inaccurate temperature measurements, or disappointing, ambiguous results.

Marketing demands have had considerable influence in the design and operation of these systems. In the past, many thermographers were scientists, engineers and researchers. Today, however, the majorities of people using these instruments work in the industrial sector and are involved in highly technical skilled Documents required tovalidate thermal equilibration, laboratory conditions, quantification of response to therapeutic interven the status of these devices from a "scientific instrument," to an "essential tool." Manufacturers have recognized this trend and responded accordingly, as seen in their product designs.

This paper explores the history of commercial infrared imaging systems and accessories. Emphasis is placed on, but not confined to, real time systems with video output, capable of temperature measurements.

DEVIATIONS IN NORMAL DERMATOMEPATTERNS: A COLLECTION OF THREE CASE STUDIES.

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As somatic skeletal nerves are directly associated with their respective dermatomes, neuromuscular dysfunction in areas can be positively linked to impingements or damage to specific spinal nerves. However, due to the neural divergence and convergence that occurs within the paravertebral and collateral ganglia, there is a dilution in direct specificity concerning sympathetic outflow. Traditional diagnostic techniques are sometimes inadequate in the diagnosis of neural impingements and/or disruptions in sympathetic outflow to specific dermatomes. Infrared imaging provides a noninvasive means of visualizing and qualifying these types of circulatory, neuromuscular, and/or thermoregulatory aberrations. **Purpose**: The purpose of this collection of case studies is to demonstrate infrared images of select cases displaying neural or vascular impingements and/or interruptions in sympathetic outflow to specific dermatomes. **Methods**: Infrared images obtained from a CTI Thermal Imaging Camera are presented with accompanying subject information. **Results**: Follow up details are provided on subjects for whom the displayed problem has been resolved. **Conclusions:** Infrared imaging provides a fast, noninvasive method for visualizing neural or vascular impingements and disruptions in sympathetic outflow to specific dermatomes; and may prove beneficial in determining cause/effect relationships.

THE EFFECTS OF ACUPUNCTURE ON THE PATIENTS WITH COLD HYPERSENSITIVITY USING COLD STRESS TEST.

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Purpose: The number of patients with cold hypersensitivity would like to be treated with Oriental Medicine. However, there has not been any studies on the effect of acupuncture treatments on the patients with cold hypersensitivity. Therefore, we examined the effect of treatment at different acupuncture points and also compared the results of the first and the second Cold Stress Test(CST).

Method: In this study, 8 patients with cold hypersensitivity on hands participated. In order to avoid the bias, we excluded the patients with skin diseases, spinal nerve disease of cervical spine, or external wounds.

We measured the patients' body temperature using Digital Infrared Thermal Imaging(D.I.T.I.). Then, we performed CST at 6 thermographic observation using D.I.T.I.. First, the test was taken after 15 minutes of resting. The second test was taken immediately after the first; to differ, the patients' hands were placed in the water at 20 degree Celsius for a minute before taking the second test. For the third, the patients were to wait 10 minutes after the second test. The fourth test was taken a week after the third; this time, the patients were to rest for 15 minutes before the test. Following the fourth immediately, their hands were again soaked in the water at 20 degree Celsius for a minute and then took the fifth test. After the fifth CST, the patients received acupuncture treatment. The sixth test was taken 10 minutes after the fifth.

We divided the patients into two different groups for the acupuncture therapy, which the patients received after taking the fifth CST. For one group, we performed the acupuncture therapy on the distal points. For the other group, the therapy was done on the proximal points. Then we compared the first and the second CST recovery rate results.

Results: The recovery rate of the patients with the acupuncture therapy on the distal points was a little higher than the one without the therapy; however, the difference is not statistically significant. On the other hand, the recovery rate of the patients with the treatment on the proximal points was much higher than the one without it.

Conclusions: Acupuncture treatment may be one of the effective therapy methods on cold hypersensitivity; according to this study, the treatment on the proximal acupuncture points would be more useful on the patients with cold hypersensitivity.

THERMAL SYMMETRY ON EXTERMITIES OF NORMAL SUBJECTS

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Infrared thermal imaging is being utilized increasingly in the study of neurological and musculoskeletal disorders providing data on the symmetry of skin peripheral temperature. Skin temperature measurements were carried out on 26 healthy subjects' thermograms. Temperature measurements were obtained using a computer interfaced application developed in past projects of this research unit, CTHERM, this thermographic instrument with the capability of obtaining average temperatures and standard deviation values in corresponding areas of interest on both sides of the body. In the healthy control subjects the overall temperature difference was maximum value 0.19º C on total body view and 0.16 º C on regional views. This study has confirmed with quantitative data from CTHERM software, the thermal symmetry in normal subjects, which can be used to assess thermal changes in specific pathologic states. This work has also compared the usage of total body view (table 1) with the regional views (table 2). No other studies have been carried out with the current generation of higher resolution cameras. There is not a substantial difference on thermograms taken by current generation high resolution thermal cameras on usage of total body views or regional views.

EQUILIBRATION PERIOD FOLLOWING EXPOSURE TO HOT OR COLD CONDITIONS WHEN USING INFRARED THERMOGRAPHY.

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Introduction: Infrared Thermal Imaging (ITI) is capable of detecting skin temperature up to 1.5 cm deep with a sensitivity of 0.01°C. Ensuring proper equilibration before thermal imaging takes place is imperative to facilitate ITI's reliability and validity when assessing temperature and thermal patterns related to cutaneous blood flow. The use of ITI requires following precise protocols that have been set by the International Academy of Clinical Thermology (IAOCT). A minimum of 15 min is the current amount of time suggested by the IAOCT. To date, there is very little data available showing 15 min is sufficient time for equilibration to take place.

Purpose: To determine the equilibration time required after exposure to a hot (31.7 °C) or cold (18.9°C) environment.

Methods: Thermal images of the anterior and posterior views for 17 subjects were taken during two separate trials; a hot trial on day 1 and a cold trial on day 2. Upon arrival to the thermal lab, a 60 min equilibration period in a climate controlled room at optimal ambient temperature (24.2 °C) was used to determine a control skin temperature. Subjects wore minimal attire in order to expose maximal skin surface to room temperature. Subjects then stood in the thermal chamber for a 20 min exposure period to the hot or cold trial. Images were taken of the anterior and posterior views at optimal ambient room temperature immediately after exiting the thermal chamber, and at 15, 30, 45, and 60 min. Views were subdivided into periphery and trunk segments; mean, min, max, and standard deviations were determined for each segment. Temperature differences between control, immediate, 15, 30, 45, and 60 min time periods were compared using repeated measures ANOVA ($p < 0.05$).

Results: During the hot trial mean trunk temperature increased 1.03 °C and remained significantly different from control until the 30 min time period. The mean periphery temperature increased 1.37 °C and remained significantly different during the entire 60 min time period. During the cold trial the mean trunk temperature decreased 1.1 °C and remained significantly different until the 15 min time period. The mean periphery temperature decreased 1.7 °C and remained significantly different until the 30 min time period.

Conclusion: Results from this study indicate that exposure to hot or cold conditions (31.7 °C and 18.9 °C) may require a longer equilibration period than the recommended 15 min for skin temperature to stabilize to room temperature when using ITI.

PERFORMANCE TESTING OF THERMAL IMAGING SYSTEMS IN MEDICINE

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Consistent and regular condition and performance monitoring is important for the reliable use of infrared thermal imaging in medicine. Infrared camera systems nowadays offer increasingly higher capabilities and improved reliability, which can lead the operator to assume that the system is continually providing optimum performance. This, however, is not the case.

We propose a series of simple experiments based on inexpensive and easy to acquire materials, which a thermographer can use under normal clinical conditions to monitor the performance of thermal imaging equipment in order to maintain confidence in the measurements made. The 7 tests proposed are not intended to replace those undertaken by manufacturers or calibration laboratories, but can provide valuable information on both short and long-term camera performance. The proposed tests identify: a) offset drift after switching on, b) long-term offset drift, c) offset variation over the observed temperature range, d) image non-uniformity, e) the thermal 'flooding' effect, f) thermal resolution and g) spatial resolution.

Measurement results based on the above experiments will be presented which demonstrate that cameras may drift over several degrees centigrade in less than 2 hours after switching on. We will also show that imaging equipment can produce a varying amount of measurement error (up to 1.5 degrees centigrade), which depends on the temperature range observed. Results also show that equipment may be prone to non-linear errors (in the region of 1 degrees C), which are caused by deficiencies of the optical system and will manifest themselves if the equipment is not calibrated regularly.

OCULAR THERMAL IMAGING AS A MEASURE OF FEBRILE RESPONSES IN FOALS TO AN ENDOTOXIN CHALLENGE TEST

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The objective of this study was to evaluate febrile responses in weaned foals on a diet, with or without probiotic supplementation, using ocular thermography as a non-invasive and rapid means of body temperature acquisition following an endotoxin challenge test. Twenty two Quarter Horse and Thoroughbred foals (4-5 months) were weaned, individually stalled and given a feed supplement (CP 16%) alone (CON, n = 11) or top-dressed with a commercial probiotic preparation (Fastrack Microbial Pack, Conklin Inc.) at 28.4 g/head/d (PB, n = 11) for 30 d, with free access to hay and water. On d 30, a subpopulation of six foals per treatment group had indwelling catheters placed in the left jugular vein and iButton® data loggers configured to record body temperature at 10 min intervals placed under the tail-head. On d 31, foals were infused via catheter with lipopolysaccharides (LPS; *E. coli* 055.B5; 30 ng/kg BW). Infrared ocular thermal images and digital rectal temperatures were obtained at -0.5, 0, 0.5, 1, 1.5, 2, 4, 6, 12, 24 h as were blood samples for cortisol RIA and cytokine macrophage analysis (data not shown). Within 1 h of infusion all foals showed stress-induced clinical symptoms (dry cough, recumbency, mild diarrhea). Correlative analysis was performed between maximum ocular eye, rectal and data logger temperatures. No significant effect of probiotic treatment was observed for body temperature. Rectal temperatures (°C) peaked at 1.5 h in both groups (CON, 38.8 ± 0.22; PB, 38.7 ± 0.15) and returned to baseline 24 h post infusion. Both infrared ocular and data logger temperatures (°C) were positively correlated ($p<0.001$) with digital rectal temperatures ($r = 0.48$ and 0.56, respectively). These data suggest that ocular thermography may be an effective, alternative and non-invasive method of assessing body temperature of horses.

[Supported by MAFES and Conklin Inc., Shakopee, MN]

EARLY DETECTION OF HYPERELASTOSIS CUTIS/HERDA LESIONS IN HORSES USING DIGITAL INFRARED THERMOGRAPHY

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Hyperelastosis cutis (HC) is an autosomal recessive skin disease of economic significance in Quarter Horses. Affected animals do not generally develop lesions until one to two years of age. There is currently no test for carrier animals. The objective of this study was to determine whether digital infrared thermal imaging could be used to detect HC carrier foals. Studies using digital infrared thermal imaging (DITI) of mature affected horses detected cooler areas of skin ($P = 0.01$) associated with developing HC lesions compared with normal animals. Based on these findings, four HC-affected and two carrier foals were compared using DITI with aged-matched normal foals (n = 5). Digital rectal temperature and thermal images of the skin surface were recorded at two to three-week intervals using a ThermaCam® S60 camera (Flir Systems, Boston, MA) and location of thermal lesions were documented. Data analysis is based on five imaging sessions. Affected animals demonstrated a greater ($P < 0.05$) range of skin temperatures when compared to carriers and control animals, while carrier skin temperatures also differed ($P < 0.05$) compared with controls. There was a strong correlation between rectal and skin temperatures in normal ($r = 0.94$) foals but poor correlations existed in affected ($r = 0.38$) or carrier ($r = 0.47$) foals. One affected foal developed a thermal lesion one week prior to developing a visible skin lesion. Measurements were repeated in these animals as yearlings and the thermal image patterns remained consistent with observations made as foals. In addition, histology confirmed the presence of HC lesions as detected by thermal imaging. Electron microscopy demonstrated irregular tangled arrangement of collagen bundles in HC lesions compared to normal skin. These observations indicate that DITI may be a useful, non-invasive means of early detection of HC carrier foals.

[Supported by American Quarter Horse Foundation]

TISSUE COMPRESSION AT THE ISCHIAL TUBEROSITY AND THE MIDDLE POSTERIOR THIGH: IMPACT ON NERVE FUNCTION, BLOOD FLOW, AND TISSUE OXYGENATION

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Paresthesia of the lower limb is a common condition associated with extended sitting. Although these sensations are typically produced by spontaneous action potential propagation originating from ischemic regions of affected axons, total limb blood flow and tissue oxygenation may also contribute to the condition. The purpose of this investigation was to evaluate the effects of controlled tissue compression on nerve function, blood flow, and tissue oxygenation. Counter balanced compression intensity (30, 90, 150, and 210 mmHg) produced by a purpose-built plunger was applied to either the ischial tuberosity or the middle posterior thigh of four participants lying prone. Nerve function, blood flow, and tissue oxygenation were evaluated by the soleus' response to repeated 50% H-maximum Hoffman reflex stimuli, thermography, and near infrared spectroscopy (NIRS) measures, respectively. Each measure was recorded each minute throughout compression and the ensuing 10-minute post-compression period. Nerve function was altered for the 150 and 210 mmHg middle posterior thigh condition as evidenced by an increase in the soleus Hoffman reflex amplitude. This response did not occur at the ischial tuberosity location or during the other compression intensities. Thermography comparisons between the baseline condition and the uncompressed lower limb showed no change, indicating that blood flow within the compressed limb was not altered. NIRS demonstrated that tissue oxygenation did not change for any condition. However, the areas immediately proximal and distal to the compression surface showed a marginal total hemoglobin reduction. This change likely occurred due to tissue deformation produced by the compression since both oxyhemoglobin and deoxyhemoglobin showed equivalent reductions. Paresthesia sensations may be attributed to altered nerve function and not noticeable differences (as assessed by thermography and NIRS) in total lower limb blood flow or oxygenation.

THERMAL WINDOWS IN SEALS AND SEA LIONS: NON-INVASIVE INDICATORS OF HEALTH?

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Alaskan harbor seals and Steller sea lions have adapted to the extreme weather conditions of their aquatic and terrestrial habitats through the use of blubber, which is not only a remarkable energy source but also an efficient insulation system that provides security from their harsh surroundings. Despite their shared habitat, the anatomy and life history traits of the two groups differ such that energy resources and thermoregulation may take variable precedence with different body sites and physiological states. Nine harbor seals (8F, 1M) and two female Steller sea lions at the Alaska SeaLife Center in Seward, AK, are the focal subjects of the validation of the use of infrared thermography as a diagnostic tool. Data are collected from each individual up to biweekly with a FLIR P25 camera, coupled with a non-invasive assessment of blubber depth via a SonoSite 180Vet portable imaging ultrasound from up to 10 body sites. Preliminary studies suggest that thermal windows vary between the two species as well as among individuals, between seasons and with body condition (i.e., blubber depth). Establishment of a thermal window baseline may allow for future diagnostic applications in both long-term captive and free-ranging pinnipeds, such as identification of inflammatory processes, disease, or nutritional stress.

USE OF IR THERMOGRAPHY IN DETERMINING SPATIAL HEAT DISTRIBUTION OF VARYING ULTRASOUND TREATMENT TECHNIQUES

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Background and Purpose: In physical therapy, short wave heat is used as a possibility to achieve deep heat in patient treatment. One of the modalities used is ultrasound, where the ultrasound transducer is moved in order to avoid the non-uniformity of the ultrasound beam. The purpose of this research paper is to see if infrared thermography can be used to determine if different techniques have different characteristics in spatial heat distribution.

Methods : The experiments were performed on the cross section of a fresh pig cadaver hind leg, reflecting a location a physiotherapist may encounter in clinical situations. The experiments were carried out with an ultrasound frequency of 2MHz, an intensity of 1W/cm^2 and three different techniques, i.e. an 8cm/sec circle technique, a 3cm/sec circle technique and a 3cm/sec linear technique. The temperature increase patterns were thermally imaged at 30 sec. intervals with an insonation period of 5 minutes. In the computerized comparison, every temperature data point from the reference image was "subtracted" from the thermal image after the respective intervals.

Results: The circle techniques show that the heat distribution is concentrated around the middle of the circle. In the 8cm/sec circle technique the heat distribution is found in the superficial tissue layers, while for the 3cm/sec circle technique the heat is also found in the deeper tissue layers. The linear 3cm/technique shows heat at the turning points of the movement.

Conclusions: The different techniques are not interchangeable. A faster circular movement and a slow longitudinal movement of the transducer influence the heat penetration depth. The three techniques have different heating characteristics.

CRYOGENICS CHANGES IN DIFFERING ICE TREATMENTS

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The purpose of this study is to look at the differences between a fifteen minute ice bag treatment and a fifteen minute ice towel treatment. If they differ which treatment would be more beneficial to rehabilitation of injuries? Three factors were compared in this study: 1) Coverage area of the treatment 2) time for surface temperature to return to normal 3) Average change in surface temperature. Seven college students were tested in two trails on separate days (4 m, 3 f, age 22.2 ± 1.8). A baseline themographic image was taken of both the anterior and posterior torso. The area of the deltoid, scapula and pectoralis were used as the treatment area. From baseline images an average surface temperature was determined for the treatment area. A fifteen minute ice treatment was administered using either a standard plastic ice bag or a cotton ice towel. Immediately following the treatment, an image was taken to determine the maximum and average decline in temperature. Images were then taken in thirty minute intervals until the average temperature returned to within one degree Celsius of the baseline. The results showed the ice towel covered a space 30% larger than the plastic bag, and that the towel effectively doubled the treatment time. On average the towel was 6ºc cooler than the bag. Cooler temperatures allows for a better guarantee that the vessels are being constricted and reducing swelling. The larger coverage insures that both the injured and surrounding areas can be treated. Finally, doubling the amount of time it takes for the surface temperature to return to normal means that the treatment is still working long after the ice is removed. Taking these factors into consideration it is important to look to ice towels as a viable substitute for the standard ice bag.

A THERMOGRAPHIC COMPARISON OF COLD THERAPY DEVICES ON SURFACE SKIN TEMPERATURE

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Purpose: This study compared the practical effects of two medical cold therapy devices, ProThermal (Pro) and Game Ready (GR), to a conventional ice treatment (CI) on surface skin temperature using infrared thermal imaging. **Methods**: Six male subjects (ages M=23.2 years) were randomly assigned to each cold modality for a treatment period on three separate days. Following 15 minute room equilibration (EQ), each modality was applied to the anterior upper right leg (treatment site; indicated by the superior 1/3 of the tibia) for a twenty minute cold treatment period. Using infrared thermography, skin temperatures were imaged at the treatment site at four different time periods: Pre-treatment (PT), after EQ; Post- cessation of the treatment period; Post15- fifteen minutes post treatment; Post30- thirty minute post treatment. Area skin temperatures of the treatment site were measured for each image and the mean values were collected using Computerized Thermal Imaging software. **Results**: Repeated ANOVA's were employed to determine statistical differences between treatments ($p = 0.05$). No statistical differences were identified after equilibration during PT conditions. All three modalities resulted in significantly colder skin temperatures from PT to Post. However, Pro achieved significantly higher Post skin temperatures than CI and GR (Pro 17.7 ± 2.06; CT 10.6 ± 2.53; GR 11.71 ± 2.53). The warmer temperatures demonstrated by Pro at Post treatment resulted in skin temperatures statistically insignificant from Post15 to Post30, compared to PT. Consequently, Pro displayed significantly higher skin temperature than GR and CI at Post15, and with CI only at Post30. There were no significant differences between GR and CI at any time period, thus showing a similar beneficial lowering of skin temperature during the Post treatment periods. **Conclusion**: Our data suggests that a CI treatment along with the medical cold therapy devices GR and Pro are capable of significantly lowering skin temperature after a twenty minute cold therapy treatment. However, only CI and GR were cooler and were able to maintain a lowered skin temperature for 30 minutes, following a cold treatment.

RELATIONSHIP BETWEEN DIGITAL INFRARED THERMAL IMAGING DETERMINED KNEE TEMPERATURES AND KNEE PAIN IN DISTANCE RUNNERS DURING A 3-MONTH CROSS-COUNTRY SEASON

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Introduction: Attempts have been made to identify or predict tissue injury in animals and humans using digital infrared thermographic imaging (DITI). Limited data are available describing normal DITI profiles of human limb joints, although progress has been made towards establishing a normal DITI profile of the knee of distance runners. **Purpose**: To develop case studies describing the relationship between DITI-determined knee temperature and knee pain in two collegiate distance runners. METHODS: Two males, out of 26 male and female athletes, reporting unilateral knee pain ≥ 4 on the Nirschl Phase Pain Scale (NPPS) on multiple assessments during a 3-month cross-country season were selected for analysis (subject 1: 23% of visits; subject 2: 43%). NPPS ratings ≥ 4 are defined as causing and an athlete to alter performance. At each assessment, subjects rated knee pain bilaterally with the NPPS and Visual Analog Scale (VAS). Anterior (A), posterior (P), lateral (L), and medial (M) DITI were recorded for each knee. For each view, temperature points within a standard observation area were analyzed to determine mean, maximum, minimum, and range using Therma CAM Researcher Professional software (Flir Systems, Wilsonville, OR). DITI data were correlated with NPPS and VAS pain ratings using Pearson's *r*. RESULTS: Correlations between knee pain, determined using NPPS or VAS, and DITI-determined knee temperature were consistently low and not significant. R values between knee temperatures and NPPS for A, P, L and M views ranged from 0.05 to 0.52; for VAS and DITI, r values ranged from 0.00 to 0.48. The only statistically significant correlation ($p < 0.01$) was between NPPS and anterior maximum temperature ($r = 0.52$). CONCLUSIONS: In the two case studies, there was a lack of a strong and consistent relationship between DITI-determined knee temperatures for various views and subject reported knee pain during a cross-country season.

APPLICATION OF A NEW RADIOLOGICAL IR IMAGING TECHNIQUE. MRI WITH IR 3D FUSION AND 3D STEREOSCOPIC PRINTING

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MRI fusion and 3D IR imaging: We are developing a new IR imaging technique which consists of fusing magnetic resonance imaging (MRI) (1.3 Tesla Magnetom MR Systems, Siemens) and thermal infrared (IR) imagery to generate a diagnostic 3D image in real-time. The authors used high resolution IR images (0.02° C) produced by sensitive QWIP FPA IR detectors acquired through a high sensitive camera (ThermaCam SC3000, FLIR Systems, Sweden). In order to build an Image Fusion Scheme, it was necessary to standardize the MRI image acquiring process by filming the whole body 360° upstanding under automatic rotatory motion. The best incidences acquired through real time 14-bit digital output connector for fast image caption and recording were chosen. A sophisticated and dedicated software (ThermaCam Researcher 2001, FLIR Systems) was used in the evaluation of high resolution images in continuous color pallet. After acquiring the images, a 3D reconstruction with graphics computer systems was performed. Contrast-enhanced MRI for breast cancer assessment has been increasingly used. This modality of imaging provides 3D functional information, via pharmacokinetic analysis of the interaction between the contrast agent and tumor vascularity. MRI is an important breast imaging modality: it can be applied to women of all ages including patients with surgical/radiotherapy scarring, in contrast to X-ray mammography , which has limited use in younger women, HRT users and for postoperative assessment. IR imaging was frequently used in the past to detect changes in skin surface temperature associated with breast cancer. A 1-2° C elevation in skin surface temperature can usually be observed at the tumor periphery. Such effect suggests that there is a local change in temperature that might be due to the hypervascularity resulting from tumor-associated angiogenesis. Pathological changes (such as calcifications and fine spiculations) are more difficult to be assessed through MRI. Therefore, there is clinical and diagnostic application of this technique that fuses high-resolution functional data acquired from IR imaging with the structural data acquired from MRI imaging. Using breast imaging fusion software, the clinician is able to analyze areas of interest seen in X-ray mammogram with the aid of MRI and IR 3D imaging acquisition. Application of this research technique include improving MRI diagnostic capability that can be applied towards breast cancer angiogenesis, intracranial diseases and peripheral vascular occlusion diseases.

3D anaglyphic stereoscopic IR imaging: The authors describe how to use the 3D anaglyphic method in order to produce stereoscopic IR imaging prints for anatomical and physiological teaching and report preparation by using professional photographic and computer software. Similar to any other method of producing stereoscopic images, the anaglyphic procedure is based on the superimposition of two slightly different images of the object to be seen in a 3D fashion. One image is generated with the camera angled from the left side and the other image from the right angle. Both pictures are obtained through a single camera, or by using two cameras affixed to each other. After the images are processed by applying different complementary color dyes, they are scanned and superimposed to each other with the aid of professional imaging-manipulation software and printed out. Glasses with colored lenses, normally one red and one blue, are employed to allow stereoscopic vision. Stereoscopic 3D IR anaglyphic prints can be reproduced using photographic and personal computer equipment; so the prints can be easily reproduced without significant cost and are of particular help to disclose the 3D character of IR imaging.

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HIGH SENSITIVE IR IMAGES REPORT. NEW SYSTEM OF MUSCULOSKELETAL INJURIES DESCRIPTION

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IR imaging has an important role in worker's compensation and insurance reimbursement. It is necessary though that the report is official as a traditional radiological report. We developed a new evaluating system to describe IR signaling of 3D vascular territories (callled "angiosomes") (Govidan, 2005), in order to better assess musculoskeletal pain diseases using high sensitive IR imaging equipment The aim of this study is to compare the IR imaging skills of physicians in training with those of experienced IR radiologists. Also we evaluate the impact of a training program using a new evaluating system applied to real patients.

Method: In an academic setting, 32 physicians (neurology, orthopedic and occupational medicine residents) evaluated patients using a high sensitive device (Thermacam SC3000 FLIR Systems, Sweden). The thermal camera produced high resolution and high sensitivity images (0.02 ºC) through a QWIP FPA IR detector. It can detect IR radiation in the 7.5-13 μm range. These parameters of sensitivity are necessary for detailed medical observation and quantification of heat flow.

A Volunteer control group comprised of 333 patients with musculosk eletal pain injuries whose IR signs were identified after completing a clinical questionnaire. IR signs (IR imaging Area Interpretation Criteria (Brioschi, 2002): region of interest, intensity, size, shape, distribution, delimitation and margins) were determined beforehand by an independent skilled IR imaginologist and were validated by ultrasonography (US) and a skilled pain physician. All patients were seen pre and post-interventional by the same physician in a course of one week.

Results: Exams were normal in all participants from the volunteer control group. The sensitivity and specificity of the US were 79 and 100% respectively, while the IR imaging was 100% and

100%. The total accuracy was 89% for US and 100% for IR imaging. When US was compared with IR imaging findings, it showed a positive correlation of 89%. In 11.2% of the cases the IR imaging was abnormal while the US result was normal; these were non specific injuries without anatomic correlation. The experts were the most skillful, achieving 100% recognition of IR signs and making correct diagnoses in 100% of cases. The residents identified 80% of the thermal signs and made correct diagnosis in 70% of cases in the first month. After one week of training sessions of the new system, the mean percentage for correct diagnosis was 98% [an increase of 28% ($p<0.05$)].

Conclusion: The level of diagnostic skills in this relatively small group of physicians in training was indeed high and was improved by a short period of training with this new IR training course for musculoskeletal pain diagnosis. Actually the system is a tool available in the internet for continuous training and supporting to the affiliated physicians.

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INFRARED EXPERTISE: FROM DIAGNOSIS TO TREATMENTS. INFRARED IMAGING OF FAR-INFRARED RADIATION IN DIFFERENT TYPES OF APPLICATIONS.

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Infrared radiation is subdivided in an arbitrary pattern into three categories: near- (0.8–1.5 ìm), middle- (1.5–5.6 ìm), and far-infrared radiation (5.6–1000 ìm). Only little is known about the biological effects of infrared (IR) radiation, although human skin is increasingly been exposed to IR from several natural as well as artificial sources. IR, similar to ultraviolet (UV) radiation, is likely to exert biological effects on human skin. IR radiation has increasingly been used for cosmetic and wellness purposes. Apart from this, IR radiation is used as a therapeutic approach in the treatment of several entities such as autoimmune, inflammatory and malignant diseases and also wound healing disorders. Electromagnetic energy in the form of far-infrared rays (FIR) is now under extensive investigation as local, regional, and whole-body treatment. Recently, much attention has been paid to its activities concerning health and food preservation. Accumulated evidence indicates that FIR is biologically active. FIR has been reported to inhibit tumor growth in mice and has been applied as a therapeutic approach of bedsores in clinical settings. However, there are few reports of scientific analysis of biological activities of FIR radiation, with most of these being related to the hyperthermic effect of FIR. The biological effects of FIR on whole organisms remain poorly understood. Herein we report different applications of continuous exposure to FIR and its evaluation through IR imaging with high sensitivity sensors.

Methods: A randomized, controlled trial was approved by the hospital ethics committee and conducted at the Center of Pain, Division of Neurology and Neurosurgery at University of Sao Paulo from January to December 2006. 110 subjects aged 27 to 66 years old were evaluated. All subjects provided written informed consent for their participation in the study. Skin blood flow and temperature of individuals were measured using a FIR camera (ThermaCam A40M, FLIR Systems) in a room with constant temperature ($T = 20^o$ C) and constant relative humidity of 50%.

Skin blood flow, edema, inflammation and pain from study group ($n = 80$) was compared to control group ($n = 30$); study group was composed of different conditions (pos-poliomyelitis syndrome, lumbar pain, neuropathic pain, cellulite, carpal tunnel syndrome, fibromyalgia, obesity, leg varices, tendinopathies, toe inflammation).

Garment ceramic-impregnated by aluminum, silica and magnesium (95% polyurethane and nylon; 5% ceramic) that absorb ambient FIR (3 to 15 micrometers wavelength) from the environment and body was utilized for this study. The garment reflects a thermal energy intensity of 12.6 to 71.5 kcal/m^2 per hour to the underlying tissues. These products, known as "INVEL® garments," were approved in 2005 by the National Health Surveillance Agency in Brazil. Different garments were used: short drawers, shirts, gloves, cards, multi belts, plush, and elastic bandages. Also an emulsion prepared with the ceramic-impregnated powder was tested.

Results: Measured skin blood flow, edema, inflammation and pain change significantly after FIR radiation application via the ceramic-impregnated garments. Secondary improvement occurred through vasodilatation and improved circulation. Skin temperature increase ranged from 0.6 to 1.5^o C. Average measured decrease in medium body circumference was 1.8 cm.

Conclusions: These results suggest a biological effect of increased exchange of body fluids, due to decrease in size of water clusters, without a significant increase in the temperature of the body tissues. The results suggest that the FIR increase the lymphatic drainage in the first steps of the inflammatory process. Nitric oxide (NO), constitutively produced by endothelial NO synthase (*e*NOS), plays an important role in vascular biology including regulation of vascular tone and blood pressure, as well as the regulation of angiogenesis. These findings suggest that FIR therapy also up-regulate the expression of arterial *e*NOS increasing circulation as demonstrated by IR imaging.

The potential effect of FIR radiation in the improvement of circulation is suggested by our studies. This study suggests that FIR radiation has the potential to increase skin blood flow to the tissues. FIR rays show different photobiological properties. We used FIR with wavelengths ranging from 3 to 15 ìm in these studies, whereas lasers deliver a specific coherent beam (helium-neon at 632 nm and argon at 488 nm). Although it is thought that further studies of FIR are required, the biostimulatory effects of FIR radiation might be similar to those of low energy lasers or near-IR rays. FIR can be combined with radiation, chemotherapy and biological therapy in an effort to increase their effectiveness. These findings suggest that whole-body FIR radiation at room temperature could be a promising way of photochemical therapy. Further analysis of the molecular 'IR response' and the photophysical and photochemical reactions induced by IR should provide valuable information on the role of IR on cellular functions with its impact on aging, tumor inhibition and stress resistance. These studies may also disclose novel therapeutic applications of IR radiation in clinical settings. In addition, it was very practical to evaluate the biological effects of IR by IR imaging in vivo studies. Moreover, these results should allow the development of IR photochemical therapy magnifying the spectrum of knowledge and research for IR beyond diagnosis.

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SURGICAL INFRARED IMAGING APPLICATIONS: DIRECTIONS FOR THE FUTURE.

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The 20th century brought with it the bundle of the wars. From 1914 to 1945, in only thirty-one years, mankind witnessed the largest scientific revolution ever seen. Men achieved, in those years, what had not been accomplished in nineteen centuries. At the same time that it caused an enormous destruction in the world, the two great world wars brought scientific and technological progress. The most recent example is the use of infrared (IR) thermal images by the Coalition Air Forces, utilized against the Iraq attacks of high precision as intelligent weapons guided by the heat. Thanks to the high resolution and sensitivity IR vision technology, today it is possible to visualize the coronary arteries flow during revascularization surgery of the myocardium, observed through a monitor in a totally non-invasive way. This increases the surgical success rate and the quality of life offered to the patient. Surgical IR applications are being more extensively studied by our group in the last 5 years.

Thermocoronary angiography: Brazil has one the highest rates of death by heart disease in the world (34 %). One third of these cases are caused by coronary artery disease which is the main reason of sudden death, infarction, angina and cardiac pathology. In coronary occlusions, the most common approach is the revascularization procedure by using either an arterial or venous graft. Inadequate anastomosis leads to reintervention surgery or even death by infarction either during or after surgery. Intraoperative coronary angiography has always been favoured by cardiac surgeons. The arterial coronary net lies in the heart surface (epicardium). Right after the surgical clamp is released during coronary anastomosis, the warmth of the blood pattern can be observed flowing to the 4th order arterial branch. Because of its benefits, it is likely to become the gold standard in safe cardiac revascularization surgery. Thermal coronary angiography (TCA) is a useful method for intraoperative control of graft patency. It detects heat differences between tissues, provides easy-to-interpret angiographic images and even measures quantitatively the graft flow. Thermal imaging provides decisive coronary angiographies, and detects the perfusion area and flow of the implanted graft. It allows real-time detection of technical failures, reveals unexpected occluding plaques or any kind of flow-restricting lesions, and gives the chance of refinement of the anastomosis during the arrest period. Thermal imaging technique is a safe, non-invasive and feasible method to document the quality of the myocardial revascularization intraoperatively.

Sympathectomy IR imaging studies: Endoscopic sympathetic block (ESB) is used as a treatment of excessive palmar sweating and sympathetic dysfunction. IR imaging study of palmar and facial skin temperature can be performed pre-, intra- and post-operative during thoracic sympathectomy. IR imaging studies offer descriptive information about the autonomic innervation of the upper thoracic sympathetic trunk.

IR evaluation of organ transplantation: IR imaging use in surgery has increased, especially in the evaluation of the organ and tissue microcirculation. Unlike skin surface, the surface of internal organs are not wrapped up in a thermal insulator. According to Newton's third law, they get cold when exposed to a cold environment. Their surface temperature is determined basically by the flow of the blood perfusion. For this reason, an organ's viability can be evaluated by continuous registration of thermal images. When there is an arterial net in a certain organ, its anatomical pattern is clearly observed through thermal images. Due to the increasing need for liver donors, transplantation from non-heart-beating donors (NHBD) has increased. As there are not detailed studies of reperfusion injury of these livers so far, an IR imaging evaluation of liver ischemia reperfusion immediately after NHBD organ explantation could be extremely useful. It has been applied in kidney, liver, lung and intestines transplants, in the postoperative evaluation to check for venous thrombosis, acute rejection and immunosuppressive drugs toxicity.

IR Direct Calorimetry: The authors developed a method of IR thermographic calorimetry (ITC) to estimate the protein intake requirement. Digital radiometric images were taken with a FLIR SC3000 infrared camera (FLIR Systems, Sweden), and the thermal data associated with heat loss theories were used to calculate mean body surface temperature, heat losses, and total energy expenditure caused by radiation, convection, evaporation and conduction. The personal parameters included age, weight, and height. In order to determine an ideal protein requirement, caloric needs were calculated based on their resting metabolic rate using ITC and sophisticated software. In comparison with other calorimetric method, interpretation with ITC is more accurate because it is taken when metabolic pathways other than oxidation predominate or when there are clinical conditions that affect carbon dioxide exhalation from the lungs. ITC is an accurate, noninvasive, and easy method for measurement of heat loss and energy expenditure in surgical patients, and therefore it may be an useful clinical and research tool especially to estimate the adequate protein intake.

Conclusion: With the development of faster computers and more powerful programs in data processing and complex imaging, we realized that IR imaging should be regarded as a functional and dynamic diagnostic tool and not as a conventional anatomical and static imaging exam.

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ROLE OF MAST CELLS IN CHRONIC REGIONAL PAIN SYNDROMES.

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Chronic Regional Pain Syndromes can be spontaneous or induced eg., migraine by triggers or for CRPS as a complication of surgery (or) trauma.

The majority of migraine and CRPS patients do not show maximum obtainable temperature differences at room temperature/ static measurement, in the region of interest or between ipsi-lateral and contralateral sides. The temperature differences may vary based on regional/angiosome territory and mast cell properties and can be imaged at room temperature following vasomotor challenge using thermal (or) nonthermal factors. Central and regional vasomotor control may require/respond to specific vasomotor stress requirements eg., for facial/ trigeminal(hyperoxia, hypercarbia, positive pressure and / or drug) and for extremity cold or warm temperature challenges/ regional or whole body cooling and warming.

Mast cells are critical players in inflammatory diseases. These cells are located perivascularly, in close association with neurons. Neuropeptides such as CGRP, hemokinin A, neurotensin (NT), Pituitary adenylate cyclase activating peptide (PACAP) and substance P (SP) activate mast cells leading to secretion of vaso-active, proinflammatory and neurosensitizing mediators, thereby contributing to migraine and CRPS pathogenesis.

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

Is associated with allodynia and hyperpathia, show regional perfusion abnormalities, have neuropeptide changes, e.g., CGRP, have tissue hypoxia/ A-V O^2 difference, AVAs are involves in altering flow independent of metabolism, functional anatomy correlates with angiosomes and physiological anatomy correlates with activation of perivascularly located mast cells and its vaso-active mediators.

Use of thermal and non thermal stress to study vasomotor capacitance allows thermologists to monitor and provide a non invasive method with increased sensitivity and specificity to be applied clinically in chronic pain.