11th Europen Congress of Thermology

Abstracts

History, presence and future of thermology societies

THERMOGRAPHY AND ITS CLINICAL APPLICATIONS-NEW YORK 1963

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From 1940 until the late 1950's infrared imaging had been classified as a military technology. In 1963, early cameras used for medical research were in use, and the New York Academy of Sciences announced a special conference for a number of pioneers. Engineers, physicians and physiologists came together for that first meeting in the USA, which was published by the Academy. This book provides a detailed account of that conference and is well illustrated. From this we have a record of the early technology available, but more especially it provides a very useful appraisal of the background science, human physiology of temperature, and expectations of the future.

Some significant pioneers were present, including J.Gershwin Cohen and R Bowling Barnes. The Barnes thermograph was one of the first imaging systems made available for medical trials in the USA. Another pioneer was Dr Ray Lawson who not only reviewed the potential applications in medicine, but presented his early work in breast cancer thermography. His work has been widely recognized across the world in this area. A new British camera called The Pyroscan was developed in the UK, and preliminary medical studies had been carried out in London by Lloyd Williams in breast cancer and Bath by Ring et al. in rheumatology. There are several papers in the proceedings outlining very good principles for understanding localized temperature changes shown by thermography. The anatomy, physiology and pathology of a number of clinical conditions where thermography had shown useful information was expertly discussed. These principles are of continuing value today. The section of the proceedings dealing with the different clinical applications takes up over 200 pages of this 300 page book.. A good paper on the value of thermography in medical research was given by Lloyd Williams. The applications include varicosed veins and venous insufficiency, peripheral vascular diseases, orthopaedics trauma medicine, neurology thoracic and abdominal conditions. Obstectrics, rheumatology and breast diseases wwere also included. Breast screening potential and early diagnosis of breast cancer to improve the results of surgery were presented. Veterinary medicine was presented by Wendall Smith.

The camera technology used was of course slow and difficult to use. A major problem of that pre-computer era was in attempts to measure temperature from a thermogram. A group of thermal references was often included in the scanning area, and several different devices were used to make comparison of density in the monochrome image with the references to derive temperatures. There were however many problems with this method. Scanning times were slow, and a single image could take many minutes to acquire.

A striking feature at this time however, is that with all the limitations of the technology, most of the clinical applications of thermography today were investigated. There were just a few areas of medicine that have not been continued. Today we have modern high speed and higher resolution systems, with the outstanding advantages of computer technology and image processing.

HISTORY OF JAPANESE ASSOCIATION OF THERMOLOGY

Hisashi Usuki

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Japanese association of thermology had been established as "Thermography Study Group" at the beginning. It was 1984 that the study group was promoted to the academic society. Its name was "Japanese Association of Thermography" at that time. Then, the name was changed to "Japanese Association of Thermology" in 1987. The number of papers presented in the annual meeting in those days was more than 70. There were many kinds of papers presented in the meeting in those days. But, the number of papers presented in the annual meeting has been diminishing after the function of the medical equipment becoming to plateau. The average number of the papers presented in the recent four annual meetings was 21. The number of active members has also decreased. It is two-thirds of members belonging to the association in 2004. In this presentation I will demonstrate the history of Japanese Association of Thermology and the transition of the papers presented in the annual meetings.

55th ANNIVERSARY OF THE GERMAN SOCIETY OF THERMOGRAPHY

R.Berz

German Society of Thermography & Regulation Medicine, Waldbronn, Germany

55 years ago, the physician Schwamm and the physicist Reeh founded the very first society of thermography, named "Medical-physics Work Group of the County Unterlahn". The name changed several times, from "Society for Thermodiagnostics" to " German Society of Thermography" to the current " German Society of Thermography & Regulation Medicine". Originally based on infrared radiometry, the major progress in standardisation of the method was achieved by Rost, who used contact thermometers vor measurements in well defined body regions.

Although contact measurements are still the predominant method of temperature measurements in regulation medicine, infrared cameras are often applied nowadays. This techno- logy provide the facility to combine the principles of regulation thermography with mainstream evaluation of thermal images which is based on quantitation of temperature distribution on the body surface in a quasi steady state of heat exchange with the environment. Most recently the German Society of Thermology and the German Society of Thermograpy & Regulation Medicine have merged..

EUROPEAN ASSOCIATION OF THERMOLOGY HISTORY AND FUTURE

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Objective: To describe the history of the EAT.

Method: Reports and protocols of General Assemblies, Board Meetings and Proceedings of European Conferences were retrieved and information on the executives and members of the Association was extracted.

Results: The number of members in national thermology societies varied over the years and the focus of research in thermology migrated from western to central Europe. Spain and Italy reduced their activities in the early nineteen eighties, most of the activities in France and the Netherlands stopped in the late nineteen eighties, Great Britain continued its interest in Thermal imaging, although with a reduced manpower. Germany decreased also the research in thermology by the early nineties. At the same time new interest in the subject raised in Austria and in Poland. In the last decade valuable input came from Norway and recently from Romania.

In total 10 presidents from 7 different countries served the EAT which currently has 8 society members and some individual members. Until now, 11 European conferences of thermology were organized, and this year´s congress has more papers than the last meeting. The journal Thermology international is the official publication organ of the EAT and 7 other national thermology societies around the world. A website at supports the publication activities of the EAT.

Conclusion: After a numerous membership in the EAT and high interest in thermal imaging in the seventies and eighties, a difficult time followed in the nineties and the beginning of the 21st century. Currently the interest in thermology seems to revive and the EAT might grow again in the future.

Standards for thermal imaging

STANDARDS FOR TEMPERATURE MEASUREMENTS

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The current temperature scale established throughout the world is the International Temperature Scale of 1990 (ITS-90). While this is generally recognized in trade and industry it is not so widely promulgated in other sectors such as healthcare. This paper will begin with a discussion of how the temperature scale is established and then how the general user community can access that scale through applying the principles of calibration, traceability and accreditation.

Recent developments will then be described that have taken place in the practice of medical thermometry and how NPL is helping to validate these new methods and techniques putting them on a firm metrological footing. The following areas of medical thermometry will be addressed:

- The establishment of techniques for the calibration and validation of ear thermometers
- Improving the practice of quantative clinical thermal imaging
- Validation studies of in-situ probes for brain temperature measurement
- Validation of internal temperature measurement studies based on magnetic resonance imaging spectroscopy

One of the recurrent themes of this talk will be the deployment of fixed-point temperature references, as suitable secondary standards for medical thermometry.

ISO STANDARDS FOR FEVER SCREENING

EFJ Ring

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Influenza virus infections form a regular part of life, but periodically a more virulent strain occurs with sometimes rapid and fatal consequences for humans. Since the outbreak of severe Acute Respiratory Syndrome SARS in China in 2002-3, infrared imaging has been used in some airports as a means of screening passengers who may endanger others by travelling whilst suffering from a fever. In 2004 Singapore Standards authority SPRING produced two excellent documents as technical references. Thermal Imagers for Temperature Screening part1 requirements and test methods, and Part 2 Implementation Guidelines, were the first documents to focus on the required information for the application of this technology for fever screening. These were used as the basis for a new working group for the International Standards Organization. The content of the Singapore documents were updated and expanded to provide a new standard for the correct deployment of thermal imaging for fever detection.

Many of the first installations were (and still are) positioned in a way that reduces the efficiency of temperature measurement. Strict protocols, as in medical thermography, are the key to reliable and reproducible use of the technique. Proper understanding of the conditions for installation and use are essential, as are the regular testing of camera performance and training of personnel involved. The new standard is called "Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening" IEC80601-2-59and ISO subcommittee SC3. and was published after an international vote in September 2008.

A second document based on the SPRING document Part 2, is being published in 2009. This is not an international standard as such, but a technical guide to the "deployment, Implementation and operational guidelines for identifying humans using a screening thermograph". ISO/IEC TC 121/SC 3 N.

The ISO standard sets out the technical minimal performance required for a thermographic system used for fever screening. It refers to a number of existing standards relating to calibration of cameras, use of black body radiators etc. and the optimal performance needed to image to face and measure as accurately as possible. The inner canthi area of the eyes is a preferred and recommended site to represent core temperature. The procedure requires correct positioning so that the face fills the majority area of the image. It also requires a minimal number of pixels in the measured area, to derive the temperature. This contrasts with many of the pictures shown in the media where the camera may be directed at groups of people, and maximum temperature displayed in a thermogram may be based on a single pixel. Many images shown in thermograms drawn from image libraries by the media are of low resolution, probably out of focus, and the subject is too far away to measure temperature. The main items of these documents will be described and their importance to the future use of medical thermography will be discussed. At the present time the H1N1/A virus alert has resulted in more thermography installations, although it is not yet clear if they will be used in compliance to the new standard.

THE IMPACT OF THE EUROPEAN UNION'S MEDICAL DEVICES DIRECTIVE FOR MEDICAL INFRARED IMAGING AND MEASUREMENT

N.N., R.Berz

German Society of Thermography & Regulation Medicine, Waldbronn

The Impact of the European Union's Medical Devices Directive for medical infrared imaging and measurement

The EU's MDD is binding law for all countries of the union and ensures a high quality of security, accuracy and reliability of medical devices. Thermal measurement by infrared cameras or other devices is classified as class 1m equipment. This means that all thermal measurement has to undergo the whole process of certification, comparable to class 2 equipment. Only thermal imagers without any temperature reading (in °C) are class 1, where a simple CE sign is sufficient. Class 1 m as well as class 2 needs the participation of a "notified body", an external certification expert independent of the manufacturer of the equipment. This is documented by the addition of the ID number of the notifying body behind the CE sign.

PROCESS OF STANDARDIZATION OF BREAST THERMOGRAPHY IN JAPAN

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Many kinds of diagnostic criteria and conditions for thermographic examinations had been published over twenty years ago. However, some factors did not suit to Japanese. Because, the room temperature recommended for the examination was too cold for Japanese. So, the temperature of the examination room had to be changed. Changing the room temperature influence to diagnostic accuracy, then, we had to create a new standard adapting to Japanese. Some teams were constituted for standardizing several thermographic fields. A working group for breast disease was one of those teams.

The standardized factors were "Conditions of patients, examination rooms and taking thermogram", "Terminology" and "Diagnostic criteria". At first we made standardization of the conditions at the time of examination. The temperature of examination room was determined to be 24 centigrade. This was warmer than the temperature recommended in the foreign study. The warmer temperature might depress the diagnostic accuracy rate. Then, the terminology of thermographic findings was standardized. And we began to create the diagnostic criteria suitable to Japanese women. The positive rates of many findings were calculated in breast cancer patients and patients with benign diseases. Some findings were selected, because, the positive rate in the breast cancer patients was differ from that in the patients with benign diseases. In the last stage of creating the criteria quantitative factor was removed from the diagnostic factors. The reason of this was that there was no breast cancer, which was detected only by quantitative finding

PROPOSAL FOR STANDARDS OF PERFORMING INFRARED IMAGING IN PATIENTS WITH SUSPECTED RAYNAUD´S PHENOMENON

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Background: Raynaud´s Phenomenon is characterised by 3-phasic colour changes of fingers and toes caused by vasospam of the digitial arteries due to low temperature and/or psychological stress. These colour changes may be accompanied by decreased skin temperature which can be identified by infrared thermal imaging.

Objective: To identify procedures which address patient´s preparation, temperature of the examination room, temperature and duration of the immersion bath, position of hands, time of follow-up after the cold challenge and method of evaluation

Method: A computer assisted literature search was performed for publications related to thermographic investigations of patients with suspected Raynaud´s phenomenon in Embase and the literature archive of the author.

Results: The information on procedures performed is incomplete in the identified studies. In addition there is a wide variation in water temperature of the immersion bath and also of duration of immersion. At least 3 different approaches for evaluation of hand temperatures were used. The following proposal for performing thermography for the identification of Raynaud´s phenomenon is given:

The patients is sitting with freely hanging arms which are undressed below the elbow on a chair at a room temperature of 24° C for at least 15 minutes without moving the fingers. A thermal image of both hands in the dorsal view is recorded following the position described in the Glamorgan protocol. Then both hands, covered with plastic gloves, is immersed in water of 20°C for 60 seconds. Immediately and at an interval of 10 minutes three other images are recorded. Circular regions of interest were defined and placed on the tip of each finger and over the mid of the metacarpal bones. The temperature difference between the distal and the proximal measurement area is calculated for each finger on the images recorded prior, 10 and 20 minutes past the cold challenge. The combined temperature gradient is computed from the temperature difference from the images prior and 10 minutes or 20 minutes past the cold challenge repectively. A combined negative temperature gradient greater than 1 degree represents a pathological finding. The diagnosis of Raynaud´s phenomenon is based on pathological combined gradients prior and 20 minutes past cold challenge.

Fever Screening by a Infrared Thermography

COMPARISON OF CORE AND SURFACE SKIN MEASURING SITES FOR THE ASSESSMENT OF BODY TEMPERATURE

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Background: The use of measuring surface skin temperature as a quick assessment or screening tool to predict elevated core temperature has progressed from parents feeling their child's forehead to elaborate infrared screening procedures to identify potentially febrile individuals for pandemic screening.

Objective: The purpose of this investigation was to compare core temperature (oral, rectal esophageal, and tympanic) with skin temperature (axillary, inner canthi, forehead, and temporal) as influenced by differing environmental conditions.

Method: Twenty-two college aged, healthy participants (11 males, 11 females) performed six trials at three ambient temperatures (15.5, 21.1, or 26.6 °C /60, 70, 80 °F) and either 35% or 70% humidity. Participants wore similar clothing in all trials. The trials were performed at the same time each day with participants being equilibrated for at least 15 minutes before temperature measurements were obtained. There was a separation of at least 24 hours between each trial.

Results: There were significant differences between core temperatures (rectal, esophageal, tympanic, and oral) observed for all environmental conditions. Tympanic temperature was the least

consistent measurement of core temperature due to variations in both ambient temperature and humidity. Variations in ambient temperature and humidity had a significant affect on all skin surface sites. The axillary site showed the most consistent skin surface measurements, while the forehead and temporal sites were the least. The inner canthi measurements increased in a linear fashion (R2= 1) as the temperature of the environment increased.

Conclusion: As environmental temperature increased, the variance associated with the measurement of each site decreased irrespective of the humidity. Rectal temperature was the highest and most consistent measurement of all core measures regardless of changes in environmental temperature and humidity. Axillary temperature provided the most consistent measurement of the skin surface sites. The inner canthus provided the best predictive non-contact measurement of skin surface sites across all trial conditions. Thus, the inner canthi may be useful in detecting individuals with high temperatures as a potential screening method for fever related pandemic diseases.

DETECTING FEVER IN POLISH CHILDREN BY INFRARED THERMOGRAPHY

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Background: Recent attention on the need to detect fever during a pandemic influenza outbreak has shown that thermography of the face, tympanic radiometry, and other methods of clinical thermomety have limited documentation. Few papers on temperature values in thermographic examination for potential detection of fever have been published and very little on the expected normal values in children.

Objective: This study was designed to apply thermographic investigation of the face in children who are at high risk of infection during any virus outbreak, and compare the data from other measurement methods. We were unable to find normal data, so have studied a cohort of young patients at the hospital clinic in Warsaw, of whom a small percentage presented with a confirmed fever.

Method: 264 Children aged 1-16 years were seated in a room (ambient 22-230C) and thermographic recording of the frontal face was made with a FLIR camera (T400 and P400). Axilla thermometry and tympanic radiometry was also recorded in 254 afebrile and 10 febrile children. The sample size of tympanic ear measurements was smaller and the method was not always achievable in the youngest children.

Results are shown in the following table

normal non febrile children (n=253)			
	Mean ± SD (C°)	1-ANOVA	
eye maximum temperature	36.4 ±0.5	eye vs axilla	p = 0.000 sigf
Mean forehead (from thermogram)	35.0 ±0.64	forehead vs axilla	p = 0.044
axilla (from thermometer)	36.3 ± 0.7	ear vs axilla	p = 0.26
ear (tympanic) (n=141)	36.0 ± 0.76		
febrile group (n=10)			
eye maximum temperature	37.80 ± 0.4	eye vs axilla	p = 0.012
Mean forehead (from thermogram)	36.1± 0.8	forehead vs axilla	p = 0.038
axilla (from thermometer)	38.2 ±. 0.4	ear vs axilla	p = 0.092
ear (tympanic)(n=7)	36.9 ±1.3		

No differences were found in these data relating to either sex or age.

Conclusion: A high correlation was found between inner canthus eye temperatures and the underarm axilla, but forehead and ear temperature measurements were less well correlated. Temperature values from the non febrile children were all below the febrile, and in this study we included axilla temperatures of >37.8 as febrile, as all cases were confirmed clinically, and accounting for measurement errors of the individual systems used.

FEVER SCREENING FOR TRAVELERS BY INFRARED THERMOGRAPHY

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Airports are the entry gates of global infectious diseases such as SARS, "avian flu" or recently "swine flu ". There is cur-rently no effective method to identify individuals already infected. While there are some Asian airports using thermal imaging cameras, however, the applied method of the investigation does not comply with the required standards.

InfraMedic, the European provider of medically approved infrared thermography examination systems, has developed FeverScreen, a new device for instant fever measurement. It is based on recent scientific studies and was developed by a team of experts from medicine and computer science. Using special high-precision infrared cameras, the system can detect passengers with fever or elevated body temperature. The measurement of a person lasts only a few seconds, and a green or red signal (with optional warning) shows the measured value and its relevance.

If FeverScreen indicates a conspicuous result, further investigations, advice or other means by the medical service of the airport will follow. Admittedly, not all infected individuals are already fevering, but at least the potentially very contagious virus carriers with elevated body temperature are well recognized.

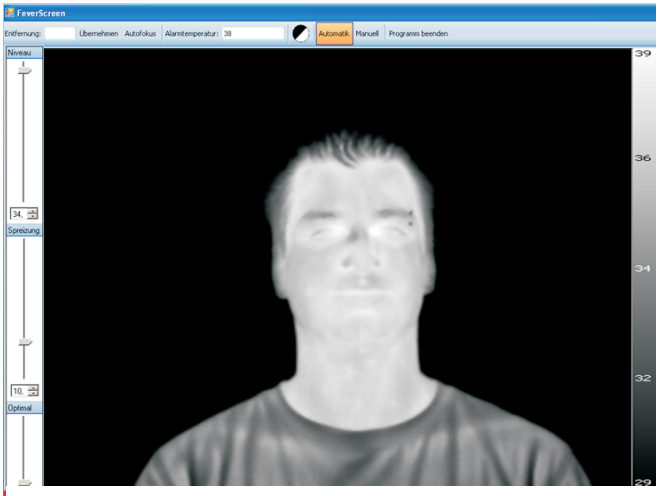

Figure 1
Body Temperature: 38, 7° C

FEVER SCREENING AND INFRARED THERMAL IMAGING: CONCERNS AND GUIDELINES

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The aim of this presentation is inform those either using or considering using infrared thermal imaging mass screening systems for fever detection of recent developments surrounding this concept. The recent publicity surrounding the Swine influenza outbreak (H1N1 strain of influenza type A) has spurred interest

in the use of this technology. However, the publicity has also sparked a debate concerning the effectiveness of using infrared thermal imaging for this purpose. It is important to note that this document is not intended to answer the question as to the reliability of infrared thermal imaging for fever screening. Clearly opinions will vary depending on the interests and experience of the reader. Nevertheless, the EAT feel that there are some basic facts that need to be taken into account when either using and/or designing specialized infrared thermal imaging installations for mass screening of human subjects

PANEL DISCUSSION
FEVER SCREENING AND INFRARED IMAGING

Chaired by the physiologist James.Mercer, Norway,
the panel members R. Berz, Germany,
Francis Ring, United Kingdom,
David Pascoe, United States and
Marcos Brioschi, Brazil
will discuss recent developments, standards, pitfalls and special needs for applying infrared cameras in mass screening for fever detection.

Thermography in surgery

DYNAMIC INFRARED THERMOGRAPHY OF PERFORATOR FLAPS PROVIDES VALUABLE INFORMATION ON SKIN PERFUSION FOR BOTH RECONSTRUCTIVE SURGEONS AND PHYSIOLOGISTS

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Large defects due to trauma, tumour resection and pressure sores are nowadays preferably closed with so-called perforator flaps. A perforator flap is defined as a flap of skin and subcutaneous tissue, which is supplied by an isolated perforator, which is in contrast to its musculocutaneous counterpart that is based on a large number of perforators originating from the source artery. One of the reasons for the popularity of perforator flaps is that they are associated with low donor site morbidity. The use of perforator flaps requires meticulous surgical technique and understanding of the vascular anatomy. Preoperative planning includes selection of the most suitable perforator to supply the flap. This can be done intraoperatively. However, this requires time and may easily lead to damage of the vessels due to inadvertent traction. Therefore it is recommended to perform a preoperative mapping of suitable perforators. In cases of free flaps, the microsurgical anastomosis is one of the most important aspects for adequate perfusion of the flap. A suitable monitoring technique that allows evaluation of the patency of the anastomosis would be very beneficial. During the postoperative phase perfusion problems may lead to partial or total flap failure, a devastating experience for the patient. A close monitoring of flap perfusion is therefore important since early recognition of impaired perfusion makes early intervention possible and increases flap survival. We have been using dynamic infrared thermography (DIRT) in the preoperative, intraoperative and postoperative phase of perforator flap surgery during the last 5 years. The results from the DIRT examinations have contributed to a better understanding of the perfusion of perforator flaps. In addition, new questions have been raised on the function of perforators on skin perfusion and thermoregulation. Recent results illustrating these points will be presented

COMPARISON OF BODY TEMPERATURE IN LAPAROSCOPIC SURGERY WITH THAT IN OPEN SURGERY AND THE USEFULNESS OF BODY THERMAL IMAGE IN SURGERY

Hisashi Usuki, Hiroshige Sutou, Hirotaka Kashiwagi, Ryuusuke Takebayashi, Takanori Sano, Shintarou Akamoto, Tatsushi Inoue, Keitarou Kakinoki, Masanobu Hagiike, Keiichi Okano, Kunihiko Izuishi, Yasuyuki Suzuki

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It is reported that there is a close relationship between the hypothermia of patients undergoing operations and the risk of surgical site infection. Then, it seems to be important to keep patients warm in peroperative period. In this report body temperature of the patients undergoing laparoscopic surgery were compared with those of the patients with open surgery. The subjects of this study were 14 colon cancer patients. Ten of them were male and four were female. The age of them were 73.6±7.2 years old. Eight of them underwent open surgery and six did laparoscopic surgery. There was no significant difference between operation periods of laparoscopic surgery and those of open surgery. The body temperature of the patients with laparoscopic surgery was almost same as the patients with open surgery at the starting point of the surgery. But, the temperature of the patients with laparoscopic surgery at the middle point of surgical period was 35.8±0.50 degree centigrade. This tended to be lower than the patients with open surgery (36.4±0.5) ($p=0.0545$). The temperature of the patients with laparoscopic surgery at the point of one-hour prior to the finish of the operation was 36.1±0.7, and that of the patients with open surgery at the same point was 36.9±0.6. This difference was statistically significant ($p=0.0496$). The reason of this difference seems to be influenced by pneumoperitoneum used in laparoscopic surgery. For diminishing surgical site infection and avoiding hypothermia, that is uncomfortable for the patients just after the anesthesia, it is important to observe the body temperature of the patients undergoing surgery, especially in laparoscopic surgery.

Infrared imaging in botany and zoology

BOTANICAL APPLICATION OF THERMOLOGY

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Botanical applications of thermography concern investigation of structural changes of leaves by many different external parameters like drought, cooling, light induced heat, stimulation by salicylic acid, stress tolerance, virus infection and stomatal resistance, to mention just a few of them.

But a considerable part of the botanical investigations – and the most spectacular ones – focus on so-called "Thermogenic Plants", plants that heat up during inflorescence for various reasons. They are found in different families and extend from a few centimetres up to about three meters of height. Again, their thermal effects reach from a few degrees up to about 40 K against ambiance. Some members produce a constant increase of temperature and thus vary with the environment, other become independent of the environmental values and keep constant temperatures ("thermoregulating") from hours to days and even weeks. Thermogenic plants have impressive flowers; the most beautiful ones are that of the water lily Victoria amazonica and V. cruziana, the sacred lotus Nelumbo nucifera, the dragon root Dracunculus vulgaris and the Philodendron selloum.

Both sections will be touched, experiments described and results explained and – in spite of the sentence above – some pretty pictures shown on Victoria and Co.

SKIN TEMPERATURES OF THE AFRICAN ELEPHANT (LOXODONTA AFRICANA) IN THE HEAT.

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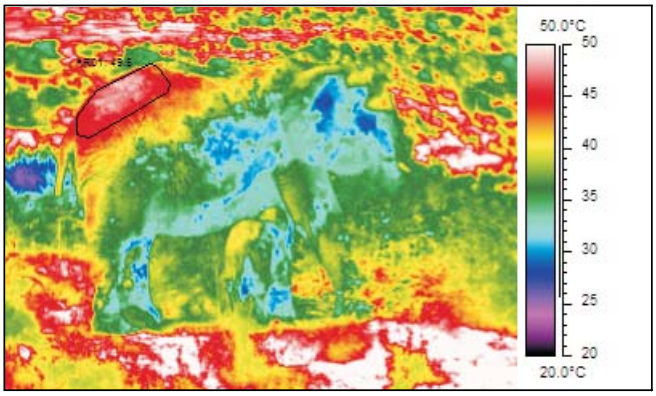
In endothermic homeotherms appropriate vasomotor control of skin blood vessels is important in regulating body temperature (Tb). Infrared (IR) thermography makes use of this fact where a warm skin temperature is accepted as indicating increased peripheral circulation and vice versa. If ambient temperature exceeds Tb mammals risk gaining heat from the environment, especially if peripherally vasodilatated. Evaporative heat loss is the main avenue for heat dissipation in such circumstances. Elephants, which do not sweat, could avoid such heat gain by reducing peripheral circulation. A consequence of this peripheral vasoconstriction is that the skin may become very hot, especially in the presence of strong solar radiation. To investigate the vasomotor state of the skin of African elephants under varying heat loads IR-thermal images were taken at regular intervals over a 24 hour period during summer (March). The animals belonged to a small domesticated herd maintained at the Letsatsing Game Reserve, North West Province, South Africa. Tb was also measured using ingested temperature data loggers. Meteorological data were measured from a local field station.

We found that the skin of adult elephants shows a great deal of local variation due to factors such as intensity of incident solar radiation, which, among other factors, is dependent on the shape of the animal. Skin temperature measured during the most intense periods of solar radiation on the most directly exposed skin areas attained values close to 50°C indicating reduced peripheral circulation at these sites. In the heat the temperature of the back side of the ears was consistently several degrees lower than that on the outside, mostly likely due to trans-cutaneous evaporative water loss. Although water loss from the ears and behavioural modifications probably assisted the elephants in maintaining Tb within a daily range of about 1.5°C, peripheral vasoconstriction also appears to play a role in allowing elephants to withstand high environmental heat loads.



Elephant in the afternoon. The mean surface temperature of the buttocks 46±1.5 °C (range 38.1 to 49.5)

New developments in infrared imaging equipment

AUTOMATED COMPARISON OF THREE METHODS FOR COLD STRESS ANALYSIS OF THE HANDS

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Background: Cold Stress Test (CST) on hands has been used as a standard in thermography for assessing Raynaud's Phenomenon (RP) for years. This test has shown to be relevant for assessing specific vascular and neurological conditions when used in combination with other provocation tests. Different temperatures of water and recovering times have been used. Three methods to grade the test have been suggested; Ring suggested in 1980 the method of areas (Method 1), where the mean temperature of fingers excluding the thumb was subtracted to the mean temperature of the dorsal palm of the hand. The index values were calculated for the thermogram before the CST and from the final one (normally 10, 15 or 20 minutes depending on the recovery), for a final index both thermograms indexes were added for each hand, in case of an index value below -2.0ºC the hand was considered hypothermic. Ammer recently suggested two methods based on thermal gradients/profiles, one using a thermal spot of at least 16 pixels on the middle of each finger (excluding thumb) distal phalanx and another spot of the same size on a proximal region of the respective metacarpal (Method 2) computing the mean temperatures of those spots, subtracting the finger spots from the metacarpals obtaining a index per finger. The other suggested method from the same author was to draw a line from the middle of each finger (excluding thumb) distal phalanx to the proximal part of the correspondent metacarpal (Method 3) calculating the mean temperature of each part of the line, corresponding the distal part of the line to the finger and proximal to the metacarpal, once again to obtain the index per finger by subtraction.

Objective: Compare the three methods of assessing CST of hands and investigate the values of thermal symmetry on healthy volunteers on recovering of CST.

Method: The CST were performed according to the Glamorgan thermogram capture protocol using exposure of 1 minute to water at temperature of 20 ºC. 10 healthy volunteers were examined. Two types of CST were recorded, one combined with mechanical provocation before and another without previous provocation. A computational application using an anthropometric model of hands was developed allowing standardization of thermal images of hands based on anatomical landmarks and preserving its thermal values per hand area of interest (AIO). This tool also produces statistical values per hand AIO's. Another complementary tool was developed implementing the three methods of assessing CST generating each statistics per minute of recovery.

Results:

	Thermal indices			
	post CST	Possible RP	Post mechanical provocation + CST	Possible RP
Method 1	-7.48 to 2.94	4	-7.89 to 1.92	3
Method 2	-13 to 4.08	4	-10.26 to 1.99	3
Method 3	-7.41 to 2.11	4	-6.19 to 1.72	3

Thermal symmetry on hands after CST:

5 min: mean $\Delta T = 0.62ºC \pm 0.56$, Δ SD. = 0.17 ºC $\pm$ 0.12

10 min: mean $\Delta T = 0.65ºC \pm 0.53$, Δ SD. = 0.1 ºC $\pm$ 0.08

Conclusion: The method that provides better discrimination is the Method 2. All methods seem to be sensitive to false positive cases of RP.

QUALITY ASSURANCE OF THERMAL IMAGING SYSTEMS IN MEDICINE

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Background: 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.

Objective: This contribution proposes 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.

Method: 5 Tests are proposed that 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. These tests are not intended to replace those performed by manufacturers or calibration laboratories, but to provide valuable information on both short and long-term camera performance

Results: 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. They 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. It is also demonstrated 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.

Conclusion: Although the methods and materials used in the proposed 5 tests are simple and inexpensive they will reliably detect equipment errors. They are useful to characterize the performance of a thermal imaging systems and to identify their individual strengths and weaknesses. They can not replace calibration by manufacturers or notified bodies such as national standards laboratories.

MAMMOVISION: STANDARDIZED INFRARED REGULATION IMAGING OF THE FEMALE BREAST

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MammoVision is based on the principles of regulation medicine. The female breast is exactly measured by a highly precise medically suited infrared camera before and after the application of a cooling stimulus. The images taken recorded before (comfort temperature) and after exposing the undressed women to an ambient temperature of 20 °C are evaluated and compared by a specially designed computer program.

After ten years of application of MammoVision thousands of examinations have been conducted, and the results so far evaluated demonstrate the clinical use: The method is highly specific and able to detect healthy women without breast diseases. The specificity depends on the end point. The rate of women with suspicious and abnormal results is much higher than the prevalence of breast cancer. This is due to the fact that many breast diseases are characterized by an up regulated breast metabolism leading to increased blood distribution and, in some cases, neo angiogenesis.

MammoVision offers tools to differentiate between minor and major symptoms that often occur together with breast cancer. Visual and automatically calculated items ensure that all thermal criteria are included into the evaluation.

Infrared imaging in breast disease

MECHANISM OF ABNORMAL FINDINGS IN BREAST THERMOGRAPHY

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Thermography is a functional examination of breast cancer. It is well known that there is close relationship between thermographic findings and the prognosis of breast cancer patients. The reason of this is that the thermographic findings relate with the tumor progressive stage and the malignant grade of breast carcinoma. In my previous study it was revealed that thermographic findings of breast cancers are influenced by some histological findings. And it was also proved that the thermographic findings had intimate association with the malignant grade of tumors investigated by mitotic index, DNA index and neo-angiogenetic factor. The next study was performed for elucidating the mechanism of abnormal thermogram. In the results it was revealed that the nipple hyperthermia was related to the distance from tumor to nipple. This shows the heat produced in the tumor conducts to the nipple through the mammalian tissue. This hypothesis is inferred by the characteristics of mammalian tissue with good thermal conductivity. On the other hand, hyperthermia of tumor covering skin could not explained by direct thermal conductivity. Because, the adipose tissue exist between the tumor and the tumor covering skin does not have such thermal conductivity. In the results of studies the thermal abnormality of tumor covering skin was related to the dilatation not of the peri-tumorous vessels, but of the subcutaneous vessels. This shows that some chemical mediator is involved in hyperthermia of tumor covering skin.

DYNAMIC INFRARED THERMOGRAPHY (DIRT) AND EARLY DETECTION OF BREAST CANCER - A DOUBLE-BLIND INVESTIGATION

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Background: Breast cancer (BC) is the type of cancer with the highest incidence in Norwegian women. In Norway, a nationwide mammography screening programme was introduced in 2004 offering screening every two years to women aged 50-69 years. The current diagnostic method used when results from mammography screening are non-specific or suspicious is called the "triple test" (TT) and its components are mammography, clinical breast examination (with ultrasound), and biopsy. At our breast diagnostic clinic (BDC) about 20% of these patients will have a positive diagnosis for breast cancer. The use of thermography in early breast cancer detection is well known for over 50 years. However, due to problems such as high false-positive rates and lack of large randomized studies in the last 25 years, the use of this technology has not been universally accepted. Our TT patients present a unique opportunity to carry out a double-blind study, using a modern infrared camera to investigate the diagnostic accuracy (sensitivity/specificity) of DIRT for diagnosing BC.

Objective: The main objective of the study is to investigate whether DIRT, using modern equipment can be used as an adjunctive diagnostic tool in the detection of BC in patients called in for follow-up TT examination, due to a non-specific or suspicious mammographic finding.

Method: Ca. 300 women will be examined with DIRT before undergoing the TT. Specifically trained technical staff at BDC will carry out the DIRT examination, which includes a local skin cooling and recovery protocol. The anonymised DIRT images will be independently examined by two experienced thermographers with no knowledge of the outcome of the TT. Only after completion of the examination of all subjects when we compare the outcome of the TT and DIRT results will the diagnostic accuracy (sensitivity/specificity) for DIRT in diagnosing BC be determined.

Results: Some preliminary findings will be presented.

BREAST THERMOGRAPHY AND ITS USE IN THE PREVENTION OF BREAST DISEASE.

Alexander Mostovoy

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Background: Breast Thermography has been in use since the 1970s, and was approved by the US Food and Drug Administration (FDA) in 1982. Over the years, many international studies have proven the usefulness of this non-invasive technique for the detection of breast abnormalities. However, the clinical application of breast thermography in the prevention of breast disease has yet to be fully realized.

Objective: To discuss uses of breast thermography in clinical practice. Particular emphases will be placed on understanding the clinical applications of thermographic breast imaging, its grading system and related terminology.

Method: In our clinical practice in Toronto, we have imaged thousands of women using standardized imaging and qualitative TH reporting methods. This will be discussed along with quantitative methods of evaluation. Over the years, certain risk factors relating to breast cancer have been seen in our practice, and we have subsequently initiated further study of these patterns.

Results: Our findings show that a very high percentage of women presenting with a history of breast mastectomy have suggestive same-sided dental pathology. A simple infrared image of the patient's face is able to identify this connection. In addition to these findings, the use of breast thermography to monitor the effectiveness of HRT treatment, diet intervention and life-style changes has been utilized in our practice and will be discussed.

Conclusion: Additional investigations and studies will be helpful to evaluate the connection between dental pathology and breast cancer. Breast Thermography is an effective tool in these evaluations.

EXPERIENCE WITH THE MAMMOVISION SYSTEM 3 CASE STUDIES

Nicola Hembry

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Since we introduced MammoVision into our clinical practice, we could study a number of patients in cooperation with our radiologist and other colleagues at the Litfield Medical Centre in Bristol, UK. We combined different examination methods with MammoVision, the standardized breast thermography.

Three cases of women with breast cancer and the important role of breast thermography in the diagnostic procedure are presented and discussed.

THERMAL IMAGING AS A MEANS OF MONITORING INTERVENTIONS IN BREAST PATHOLOGY

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Background: Routine thermographic breast screening was used to monitor breast health in 2000 women over a 6 year period. Abnormal findings were closely monitored during interventions.

Objective: To determine the clinical value of thermal imaging as a means of assessing the benefits or otherwise of interventions.

Method: Three, six and 12 month serial thermograms were used in cases showing pathology.

Results: Either earlier diagnosis of breast cancer was achieved or evidence of reversion to normal following naturopathic and other interventions was observed

Conclusion: Thermal imaging is a clinically useful adjunctive investigation in breast disease including breast cancer where clinical progress can be monitored. Protocol standardisation is needed in order that wider acceptance by the profession can occur.

Infrared imaging in dermatology

THERMOGRAPHIC EVALUATION OF PATCH TEST : THE TWO PATTERNS

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Background: The Infrared Thermography or Telethermography (TT) is a non-invasive imaging technique by which it is possible to evaluate the thermal gradients of the bodies. In the recent past, TT has been employed as a diagnostic tool in many field of medicine and in particular in dermatology for its peculiar position of the superficial organ. The last generation thermographic instruments have a high performance and lead to reproducible and comparable data.

Objective: To demonstrate that TT is an objective and useful tool to differentiate allergic contact dermatitis patch tests from irritant contact dermatitis.

Patients/Method: A group of 34 allergic patients (19 F, 15 M, and aged 23 to 62) with a history of delayed Nichel hypersensitivity (demonstrated by a positive patch test) was enrolled, and, as control, a group of 30 non-allergic patients was studied. In the subjects of the first group, a patch containing NiSO4 on a side of the back was applied (exposure time of 48 hours). Symmetrically, on the other side, a patch containing Sodium-Laureth-Sulphate (SLS) 1% was applied (24-h exposure time). In the group of non allergic subjects, only LSL 1% was applied on a side of the back. The tests were evaluated by TT after 30 minutes from patch removal. Because of the very low thermal gradients in this particularly field, TT with thermal stimulation method was performed.

Results: Patch tests elicited positive Nichel reactions in all of 34 patients of the first group, while SLS 1% patch test was positive in 26/34 of these individuals. Among the non-allergic group, 23/30 subjects showed a positive reaction to SLS 1%. On thermographic evaluation, a very clear difference between $NISO_4$ and SLS responses was seen. In fact, the allergic pattern was characterized by a *hyperthermal are*a with a lymphocentric pseudopod, or a *hypotermal area* surrounded by *pseudo-polypoid strong hyperthermal halo,* while irritant pattern (SLS1%) showed a *hypothermic area* fully corresponding to the area of patch site.

Conclusion: Thermographic analysis of patch test can be considered not only an objective and very useful tool to the evaluation of patch test, but also to differentiate allergic test from irritative responses.

THE VALUE OF INFRARED THERMOGRAPHY FOR CHILDHOOD LOCALISED SCLERODERMA (LS): EXPERIENCE OVER TWENTY YEARS.

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Background: The detection of active LS lesions in children and the evaluation of response to therapy both presuppose objective and reliable measures of disease activity.

Objective: Our presentation will review the compelling evidence that infrared thermography has a role to play in the assessment of childhood LS, beginning with the earliest case report (1), progressing to pilot studies of the utility of thermography for active lesion detection (2-4), and culminating in our recent work in London using infrared measurements in conjunction with laser Doppler flowmetry (5).

Conclusion: High frame rates (near-instantaneous imaging) and wide fields of view make thermography an effective tool for detecting skin inflammation in early LS. In older lesions the skin (and subcutaneous fat layer) may be thinned. Increased heat conduction through thinned skin may limit the utility of thermography in these older lesions. Novel laser blood flow imaging techniques may prove to be an important adjunct to thermography in the evaluation of atrophic lesions.

NORMALIZED METHODOLOGY FOR MEDICAL INFRARED IMAGING

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A normalized procedure for medical infrared imaging is suggested, and illustrated by a leprosy and hepatitis C treatment follow-up, in order to investigate the effect of concurrent treatment which has not been reported before. A 50-year-old man with indeterminate leprosy and a 20-year history of hepatitis C was monitored for 587 days, starting from the day the patient received treatment for leprosy. Standard therapy for hepatitis C started 30 days later. Both visual observations and normalized infrared imaging were conducted periodically to assess the response to leprosy treatment. The primary end points were effectiveness of the method under different boundary conditions over the period, and rapid assessment of the response to leprosy treatment. The patient achieved sustained hepatitis C virological response 6 months after the end of the treatment. The normalized infrared results demonstrate the leprosy treatment success in spite of the concurrent hepatitis C treatment, since day 87, whereas repigmentation was visually assessed only after day 182, and corroborated with a skin biopsy on day 390. The method detected the ffectiveness of the leprosy treatment in 87 days, whereas repigmentation started only in 182 days. Hepatitis C and leprosy treatment did not affect each other.

Thermotherapy

EMPERATURE EFFECTS OF THERMOTHERAPY DETERMINED BY INFRARED MEASUREMENTS: AN UPDATED REVIEW

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Background:. Infrared technology for temperature measurements was used for the evaluation of the effects of heat or cold treatment

Objective:To update a previous review of infrared based temperature measurement after thermotherapy (1).

Method: The existing literature search in the databases Medline, Embase and the archive of the author was extended to all publications included in the databases until May 1st 2009.

Results: The literature search identified 10 new papers which were added to the existing database of 43 publications. Temperature changes due to cryotherapy were most frequently assessed by infrared based measurements, followed by ultrasound and balneotherapy.

Infrared temperature measurements was used after application of various forms of cryotherapy such as cold air, ice cubes, cold packs or cooling cuffs in both animals and humans. The effects of balneotherapy on skin temperature was investigated after thermo-neutral ,hypo- and hyperthermic baths. The temperature course of hot packs used for medical treatment was studied. The effect of infrared A-irradiation was monitored by infrared imaging. The depth of warming after application of ultrasound of different frequencies and various ways of application were clearly demonstrated by thermal imaging in recent studies. Older studies have used radiometers for measuring skin temperature after short wave application.

Conclusion: Infrared based temperature measurement is an increased used technique for the evaluation of physical treatment modalities that apply or remove thermal energy.

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WATER-FILTERED INFRARED-A (WIRA) CAN IMPROVE THE HEALING OF ACUTE AND CHRONIC WOUNDS

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Water-filtered infrared-A (wIRA) as a special form of heat radiation with a high tissue penetration and with a low thermal load to the skin surface can improve the healing of acute and chronic wounds both by thermal and thermic as well as by non-thermal and non-thermic effects. wIRA increases tissue temperature (+2.7°C in a tissue depth of 2 cm), tissue oxygen partial pressure (+30% in a tissue depth of 2 cm), and tissue perfusion. These three factors are decisive for a sufficient tissue supply with energy and oxygen and consequently for wound healing and infection defense.

wIRA can considerably alleviate the pain (pain reduction throughout 230 irraditions) with remarkably less need for analgesics (57-70% less in the groups with wIRA compared to the control groups) and diminish exudation and inflammation. The overall effect of the irradiation as well as the wound healing and the cosmetic result (assessed on visual analogue scales) were markedly better in the groups with wIRA compared to the control groups. wIRA can advance wound healing (median reduction of wound size of 90% in severely burned children already after 9 days in the group with wIRA compared to 13 days in the control group; on average 18 vs. 42 days until complete wound closure in chronic venous stasis ulcers) or improve an impaired wound healing (reaching wound closure and normalization of the thermographic image in otherwise recalcitrant chronic venous stasis ulcers) both in acute and in chronic wounds including infected wounds. After major abdominal surgery there was a trend in favor of the wIRA group to a lower rate of total wound infections (7% vs. 15%) including late infections after discharge from hospital (0% vs. 8%) and a trend towards a shorter postoperative hospital stay (9 vs. 11 days).

Even the normal wound healing process can be improved. The mentioned effects have been proven by six prospective studies, most of the effects with an evidence level of 1a/b.

IMPROVEMENT OF WOUND HEALING BY WATER-FILTERED INFRARED-A (WIRA) IN PATIENTS WITH CHRONIC VENOUS STASIS ULCERS OF THE LOWER LEGS INCLUDING EVALUATION USING INFRARED THERMOGRAPHY

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Water-filtered infrared-A (wIRA) is a special form of heat radiation with a high tissue-penetration and with a low thermal burden to the surface of the skin. wIRA is able to improve essential and energetically meaningful factors of wound healing by thermal and non-thermal effects. In this prospective study wIRA was used in the treatment of patients with recalcitrant chronic venous stasis ulcers of the lower legs. The progress of wound healing as well as skin temperatures before and during irradiation therapy were documented with the help of IR-thermography. 10 patients (median age 62 years) with recalcitrant chronic venous stasis ulcers of the lower extremities were irradiated two to five times/week for 30 minutes (approximately 140 mW/cm2 wIRA and approximately 45 mW/cm2 visible light). Treatment continued for a period of up to 2 months (typically until closure or nearly closure of the ulcer). The main variable of interest was "percent change of ulcer size over time". Additional variables of interest included thermographic image analysis and evaluations of wound pain, wound healing, and cosmetic state.

A complete or nearly complete healing of lower leg ulcers occurred in 7 patients and a clear reduction of ulcer size in 2 patients. In addition there was a clear reduction of pain and of the consumption of analgesics and a normalization of the thermographic image (before the beginning of the therapy typically hyperthermic rim of the ulcer with relative hypothermic ulcer base, up to 4.5°C temperature difference). Failures of complete or nearly complete wound healing were seen only in patients with arterial insufficiency, in smokers or in patients who did not have venous compression garment therapy.

This study shows that wIRA can alleviate pain considerably and accelerate wound healing in chronic venous stasis ulcers of the lower legs. It is concluded that wIRA can be used to improve wound healing, to reduce pain, exudation, and inflammation and to increase quality of life.

THERMAL EFFECTS FROM LOW LEVEL LASER THERAPY (LLLT) ON THE HUMAN SKIN

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Background: Early reports about LLLT speculated that clinical effects were induced by increased temperature, while newer reports point out that the clinical effects of LLLT may rather be based upon modulation of photo-chemical and photo-biological processes. Little is known of whether irradiation with LLLT increases skin temperature, and whether demographic variables such as age, gender and skin color affects this outcome.

Objective: To investigate the thermal effect in human skin after different doses of LLLT in healthy persons of three different age groups, both genders and white, colored and dark skin.

Method: Subjects received six different laser doses from two laser units. The skin thermographs were filmed during laser irradiation and until 60 seconds after each laser dose were delivered. Data were analyzed for differences in three age groups, sex, and three skin colors.

Results: The thermal effect is conditioned by skin color, where the laser energy generates more heat in darker skin. Regardless of the laser doses, there were no differences in thermal effects between the sexes.

THERMAL EFFECTS OF DRY HEAT PACK IN PHYSIOTHERAPY, THERMOGRAPHY AS AN EDUCATIONAL APPROACH

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Background: Physiotherapy students have problems in understanding what kind of effects heat exposed on a human skin can have, especially in learning interaction of dose response of the thermal impulse in proportion to time and their own senses. Thermography gives an important addition to the educational impact in learning basic thermotherapy for physiotherapy students.

Objective: To investigate the thermal effect on human skin after a 10 minutes exposure to heat pack on healthy persons.

Method: Subjects received 10 minutes of heat exposure. The skin thermographs were filmed before, during and after heat exposure. Sensing data of the "patient" and of the therapist were compared to the thermal images and summarized to knowledge based learning.

Results: The thermal effect is conditioned by time, where the senses of the "patient" and of the therapist are in alteration by the heat in the skin.

COMPARISON BETWEEN CHILLING EFFECTS BY THE DIFFERENCE OF THE MATERIAL OF THE PILLOW

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A purpose of this study is compare with a usually used urethane pillow and the pillow which can be inserted a cold insulation agent about head chilling effect at the sleep. The artificial climate chamber has been controlled at the environment of temperature 30°C? and 65% related humidity. The subject has slept in this chamber for eight hours and measured temperature and humidity at that time. Naturally the pillow which coolant was inserted in was lower in the temperature, and head chilling effect has been found. Also, with the difference of the cooling time, it developed that cold insulation time was different. It was found that chilling effect during the sleep continued by cooling off for ten hours in this refrigerant.

THE EFFECTS OF COOLING AGENTS APPLIED TO THE SKIN IN NORMAL SUBJECTS

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Topical agents are now available for localised skin cooling. These are particularly useful in minor trauma, often occurring through sporting injuries. In the past packs of ice were the only practical ways of applying localised cooling, but commercial products are more convenient. In order to quantify the effects of cooling we have tested different methods for applying cooling products to the skin.

Methods After a stabilisation period, six subjects received an ice pack application to the lumbar back for 10 minutes, and the skin temperature over the area was monitored for 60 minutes at 3 minute intervals. The results were compared to twelve subjects who received a gel (Deep Freeze Cold gel, Mentholatum Co. Ltd.U.K.) applied to a 10x10cm area also to the lower back monitored for 60 minutes. In this study each region of interest was analysed to generate graphs of the cooling effects of the two treatments. All procedures were carried out in a controlled temperature 230C and under strict laboratory conditions.

In a further experiment, a new gel dressing (Deep Freeze Cold Patch, Mentholatum Co Ltd. designed to adhere to the skin) was applied to one forearm and one thigh of 12 normal volunteers for 3 hours. The same environmental conditions were used. An A40 FLIR infrared imaging system connected by firewire to a computer with CTHERM image processing software was used.

Results Temperature decrease of 3.50C was found in comparing the treated mid thigh area, with the contra lateral control area. In the forearms of the same subjects, similar findings were obtained. The cooling effect of a single cold patch dressing was significant for up to two hours. For the patch study, the dressings were peeled back from the skin for each image to be recorded, and sampled at 15 minute intervals for one hour, then 30 minutes for the remaining two hours. The two sites were tested on different days in each volunteer.

Conclusion Modern preparations localised cooling to the skin are effective, and more comfortable than ice packs. Aerosol application is convenient for immediate application, with the cold patch gel more convenient for longer term home application. The objective data from these studies supports the conclusion that Deep Freeze products when applied to the skin are better tolerated, and can be used for longer periods than conventional icepacks where localised skin cooling is found to be beneficial.

Other clinical applications of thermography

THERMAL SYMMETRY OF LIMBS IN HEALTHY SUBJECTS

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Background: Infrared thermal imaging is being increasingly utilised in the study of neurological and musculoskeletal disorders. In these conditions data on the symmetry (or the lack of it) of skin temperature provides valuable information to the clinician. The first suggestion of usage of this indicator was made by J. Freeman in 1937 measuring it with contact thermocouples. The first measurement using imaging was performed by Lloyd-Williams in an experiment in 1964. Some other studies had been carried out since then but with the appearance of newer generations of higher resolution cameras a lack of comparison between total body views with close-up regional views in both anterior and dorsal visualisations existed.

Objective: Establish a value for Sagital and Coronal thermal symmetry of the human body, to be used as indicator in clinical assessments.

Method: In this study skin temperature measurements have been carried out using thermograms, of hands 75 healthy volunteers and for other body 39 healthy subjects were imaged. Measurements were obtained from an infrared camera (FLIR A40) using the CTHERM application developed at the authors' research unit. A computational analysis application was developed to standardise and optimise the time of analysis. This tool performs thermal image morphing based on anatomical landmarks preserving the temperature values associated with the regions of interest(ROI) and generates statistics about mean temperature, standard deviation, kurtosis and skewness of those ROI's.

Results: Sagital Thermal Symmetry using regional views:

Region	mean Δ T (C°)	ΔSD (C°)
Dorsal hands	0.33 ± 0.34	0.12 ± 0.15
Anterior arms	0.49 ± 0.29	0.28 ± 0.29
Dorsal arms	0.23 ± 0.16	0.33 ± 0.23
Anterior forearms	0.44 ± 0.24	0.47 ± 0.28
Dorsal forearms	0.34 ± 0.25	0.39 ± 0.29
Anterior thighs	0.14 ± 0.13	0.07 ± 0.07
Dorsal thighs	0.17 ± 0.12	0.07 ± 0.06
Anterior lower legs	0.2 ± 0.16	0.08 ± 0.05
Dorsal lower legs	0.23 ± 0.18	0.11 ± 0.07
Dorsal feet	0.34 ± 0.34	0.16 ± 0.15
Planar feet	0.38 ± 0.36	0.14 ± 0.16

Conclusion: Total body views and regional views produced comparable results. Although better results were achieved in regional views. Using a high-resolution camera the study achieved better results on thermal symmetry in normal subjects than previously reported. Symmetry assumptions can therefore now be used with higher confidence when assessing abnormalities in specific pathologic states.

MAIN APPLICATIONS OF DIAGNOSTIC THERMOGRAPHY IN THE LAST 21 YEARS: A CHART REVIEW

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Background: The Institutes for Physical Medicine & Rehabilitation of the Hanuschspital and the Out-Patients Clinic for Physical Medicine, Andresgasse offer a thermographic services sind 1988.

Objective: To review the charts of thermal images recorded since 1988 and analyse the main indications for thermal imaging.

Method: Thermal images stored on floppy disks were retrieved. Biographic data (age, sex, diagnosis for referral) the body region imaged of investigated subject, and temperatures of the region of interest were recorded. Thermal images that were already reported in papers were marked. Descriptive statistics were performed

Results:The database contains 16000 images from more than 2500 different subjects, 200 images were recorded from non living material such as various heating pads. 66% of investigated subjects were females, 44 % males. Hands were the most frequently imaged body region, followed by knees, elbow, upper back, lower back, gluteal region, ankles, shoulder, total upper extremity and total leg. Raynaud`s phenomenon has the first rank in referral diagnosis, followed by thoracic outlet syndrome, fibromyalgia and chronic regional pain syndrome (CRPS). More than 80 percent of thermal images were reported in a total of 45 full papers

MEDICAL INFRARED THERMOGRAPHY AS A SCREENING TOOL FOR KNEE INJURIES IN PROFESSIONAL JUNIOR ALPINE-SKI-RACERS IN AUSTRIA

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Background: Medical Infrared Imaging (IFT) has been successfully utilized for injury prevention in veterinary medicine (PUROHIT et al 1980; TURNER et al 2001). Despite similar anatomical and physiological conditions there is a lack of evidence, demonstrating the successful use in human athletes with the advantage of twenty first century technology. The knee is frequently affected in alpine skiing (PUJOL et al 2007). According to TECKLENBURG et al, 53.8% of all female skiers in the Austrian National Team have already sustained an ACL rupture. These injuries usually involve a long, costly rehabilitation period and often are career ending.

Objective: To evaluate the outcome of IFT when used as a screening tool for knee injuries in alpine skiing. Moreover future application in the field of prevention, diagnostic and rehabilitation will be defined.

Method: We conducted a pre-season measurement of 35 female and 52 male junior alpine ski racers (non-injured, previous injury and acute injury) aged 14-19 years from the "Skigymnasium Stams". With an infrared camera (TVS200EX) baseline images of four aspects of both knees were recorded. In addition each non injured subject performed 40 countermovement jumps to assess the local haemodynamics. The software Studio Report (Goratec GmbH) was used to analyse the images. A physiotherapist examined the functional aspect of the knee.

Results: Intra-individual thermal asymmetries over the tibia revealed overuse reactions (Osgood- Schlatter disease, Sinding-Larsen-Johansson lesion). The clinical examinations confirmed these findings. The evaluation of athletes with an operation of the knee over the last 6 months clearly demonstrated the localisation and extent of the affected area. Images taken after the countermovement jumps showed local cooling of the knees.

Conclusion: This study clarified the potential of IFT for a more objective and uncomplicated evaluation of knee injuries. Future pathophysiological images will be analysed with more structural measurements such as magnetic resonance imaging and X-ray.

CORRELATION BETWEEN THE THERMOGRAPHIC ASSESS AND THE CLINICAL AND FUNCTIONAL REHABILITATION IN PATIENTS WITH POSTTRAUMATIC ANKLE-FOOT SEQUELAE

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Posttraumatic pathology of the lower limb regarding sprain, strain or bi/trimaleolae fracture can develop after orthopedic/surgical treatment multiple chronic pain sequelae, prolonged edema, trophic disorders and complex vegetative reactions, changes that can be measured indirectly by thermography.

The aim of the study was to highlight the thermographic dynamics and to identify issues or discord in consistent correlation between clinical functional assessment, ultrasound investigation and thermography during the rehabilitation program.

We have studied a group of 20 patients with pain and functional sequelae in the posttraumatic ankle-foot complex, also having other clinical or functional consequences in the kinematic chain of the affected lower limb, which we have treated in a rehabilitation program.

Initially, we have evaluated the epidemiological, clinical functional context, and highlight the biological and potential metabolic events (diabetes mellitus) concurrently. Laboratory evaluation included radiological examination, ultrasonography and thermography. Thermographic assessment was made under the Glamorgan Protocol at the beginning, at 5 days of treatment and at the end of treatment, under a uniform rehabilitation program with physical and kinetic therapy, the patient being monitored in the hospital.

At the end of treatment we have compared clinical data with functional result, we have analyzed their correspondence and studied other biostatistic parameters.

Because of the skin temperature assessment we could make thermographic correlation between evolution and significance in treatment of the statistics collected by thermography as a method for a clinic evaluation of the vascular functionality, and indirectly, in posttraumatic pathology, very efficient and nonaggressive especially in patients with dermatological disease, long term posttraumatic inflammatory reaction or hypersimpaticotony.

THE MODEL OF HEAT REMOVAL IN ZONE ZAHARIINA-GAEDA

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Many diseases are connected with change the metabolism, this produces change of the skin temperature. So analysis of the skin temperature allows to realize the diagnostics. The result of the work is a model, describing heat removal in zone Zahariina-Gaeda. Modeling was realized in program MathCad. By means of models possible to value the deflection an metabolism rate diseased organ on the temperature and area of the zone. For this was designed algorithm, allowing build the dependencies of the deflections of the temperature from area of the zone. Experimental given required for identification of the models. The metabolism value in size consumptions of the oxygen. The temperature of the skin in the field of Zahariina-Gaed value by means of thermal imager. For estimation of the deflection of the temperature of the skin and metabolism necessary to know the values, corresponding to normal condition of the organism. After successful identification model can be used for diagnostic and therapeutic integer. The value of the deflection of the metabolism corresponds to the certain dose medicinal preparation. On zone Zahariina-Gaeda possible to influence raised and lowered by temperature. This causes the physiological changes to organ, corresponding to zone Zahariina-Gaeda. This change the value of blood flow. Increased blood flow enlarges delivery of the medicinal preparation to internal organ, but overweening increase the value of blood flow causes its overweening cooling. Lowered of blood flow reduces delivery of the medicinal preparation to internal organ, but reduction of the value blood flow causes the reduction of heat removal, this causes increasing of its temperature. Consequently necessary to estimate the permissible the influence of low temperature and high temperature on zone Zahariina-Gaeda. This possible realize by means of offered to models.

One more field of the study is modeling of the temperature of core and skin depending on parameter surrounding ambiences. This model has allowed to analyze continuing reduction of the temperature core in thermoneutral zone after cooling. In this work the phenomena was explained by influence of the thermoreg ulation system. In work P. Webb "Afterdrop of body temperature during rewarming: an alternative explanation" this is explained by other influence (persistence).

Vascular thermal imaging

IMAGING CRANIAL ANGIOSOMES IN SLEEP APNEA.

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American Academy of Thermology.

Objective: To image the effect of CPAP (Continuous Positive Airway Pressure) treatment on facial/cranial angiosomes skin temperature in sleep apnea.

Materials and methodology. Six Caucasian subjects, ages 33-58 yrs, (mean age 45.5 yrs), three males and three females, five under CPAP treatment at night for sleep apnea and one non sleep apnea control participated in a committee for the protection of human subjects approved protocal for extracranial facial perfusion imaging using a infrared/ Agema Camera. All participants were seated and had thermograms done before and after CPAP during the daytime, while awake. The participants were allowed to equlibrate for 20 minutes, in temperature controlled, draft free laboratory. They did not have recent trauma, sunburn or sinusitis.

Baseline facial thermograms were obtained. The participants were fitted with the cushion side of the CPAP mask (Respironics Inc, Nasal CPAP Mask 50 D size medium), mask is checked to make sure there is no leak. The CPAP mask has a Respironics Sanders non breathing valve (NRV2). The end of the NRV2 Valve is attached to a 22 mm standard flex tubing 5 feet non conducting hose with 7/8 " cuffed ends (Kings system Corporation). The tubing is attached to CPAP Aries Model (Mountain Medical Equipment incorporated). End Tidal CO 2 monitor (Lifespan 100 Model), ear oximeter (Biox 11A Model) and/or trancutaneous oxygen monitor (Model TCM2) are also connected to the patient or volunteer. End Tidal CO2 and oxygen values were recorded in the room air.

The CPAP is started and over a 10-15 minute period the participant is allowed to acclimatize to CPAP and reach a pressure of 10 cm or more of water. The CPAP is maintained for 15 minutes at that pressure, following which the CPAP is discontinued. Immediate and 3-5 minutes post CPAP, facial/ extracranial angiosomes thermograms are carried out. During the CPAP, End Tidal CO2 and oxygen values are recorded periodically. Baseline and Post CPAP thermograms are reviewed to document changes of 0.5 degrees C or more change in the facial temperature following CPAP treatment (compared to baseline) was documented.

Results:Vasoconstriction in facial/cranial angiosomes by thermograms following CPAP was correlated with benefit with CPAP at night per sleep lab CPAP testing on patients sleep apnea.

Discussion.Sleep disorders have been associated with altered skin temperature regulation and activation of pro-inflammatory pathways. Studies of endothelial function in sleep apnea has shown altered levels of biochemical markers of endothelial function including circulating levels of vasoactive mediators. Long-term effect of CPAP on inflammation markers of patients with obstructive sleep apnea syndrome (OSAS) has shown the selective reduction of soluble and cellular immune response factors, providing further evidence for an ongoing systemic immune process in OSAS.

Vasomotor reactivity of facial/ cranial angiosomes is sensitive to CPAP and vasoactive mediators. Hayakawa studied changes in cerebral oxygenation and hemodynamics during obstructive sleep apnea and indicated the role of extracranial factors. Cranial vasculature are innervated by trigeminovascular system. Onodera and Ide reported identification of arterial baroreceptors associated with arteriovenous anatomoses innervated by trigeminal nerve. Molyneux found AVAs innervation is more dense and can react to vasoactive mediators. Thermography images of facial microcirculation -arteriovenous anatomoses (AVAs), representing shunting in the extra cranial circulation under trigemino- vascular control. This can compliment data on pulmonary shunting reported in sleep apnea to correlate with clinical improvements.

Conclusion: Methodology presented gives thermographers the ability to image facial/ cranial angiosomes temperature changes due to CPAP. This can be correlated with long-term effect of CPAP therapy on altered cranial angiosomes vasomotor reactivity related to inflammation markers in patients with obstructive sleep apnea syndrome and correlate it clinically.

VISUALISATION OF CAROTIS– PLAQUES ON THE BODY SURFACE BY INFRARED –MEASUREMENT - A BASIC METHODOLOGICAL STUDY AND PRELIMINARY RESULTS

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Novel high precision infrared cameras measure and calculate accurately thermal surface patterns. Tissues vary in their thermal absorption coefficient and modify thereby the heat flow to the epidermis.

Objective: Plaques show a characteristic ability for heat absorption with respect to its construction and composition. The thermal pattern projected to the surface may vary due to makeup and infrared emission of the plaque.

Method: The maximum infrared emissionfrom the neck skin (at a temperature between 30 and 35 °C) occurs at a wavelength of 10 µm. Measurements were performed with an infrared system, (InfraMedic OptiRes D, sensitivity 30 mK), which was certified as a medical device. Firstly, optimum conditions for this measurement (environmental temperature, direction and distance of measurement, stimulation) were tested.

In a first series 4 groups of 10 subjects each, with unaffected carotis or solid or fibrotic or soft plaques were investigated under standardised conditions (room temperature 20 °C, measurement distance 30 cm, angle of the measureing device 45 degrees, 10 min adaptation with undressed upper body, abstinence from vasodilating drugs). Mesurements were performed without any thermal stimulus and after a short cold stimuls (20 sec of a wet towel arund the neck). After the infrared examination all patients received an ultrasound duplex test of the carotid arteries..

Results: Preliminary evaluation showed clear differences between normal and pathological findings (solid, fibrotic and soft plaques of the carotide arteries, It was possible to relate th e thermal patterns with the ultraound findings. The discrimination power between different composed plaques needs further improvement of the methodology.

Following studies may show, if beyond the visualisation of the intravascular changes on the body surface, a clear differentiation of plaque morphology can evolve which is simple in application , reproducible and independent from the investigator. This may have an impact for monitoring of treatment and for decision making in acute cases. The clinical importance d will be related to the performance of this method.

THERMOGRAPHY IN COMPLEX REGIONAL PAIN SYNDROME (CRPS): PITFALLS AND PROGRESS

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Background: Whilst the use of thermography as a diagnostic aid in CRPS is well recognized, other conditions can mimic the symptoms and thermographic signs. Thermography can be utilized in clinical research and is helping to advance understanding of this condition.

Method: Case reports.

Results: 1). A 46 year old lady presented with a severely painful left leg and colour and temperature changes consistent with possible CRPS. Thermography confirmed that the affected limb was cooler by 2°C. Clinical examination revealed a necrotic ulcer on the left great toe, and upon closer questioning the pain was more typical of critical ischaemia. Subsequent angiography demonstrated a femoral artery occlusion which was treated successfully with balloon angiography. Thermography 12 months later showed excellent reperfusion with no significant temperature difference.

2). A 45 year old lady presented with severe CRPS of the left upper limb of 10 years duration. Thermography confirmed significant cooling of 2.1°C between the arms. Detailed quantitative sensory testing revealed allodynia (non-noxious tactile stimulation perceived as painful) over the affected limb. A well demarcated area of allochiria (tactile stimulation in the area is only perceived in the analogous location on the contralateral limb) was present on the right unaffected forearm. A cold stimulus (menthol) was applied to the allochiric area. The patient reported cold sensation on the right arm, but felt severe pain in the analogous location on the affected forearm and developed erythema and oedema in this area. Thermography confirmed a contra-l ateral inflammatory response which reactivated 3 days later after autonomic testing precipitated worsening pain.

Conclusion: Thermography can be utilized to investigate autonomic and inflammatory responses in CRPS but clinicians should be aware of potential mimics.

COLD WATER AUTONOMIC FUNCTIONAL STRESS TESTING UTILIZING REAL TIME DYNAMIC SUBTRACTION IR IMAGING IN THE DIAGNOSIS OF COMPLEX REGIONAL PAIN SYNDROME

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Background: Complex Regional Pain Syndrome is a potentially disabling condition characterized by regional pain that is often disproportionate to, or occurs in the absence of an identifiable inciting event. The condition is associated with hyperalgesia, allodynia, spontaneous pain, abnormal skin color, changes in skin temperature, abnormal sudomotor activity, edema, active and passive movement disorders and trophic changes of nails and hair.

Complex Regional Pain Syndrome is diagnosed clinically based on modified International Association for the Study of Pain (IASP-Bruehl) criteria. Diagnosis for CRPS is complicated by the fact that neuropathic and somatic conditions can mimic this complex condition. Internal and external validation research suggests problems with over and under diagnosis using the IASP criteria.

Design: Retrospective file review.

Setting: Colorado Infrared Imaging Center (established 1983), Denver, Colorado

Objective: Determine the sensitivity, specificity and Cohen's kappa index of concordance for cold water autonomic functional stress testing utilizing real time dynamic subtraction IR imaging medical software. The cold water autonomic functional stress test index (test results) was compared with the modified International Association for the Study of Pain (Bruehl) criteria for the presence of CRPS.

Participants: One hundred forty-three (n-143) consecutive patients referred to Colorado Infrared Imaging Center to evaluate for presumptive CRPS/RSD utilizing functional infrared imaging ((f)IR) that included cold water autonomic functional stress testing as part of the IR battery of tests performed during (f)IR imaging.

Methods: Prior to (f)IR imaging each patient underwent a physical examination with particular attention paid to signs and symptoms of CRPS utilizing the modified IASP (Bruehl) criteria. Following physical examination, (f)IR imaging was performed, which included as part of the IR test battery, cold water autonomic functional stress testing.

Outcome Measures: Sensitivity, specificity and kappa statistical analysis for the cold water autonomic functional stress test index utilizing modified IASP criteria (Bruehl) as the gold standard.

Results: Sensitivity 72%, specificity 94%, kappa index of concordance 0.69.

Conclusions: Cold water autonomic functional stress testing, utilizing real time dynamic subtraction imaging medical software, is a valuable and objective IR index for evaluating patients with presumptive CRPS and demonstrates substantial agreement with the modified IASP criteria (Bruehl).

UTILIZING THERMOGRAPHY TO PREDICT THE SPREAD OF CRPS

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BACKGROUND: Thermal imaging has been used to evaluate patients with RSD/CRPS for decades. It is, in my estimation underutilized in that regard and has been shown to be the BEST diagnostic test to confirm this diagnosis. Over the past 10 years it has accurately "predicted" the spread of the disease in patients, who at the time of imaging had symptoms in only one limb with thermal abnormalities in another. In all cases reported, the patients became symptomatic with 6-8 months of the study in the "predicted" areas.
OBJECTIVE: To initiate interventional pain management treatment to patients who fall into this category to observe whether or not we can forestall or at least minimize spread of symptoms
METHOD: Combining infrared imaging in a pre-and post fashion with sympathetic blockade to monitor patients without symptoms and to clinically assess them as well for subjective complaints as well as objective clinical signs of spread
RESULTS: To date the research has been only in diagnostics without therapeutics
CONCLUSIONS: The preliminary findings suggest a proactive approach to the treatment of spread. There are no conclusions offered as to the effects of interventional treatment. However, early treatment of appearing symptoms has produced a more positive outcome

FINGER TEMPERATURE IN RAYNAUD'S PHENOMENON (RP) IN SUFFERERS IDENTIFIED IN A HOSPITAL SETTING AND THOSE DRAWN FROM THE GENERAL POPULATION: A META-ANALYSIS

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Background Whilst cold challenge of the hands with infrared temperature measurement is of proven utility for diagnosis of hospital-referred RP, little is known about finger temperature in RP sufferers in the general population.

Method Using a radiometer we measured baseline finger temperature in RP sufferers. The drop in mean finger temperature

after cold water challenge of the gloved hands (15°C, one minute), and the subsequent rewarming after ten minutes was also measured.

RP sufferers were drawn from two settings.

The first was a group of patients attending the rheumatology clinic at the Royal Free Hospital, recruited to a study to validate the radiometer against thermography. Hospital staff members without RP symptoms also underwent the protocol as controls.

The second RP group comprised volunteers recruited to a twin study at St. Thomas' Hospital who were identified through their responses to questions about RP symptoms in a health questionnaire. Volunteers who were negative for RP symptoms on the questionnaire formed a control group.

All subjects were female, and gave informed consent to participate.

Results Summary data are shown in the table below

		RP		Non RP	
		Mean	Range	Mean	Range
Hospital setting		n=18		n=19	
	Baseline "C	23.8	20.9 – 27.2	29.9	23.1 – 33.9
	Drop °C	3.9	2.6 – 6.1	7.5	4.0 – 10.5
	Rise °C	1.6	0.3 – 3.6	5.7	-0.4 – 10.3
Population setting		n=175		n=404	
	Baseline C	28.3	20.3 – 35.0	30.0	22.0 – 35.3
	Drop °C	6.6	2.3 – 12.8	6.9	0.3 – 11.4
	Rise °C	4.6	-1.1 – 12.5	5.3	-1.6 – 12.0

Conclusion Mean finger temperature, drop and subsequent rise in temperature after cooling were all similar in the two control groups. In contrast, hospital based RP sufferers showed lower values for all three temperature parameters than their counterparts drawn from the general population. RP sufferers referred to hospital have lower finger temperatures than those in the general population, reflecting the greater severity of symptoms

INFRARED-MEDIATED HYPERTHERMIA IS EFFECTIVE IN THE TREATMENT OF SCLERODERMA-ASSOCIATED RAYNAUD'S PHENOMENON

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Scleroderma is a systemic autoimmune disease featuring variable organ involvement as well as Raynaud's phenomenon (RP). To date, no studies exist on the effect of systemic body temperature elevation on the severity of RP. Water-filtered near-infrared (infrared A (IRA)) irradiation is particularly effective in transdermal heat delivery. Prompted by preliminary findings we here examined the effect of IRA treatment on RP. We employed fingertip rewarming in response to cold challenge as well as a clinical activity score as outcome variables. In addition, we explored the effect of IRA treatment on skin thickness and scleroderma-associated joint pain.

Results: This study demonstrated that IRA-mediated hyperthermia reduced the severity of RP, and indicated that IRA-mediated hyperthermia may exert a transient beneficial effect on skin thickness. IRA-mediated hyperthermia transiently improved arthralgia in scleroderma patients.

In conclusion, IRA-mediated mild hyperthermia is effective for the treatment of scleroderma-associated RP and may be therapeutically effective for other disease manifestations.

Infared imaging in veterinary medicine

LEGALITY ASSOCIATED WITH THE USE OF INFRARED THERMAL IMAGING IN VETERINARY MEDICINE

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In 1970 the Horse Protection Act was passed by the United State Congress to ban use of chemical and mechanical means of "soring" of shores. It was common practice in the 1960's and 1970's, with Tennessee Walking horses, to use mechanical (boots, rollers, chains) on the horse's front legs to enhance their performances. The chains of various weights were put on the mid pastern region of the thoracic limbs during the horse show. There was also some evidence that mustard oil was applied to the skin region of the mid pastern to further enhance the horse's performance. Use of these devices induced irritation of the skin and caused lesions and also produced scars in pastern areas.

To prevent this abuse the horse protection act was passed. Just to use physical examination, including digital palpation was not a reliable enough source to prosecute the horse owner or the trainer in the court of law. This promoted the USDA-APHIS (United State Department of Agriculture and Animal Public Health Inspection Services) to fund studies for the diagnosis of "Soring". Thermal imaging was then used by Nelson and Osheim in Iowa (1) and Purohit et. al (2, 3) at Auburn to perform studies for the diagnosis of inflammatory processes in horses in response to various chemical and physical factors.

Auburn University studies resulted in revising the Horse Protection Act in 1983 This was also followed by implementing new guide line by the USDA-APHIS.

As time went by use of thermography was discontinued and horse inspection for horse shows was then done by physical examination that also included digital palpation.

Since 1970's to present day there were and are several court cases. APHIS taken a position in late 1980's to early 1990's that palpation by itself is sufficiently reliable to accurately determine whether a horse has been sored or not. Horses which were written up and not allowed to appear in show, some of those cases ended up in litigation in federal courts. In recent ruling by federal Law Judge Peter M. Davenport, he questioned that whether palpation alone was sufficient "scientific" means to allow expressing an expert opinion. (4). He cited a Supreme Court Case which set forth four factors to determine that reliability. His recent ruling caused APHIS to lose the court case. Now USDA-APHIS went back this April and reinstitutes the use of thermography as an additional means to document if horse was sored or not. During conference further details and discussion will be presented.

Author wish to acknowledge the contribution by Federal Administrative Law Judge Peter M. Davenport., United States Department of Agriculture, Washington DC. 20250

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EDUCATIONAL COURSE IN EQUINE THERMOGRAPY: RESULTS AND FUTURE DIRECTIONS

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The development of a curriculum for veterinary thermography was the main task of the 2005 founded Medical Infrared Academy (MIRA). Since 2006 the German Society of Thermography offers a certified course for equine thermography. The course participants learn in three sessions, each lasting 2 days, basics of infrared physics, methodology of measurement, equine physiology and practice standardised image recording, evaluation and interpretation of infrared thermal images. The content of the forth session is written test combined with an practical examination of a horse and a structured report of the findings.

Until now 50 thermographers have participated in a total of 5 course cycles and have received their certificates. The sixth course is under the way and the interest in this educational facility is continuously growing.

STANDARDS FOR THERMAL IMAGING IN VETERINARY MEDICINE.

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Thermography provides accurate, quantifiable measurements of skin surface temperature. The value of thermal imaging is well demonstrated by its sensitvity and ability to detect temporal and spatial changes in thermal skin responses that corresponds to temporal and spatial changes in blood flow. Its efficacy has been demonstrated in numerous clinical and research studies as a diagnostic tool for veterinary medicine. There have been some published studies that have not adhered to reliable standards and equipment prerequisites thereby detracting from the acceptance of thermography as a valuable research and clinical diagnostic technique. In some cases a simple cause-effect relationship was assumed to demonstrate the diagnosis of a disease or syndrome based on thermal responses captured by thermographic images.

Internal and external factors have a significant effect on the skin surface temperature. Therefore, the use of thermography to evaluate skin surface thermal patterns and gradients requires an understanding of the dynamic changes which occurs in blood flow at systemic, peripheral, regional and local levels. Thus, to enhance the diagnostic value of thermography in veterinary medicine, we recommend the following standards be used:

1. Minimized environmental factors which can and do interfere with the quality of thermograms. The room temperature should be maintained between 21 to 26C. Slight variation in some cases may be acceptable, but room temperature should always be cooler than the animal's body temperature and free from air draft and bright lights.

2. Outdoor thermography: Normally outdoor thermography is not recommended, because direct air draft, sunlight, and extreme variation in temperature will provide unreliable thermograms in which thermal patterns and gradients may be altered. Such observation is meaningless so as to the accuracy of data collection.. There are a few cases in which initial out door observation may be of help to perform further studies in a control environment.

3. Animals should be equilibrated at least for 20 minutes or more in a room with controlled temperature. Longer period of equilibration may be required in cases where animal was transported from extreme cold or hot environment. Equilibration time is considered adequate when the thermal patterns and temperature gradients are consistently maintained over several minutes.

4. Other factors affecting the quality of thermograms are exercise, sweating, body position and angle, body covering, systemic and topical medication, regional and local blocks, sedatives, tranquilizers, anesthesia, vasoactive drugs, skin lesions such as scars, surgically altered areas, etc. Body hair coat may also be an issue in some cases where uneven hair length and/or thick hair coat will have adverse effects on thermal emission. Thus providing unreliable thermograms.

5. It is recommended that the infrared imaging should be performed using electronic non contact thermographic equipment which meets the requirement for medical imaging and can be effectively calibrated. Proper equipment use standards should also be followed.

In conclusion, the value of thermography can only be realized if it is used properly. All species studied thus far have provided remarkable bilateral symmetrical thermal patterns. The high degree of right-to left symmetry provides a valuable asset in diagnosis of unilateral problems associated with various inflammatory disorders. Thermography has also been efficacy for early detection of an impending problem. Thus early detection and treatment can prevent financial losses associated with delayed diagnosis and treatment.

Thermography and Regulation Medicine

THERMOGRAPHY IN REGULATION MEDICINE

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Regulation medicine is characterized by the application of a defined stress test and the study how the organism does cope with the stress. Famous regulation tests are ECG triggered by physical training or EEG with acoustic or visual evoked potentials.

For a long period cold water stress tests have been used. Actually most physicians prefer air cooling (10 minutes of exposition to 20 °C ambient temperature, subject undressed).

Regulation thermography provides additional information evaluating the local and regional thermal patterns and the extent of cooling (or paradoxical heting). It is an important aid for more precise diagnostic efficiacy

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