ISSN-1560-604X
Thermology international

Thermology International

Volume 25 (2015)
Number 1 (February)

Infrared study of dew harvesting cacti spines

Policy statement, evidence based medicine
and infrared thermal imaging

Abstracts: ThermoMed 2014

This journal is indexed in
EMBASE/Excerpta Medica

Published by the
European Association of Thermology

THERMOLOGY INTERNATIONAL

Volume 25 (2015) **Number 1 (February)**

Published by the
European Association of Thermology

Indexed in
Embase/Scopus

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Manuscripts should follow the recommendations of the International Committee of Medical Journal editors (ICMJE)[1,2] and for reporting health related studies the following standards are highly recommended:

CONSORT-(CONsolidated Standards Of Reporting Trials) for randomised controlled trials with parallel group design [3]

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PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for systematic reviews and meta-analysis [5]

STARD (STAndards for Reporting of Diagnostic accuracy) for diagnostic tests [6]

CARE (Consensus-based Clinical CAse Reporting Guideline Development) for case or care reports [7]

SPIRIT (Standard Protocol Items: Recommendations for Interventional Trials) for study protocols [8]
SAMPL(Statistical Analysis and Methods in the Published Literature) for statistical reporting. [9]

In general, manuscripts hould be organized as follows: Introduction, methods, results, discussion, acknowledgements, references. A short abstract in English and, if possible, German (translation will be offered) should head the manuscript. Following the abstract, up to 5 key-words should characterize the paper.

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The internet access to the journal is supplied free of charge to members of the European Association of Thermology.

References:

[1] International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Can. Med Assoc J 1997;156;270-7.

[2] International Committeof Medical Journal Editors. Additional statements from the International Committee of Medical Journal Editors. Can. Med Assoc J 1997;156; 571-4.

[3] www.consort-statement.org

[4]www.strobe-statement.org

[5]www.prisma-statement.org

[6] ww.stard-statement.org

[7] www.care-statement.org

[8] www.spirit-statement.org

[9] www.equator-network.org/wp-content/uploads/2013/03/SAMPL-Guidelines-3-1

Uhlen Verlag Wien,
Ingeborg Machyl, Fachzeitschriftenverlag

Gusenleithnergasse 28a/1, A-1140 Wien
Thermology international
ISSN-1560-604X
Internet: http://www.uhlen.at/thermology-international

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Policy statement, evidence based medicine and infrared thermal imaging

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Recently, a policy statement received much attention in a discussion forum for medical thermal imaging [1]. The main message of this paper is "*Health Net, Inc. considers thermography, also referred to as digital infrared thermal imaging (DITI) and temperature gradient studies not medically necessary. Specifically, Health Net Inc. does not consider thermography medically necessary as a useful aid in the diagnosis or treatment of any of the following: (this is not an all-inclusive list)*

- *Breast cancer screening*
- *Neuromuscular conditions associated with spinal pain*
- *Nervous system disorders*
- *Carpal tunnel syndrome*
- *Trigger points*
- *Peripheral nerve injury/reflex sympathetic dystrophy (RSD)*
- *Metabolic disorders*
- *Repetitive strain injuries*
- *Headaches, neck and back problems*
- *Temporomandibular joint disease*
- *Pain syndromes*
- *Arthritis*
- *Vascular disorders*
- *Soft tissue injuries*
- *Stress fractures*
- *Amputation complications*

This policy statement serves as reasoning for covering the cost of medical investigations and interventions in Medicare and Medicaid services. It is also a typical example of poor understanding of diagnostic procedures and appears as an overt misuse of evidence based medicine. Anyone with a scientific medical education would become skeptic that some diagnostic test can identify everything, physical findings such as trigger points, defined diseases such as carpal tunnel syndrome or RSD (an now obsolete term for complex regional pain syndrome which is not an injury of a peripheral nerve) or total classes of diseases such as metabolic disorders, vascular disorders, nervous system disorders or arthritis. It is also unlikely that same technology can differentiate between injuries of different tissues such as soft tissue or peripheral injuries or discriminate different reasons of injury such as stress or repetitive strain. No technology can identify headaches, neck and back problems, pain syndromes or amputation complications, why should thermal imaging be able to do so?

The conclusion that thermography is not necessary cannot derived from studies results indicating poor diagnostic power of thermal imaging. It is also a sign of poor understanding when someone concludes from findings in one disease on the outcome in other diseases of the same group. The Health Net policy statement is a highly selective narrative review based on several guidelines and single studies, both data sources have not been checked for methodological quality. However, a meta-analysis requires as systematic review of studies. The annual surveys on publications related to thermography or temperature measurements identified for the time period between 1.1.2011 and 31.1. 2013 a total of 2216 papers for the search term thermography, i. e. 241 publications in 2011 [2], 403 in 2012 [3] and 1572 in 2013 [4]. Although not each of these studies published might meet the inclusion criteria of a systematic review, it would provide better information than the 14 papers added since 2011 to the database used for the evaluation of "the necessity of thermography". 8 of this 12 papers were related to breast thermography.

Such a statement about the value of thermography as a diagnostic tool or as outcome measure must be based on studies which compare the outcome of patients with defined disease, with and without diagnostic support of thermal imaging, in terms of health parameters and costs. But those studies are not yet available. Probably, a systematic review that meets the requirements of PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analysis, [5] and STARD (STAndards for Reporting of Diagnostic accuracy, [6]) will find that the data available do not allow recommendations pro or against the diagnostic use of thermography.

In fact, there are two critical points in evidence based medicine: One is the transparency and completeness of data when reporting study findings. The other is the definition of levels of evidence and the hierarchy of recommendations. The most comprehensive approach to this problem is GRADE = "Grading of Recommendations Assessment, Development, and Evaluation" [7] providing a guidance for use of the system of rating quality of evidence and grading strength of recommendations in systematic reviews, health technology assessments (HTAs), and clinical practice guidelines addressing alternative management options. However, detailed discussion of GRADE is outside of the scope of this editorial.

Data reporting

The strategy for the first problem is to apply rigorous rules on data extraction from studies and to follow standards for reporting the results of studies, investigating different health related questions with various study designs. Important guidelines in the field of publishing study results are:

- CONSORT (CONsolidated Standards Of Reporting Trials) for parallel group randomised trials [8] The generic guideline consists of CONSORT 2010 statement [9], CONSORT 2010 checklist, CONSORT 2010 flow diagram and the CONSORT 2010 explanation and elaboration document [10]. The guideline, developed in 2001 andupdated in 2010, was simultaneously published as open access document in 10 different journals. Several extensions have been made for other trial designs. CONSORT Harms [11], CONSORT Non-inferiority [12], CONSORT Cluster [13], CONSORT Herbal [14], CONSORT Non-pharmacological treatment interventions [15, 16], CONSORT Abstracts [17, 18], CONSORT Pragmatic Trials [19], STRICTA Controlled trials of acupuncture [20] and CONSORT PRO [21] for patient-reported outcomes The application of CONSORT is supported by more than 550 journals, many of them have included CONSORT in their instructions for authors.
- STARD (STAndards for Reporting of Diagnostic accuracy) appleys to studies of diagnostic accuracy [6]. The full guideline consists of STARD statement [22], checklist, flow diagram and the Explanation and Elaboration document [23]. Journals like Cinical Chemistry, American Journal of Clinical pathology, or radiology, all dedicated to diagnostic disciplines and General Medical Journals such as British Medical Journal or Annals of Internal Medicine has published the STARD statement. An extension named STARDdem for studies reporting diagnostic accuracy in dementia is available [24]. For diagnostic thermography, STARD is the most relevant guideline.
- PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for systematic reviews and meta-analysis [5]. The guideline consists of the PRISMA statement [25], checklist, flow diagram and the PRISMA explanation and elaboration document [26]. Extensions of the guideline are available for systematic reviews with a focus on health equity [27], for abstracts in journals and conference papers [28] and for protocols of systematic reviews [29]. Application of the PRISMA recommendation in systematic reviews of thermography is strongly supported.
- STROBE (STrengthening the Reporting of OBservational Studies in Epidemiology) for cohort, case-control studies, cross-sectional studies [30]. The STROBE statement [31] and STROBE explanation and elaboration document [32] are available. Extensions for genetic association studies [33], for molecular epidemiology [34], for molecular epidemiology in infectious disease [35] and for longitudinal observational drug studies in rheumatology [36] have been published. Also available is a first draft of the STROBE checklist of items to be included when reporting observational studies in conference abstract [37]. Following STROBE in longitudinal and cross-sectional studies of themographic findings of cohorts with defined disease is recommended.
- CARE (Consensus-based Clinical CAse Reporting Guideline Development) for completeness, transparency and data analysis in case reports and data from the point of care [38]. The guideline [39], a checklist [40] and a CARE writing template for authors [41] are available. The use of CARE is strongly recommended when writing case reports related to thermographic findings.
- SPIRIT (Standard Protocol Items: Recommendations for Interventional Trials) Defining standard protocol items for clinical trials [42]. The SPIRIT statement [43] and the SPIRIT explanation and elaboration document [44] are available. A proposal for reporting protocols of systematic reviews have been published within the PRISMA initative [29]. The most appropriate of these proposals should be considered in protocols of infrared thermal imaging.
- SAMPL(Statistical Analysis and Methods in the Published Literature) is related to Basic statistical reporting for articles published in biomedical journals [45]. Only the guideline is available.

Links to all guidelines mentioned above are available at the EQUATOR-network, dedicated to "Enhancing the QUAlity and Transparency Of health Research" [46]. Rigorous application of these guidelines on manuscripts related to thermology will improve the transparency and quality of publication in temperature related research. Consequently considering the recommendations of CONSORT, STROBE, PRISMA, STARD, CARE, SPIRIT and SAMPL in submissions to Thermology international has recently been included in the "Instructions for Authors"

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Infrared study of dew harvesting cacti spines

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SUMMARY

The focus of this study was to gain further understanding on the thermodynamic behaviour of the dew and non-dew harvesting spines of cacti. Four species of cacti were chosen, three that were known to harvest dew on their spines and one that does not. The temperature gradient of the spines of the most efficient dew harvesting species, *Copiapoa cinerea* var. *haseltoniana*, and the IR emissivity of the cactus spines for all four species were determined. When placed outdoors, around the hours of sunrise and sunset, the tips of the spines of *C. cinerea* appeared constantly warmer than their base or mid-sections, even during the cooling hours of sunset. Also, the IR emissivities of the spines of the three dew harvesting cacti were higher than those of *Ferocactus wislizenii*, the cactus species which does not harvest dew. The highest spine IR emissivity was recorded for *Mammillaria columbiana* subsp. *yucatanensis* at 0.98 ± 0.016 followed by *C. cinerea* and *Parodia mammulosa* with IR emissivities of 0.97 ± 0.007 and 0.93 ± 0.004 respectively. *F. wislizenii*, which does not harvest dew on its spines, was found to have the lowest spine emissivity of 0.89 ± 0.009.

KEYWORDS: **thermography, water harvesters, dew, cacti, emissivity, infrared**

INFRAROT-UNTERSUCHUNG AN KAKTUSDORNEN, DIE TAU SAMMELN

Der Schwerpunkt dieser Studie war es, weitere Einsichten über das dynamische Wärmeverhalten von Kaktusdornen zu gewinnen, die an der Oberfläche Tau sammeln. Vier Kakteenarten wurden untersucht, wobei von drei dieser Arten bekannt ist, dass sie auf ihren Dornen Tau sammeln, und von einer Art, dass sie dies nicht tut. Der Temperaturgradient an den Dornen der am effizientesten Tau sammelnden Kakteenart, *Copiapoa cinerea* var. *Haseltoniana,* aber auch die Infrarot-Emissivität der Dornen aller vier Kakteenarten wurden bestimmt. Zur Zeit des Sonnenauf- und -untergangs, im Freien platziert, erwiesen sich die Dornenspitzen von *Copiapoa cinerea*, regelmäßig wärmer als die Basis oder der Mittelabschnitt der Dornen, sogar während der Abkühlung beim Sonnenuntergang. Ebenso war der Emissionsgrad von Infrarot an den Tau sammelnden Dornen höher als der von *Ferocactus Wislizenii*, der nicht Tau sammelt. Der höchste Emissionsgrad wurde für *Mammillaria Columbiana* subsp. *yucatanensis* mit 0,98 ± 0,016 gemessen, gefolgt von *C. cinerea* und *Parodia Mammulosa* mit 0,97± 0,007 bzw. 0,93 ± 0,004. Die Art *F. wislizenii*, die an ihren Dornen nicht Tau sammelt, bot mit 0,89 ± 0,009 den geringsten Emissionsgrad.

SCHLÜSSELWÖRTER: **Thermographie, Tau-Sammler, Tau, Kakteen, Emissivität, Infrarot**

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Introduction

This study forms part of a broader investigation looking into the possibilities of translating nature's own methods for harvesting airborne moisture into a biomimetic moisture harvesting device. Here, infrared (IR) measurement was used to gain further understanding into the formation of dew on the surface of some of nature's known dew harvesters (in this case cactus spines), since dew forms only on surfaces cooled below the dew point temperature. Four species of cacti were studied, three known to harvest dew on their spines and one that is known not to do so. Two of the three dew harvesting cacti, *Mammillaria columbiana* subsp. *yucatanensis* and *Parodia mammulosa*, were part of a previous study on dew harvesting cacti (i.e. prior exploratory investigations carried out during dewy weather in the UK), the third, *Copiapoa cinerea* var. *haseltoniana* was also part of this study but had additionally been reported in the literature to have dew harvesting capability [1]. The last of the four species, *Ferocactus wislizenii*, was likewise observed in this study but was chosen as a comparative species, with Shreve (1916 cited in Nobel [1]) finding it not to harvest airborne moisture on its spines.

The aim of this paper was to study the thermal response of the cactus spines during sunrise and sunset, using thermal imaging cameras to gain insight into the dew harvesting mechanisms and to further determine the emissivity of the spine surfaces. Cone shaped structures, such as cactus spines, have previously been identified as an important structure for harvesting airborne moisture [2]; it was thus deemed important to assess the spines in detail, using thermographic analysis to study their temperature gradient. Infrared Thermal Imaging (IRT) has previously been used to study plants and the nucleation of ice or frost on their surfaces [3-5] as well as signs indicating plant stress [6, 7] but not, to our knowledge, with regard to dew formation.

Object emissivity values lie within the range of 0 to 1.0, with 1.0 being highly emissive and corresponding to that of a blackbody and 0 having no infrared energy emission. The emissivity of cacti has been reported in the literature for several different species, with values of at least 0.96 in a study of eight cactus species [8-10] but no figure for emissivity has been assigned to cactus spines *per se*. Establishing this was one of the principal aims of this study.

Methodology

The methodology chosen was, firstly, to analyse the temperature gradient along a spine of the most efficient dew harvesting cactus, *C. cinere*a, by capturing temperature gradient data for the spine observed outdoors during the hours of sunrise and sunset. The second element of the methodology utilised a climate chamber to maintain a stable environment to measure the IR emissivity of cactus spines for three species known to harvest dew and to compare these emissivities with that of the species of cactus whose spines do not harvest dew.

Thermographic data was captured using the Longwave Optris PI450 Infrared Camera to collect temperature data for the cactus spine of *C. cinerea* when placed outside around the hours of sunset and sunrise. The IR camera used had a spectral range of 7.5 to 13μm, enabling detection of infrared wavelengths whilst minimising atmospheric absorption and, as a consequence, increasing detail. The camera had a detector resolution of 382 x 288 pixels, frame rate of 80 Hz and a system accuracy of ± 2°C. The thermal sensitivity varied depending on which lens was used. For the 13° lens, the temperature resolution was 60 mK and for the 38° lens, the lens of choice for the key elements of this study, it was 40 mK. The rainbow thermo-

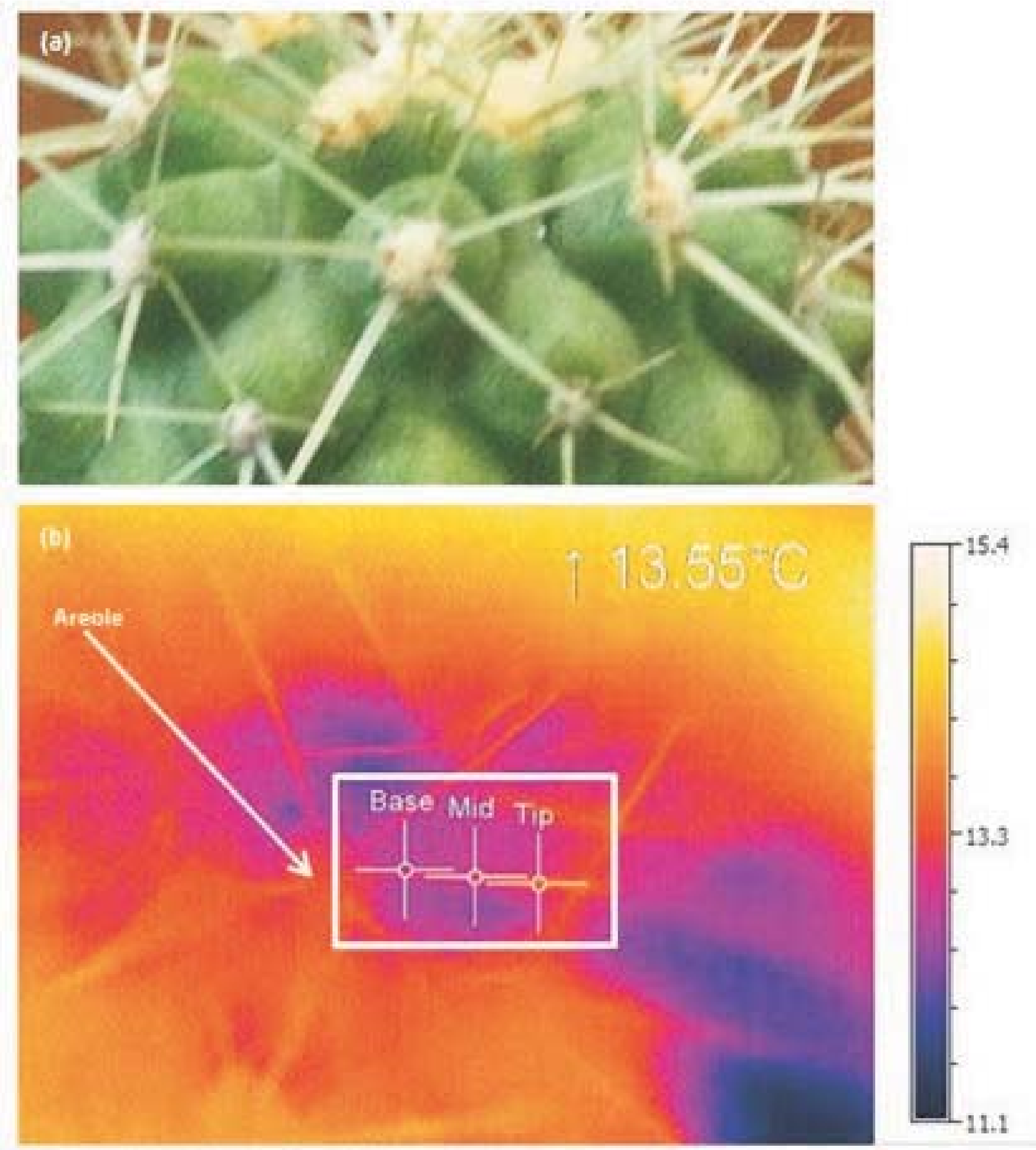

Figure 1:
Digital microscope and IR images taken of *C. cinerea*
(a) Digital microscope image of *C. cinerea*; (b) Infrared image of an areole of *C. cinerea* showing the target measurement areas on the spine (highlighted in the white box and showing the target area at the base, mid-section and tip), image is not of the same area as in (a).

gram palette (the preferred choice in medicine [11]) was utilised throughout this study to provide a visual indication of the temperature (warmer areas are red and the cooler areas are blue).

Temperature gradient of individual spines

C. cinerea was placed outside on a night during which dew was likely to form, away from any objects such as buildings or trees that would obscure it from having full view of the night sky. This was achieved by placing it on a flat roof on top of a sheet of polystyrene to insulate it from below and raising it, using a plastic container, to a height that enabled the IR camera to focus on the cactus apex. The 38° lens was utilised to maximise the spatial resolution, imaging only the area of the single spine under investigation. Thus highly resolved thermographic data was captured to assess in detail the spine temperature gradient. The material of a spine is the same along its length and it is therefore possible to draw meaningful temperature gradient results using the technique outlined here. Different cacti species cannot be compared with each other unless their emissivity is calculated and used to obtain true temperature readings.

A spine orientated horizontally was selected for monitoring and target measurement areas were identified and positioned using the software to capture the temperature at the base, mid-section and tip of the same spine (Figure 1b). To ensure these target areas were accurately aligned over the area of the spine in focus and that background thermal data was minimised, a metal rod was used during the set up phase to increase the contrast of the spine against the background, allowing the target measurement area to be positioned accurately.

The average length of a spine from this plant was measured to be typically 8.6 mm ± 2.7 mm with an average spine base width of typically 0.4 mm ± 0.08 mm. As the tip of the spine tapered to a point, the measuring area at the tip was not positioned exactly on the spine tip but rather slightly below it, again to ensure no background thermal data was captured due to a larger measuring target area compared to the area of the narrow tip.

The earth's key source of surface energy is the sun's shortwave radiation, with the hours around sunset seeing a cooling of the earth's surface and heating occurring soon after sunrise [12]. Thus the periods around sunset and sunrise were chosen as times of interest for this study. The camera was set to run for one hour between 21:30 and 22:30 hours GMT as the sun was setting on 2 July 2014 (at approximately 21:31 hours GMT) and again for an hour, between 04:50 and 05:50 hours GMT, as the sun was rising on 3 July 2014 (at approximately 05:08 hours GMT).

Emissivity of Cactus Spines

The spines of cacti occur in an array of different shapes, sizes and colours. As a consequence, this study did not generalise and the precise spine emissivity for each of the four species of cactus under investigation was measured, although, spine emissivity was assumed to be constant along a spines length. The woody nature of the spines was likened to that of tree bark of which emissivity of certain species has been measured, with an average recorded value of 0.95 [13].

The standard method of using a reference material as an aid in measuring the unknown emissivity of a material was employed [14]. Thus a thermocouple attached to a spine on each of the four species under investigation was used as a temperature reference (in the same manner in which a reference material would have been used) from which to compare the IR camera temperature readings at the target measurement area. To ensure that the target measurement area was positioned accurately on the spine and close to but not on the attached thermocouple, a metal rod was utilised once again in the set-up phase, to increase the contrast between the spine and the background. Furthermore, the thermocouple wires were made into a coil shape and wrapped tightly around the spine, ensuring there was good thermal contact with the spine along with adequate thermal mass from which to obtain an accurate temperature measurement from which to be used as a comparative reference. The emissivity settings on the IR camera were then adjusted until the spine temperature displayed on the camera matched the thermocouple temperature reading. Increasing the emissivity of the area in question caused a decrease in the measured temperature for that region [15], the relationship of which is given in Equation 1.1 in the next section.

The measurements were taken at a temperature of 20°C and at 40% relative humidity. The presence of gas, dust, moisture and other atmospheric particles is known to cause absorption and scattering of radiation between the IR camera and the object being imaged [16]. Thus atmospheric attenuation of the measured infrared radiation was minimised by carrying out the measurements in a Sanyo MTH 2400 climatic test chamber to keep dust and moisture particles low by maintaining a low humidity.

Results and Discussion

Outdoor spine temperature gradient experimental results and discussion

Dew was observed to form on the spines of the cacti exposed to the night sky on the night chosen for the test. (i.e. on the planographic surface areas). A thermogram and digital microscope images were captured as shown for *M. columbiana* (Figure 2). Dew droplets can be seen on the spines in both of these images. This led on to the temperature gradient estimate for individual spines being carried out on *C. cinerea* to enable a better understanding of this dew formation.

Following the recording of the thermograms around sunset and sunrise, the temperature-time diagram data was extracted from the images. The temperature at a spine tip, mid-section and base was recorded for *C. cinerea* (see Figure 3 and Figure 4). This particular species of cacti was chosen

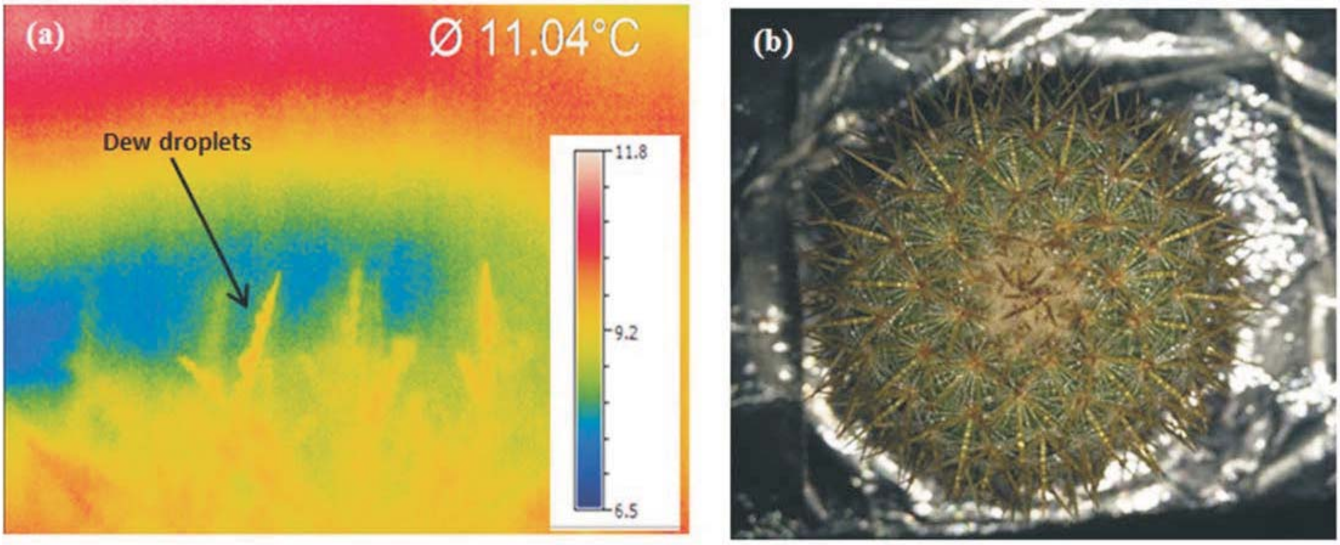

Figure 2:
Thermogram and digital microscope image of *M. columbiana* following a dewy night
(a) Thermogram using the 13° lens, clearly showing dew droplets on a spine but no clear thermal difference and (b) the apex of the plant showing the dew that formed during the night.

as it was found in earlier experiments to be the most efficient at harvesting dew on its surface. It appears that, as expected, the spine cools as the sun sets and warms up as the sun rises.

The temperature differences over an object under investigation can be masked by the temperature achieved due to the heat energy flux variation during the daily cycle. So the hours of sunrise and sunset, during which the solar heat source changes and the temperature differences become evident, were chosen for this study. Equation 1.1 was used to calculate the amount of radiation emitted ($Q_{Emitted}$) from an object during radiative cooling to a background reference of 0K:

$$Q_{Emitted}=\varepsilon\sigma AT^4 \qquad \text{Equation 1.1}$$

Where ε is the emissivity of the object, σ is Stefan-Boltzmann constant equal to 5.669×10^{-8} W/m^2.K^4), A is the surface area of the object and T is the object's absolute temperature. Thus, we hypothesise that the smaller the object's surface area (i.e. smaller tip compared to the wider spine base), the less radiation is emitted from it and therefore the higher its temperature will be.

At sunset the tip of the spine cools more slowly than the mid-section (Figure 3a). This finding is in keeping with Equation 1.1 as well as with 3D simulation results by Fu et al. [17] who found that during cooling and for a wind velocity of 0.5 and 2.5 m/s, a cactus spine tip is warmer than its base for both wind velocities (although for the higher wind velocity, the spine was warmer as a whole). A three-second section of the temperature-time data was selected to observe the temperature difference between the three sections of the spines in more detail (Figure 3b). A similar temperature was measured at the base and mid-section of the spine. The base was marginally warmer than the mid-section for the first 10 minutes around the hours of sunset, after which the mid-section became warmer than the base.

It is also clear that, as the sun sets, there is no sudden temperature drop in the spine as a whole, with a gradual decrease in the spine temperature and with the tip taking longest to cool. We do not expect this to be due to internal thermal conduction from the body of the cactus to the spine because then the base of the spine would be expected to be warmer, although the plant stem and the arrangement of spines could create a microclimate around each plant. This, along with internal heat transfer, could be of interest in future studies.

Around the hours of sunrise (Figure 4), the tip of the spine warmed most quickly with the base and mid-section recording similar temperatures, and the mid-section recording a slightly warmer temperature than the base overall. During the first few minutes of sunset, similar temperatures were recorded at the tip, mid-section and base albeit the tip was marginally warmer.

The tip was always warmer than the rest of the spine throughout the recorded hours around sunset and sunrise, which could explain why dew droplets were observed forming at the base and mid-sections of the spines before appearing at their tips. The recorded temperature gradient on the spine needs to be taken into account when considering droplet growth, as it is this gradient which could impact on the formation of dew on the spine. That is, the cooler spine areas will have a greater expected rate of condensation. However, even though this temperature difference is real, it is less than a degree, which may not be a significant enough to affect the dew formation rate along the spines.

Emissivity of Cactus Spines

To facilitate detail thermal analysis, typified by that of Yu et al. [17], it is important to gain an accurate determination of the emissivity of the spines since this is absent from the literature. Five measurements were taken from the same point on the same spine (close to but not touching the attached thermocouple reference) of each of the four species in this study. The measurements obtained are given in Table 1, along with the mean (M) and standard deviation (SD). All the spines were found to be highly emissive, with the measurements of *F. wislizenii* found to be the least emissive at 0.89 ± 0.009. The spine emissivities of *M. columbiana*, *C. cinerea* and *P. mammulosa* were measured to be 0.98 ± 0.016, 0.97 ± 0.007 and 0.93 ± 0.004 respectively. The fact the spine emissivity of these four species of cacti are all high, does not explain the absence of dew on the spines of *F. wislizenii* compared to the other species. Other reasons, such as spine surface morphology, could play a role in inhibiting the nucleation of dew droplets on *F. wislizenii* which has a high density of tightly packed microstructures on its surface.

Whilst carrying out these measurements, all but *F. wislizenii* gave consistent readings on the IR camera and the emissivity

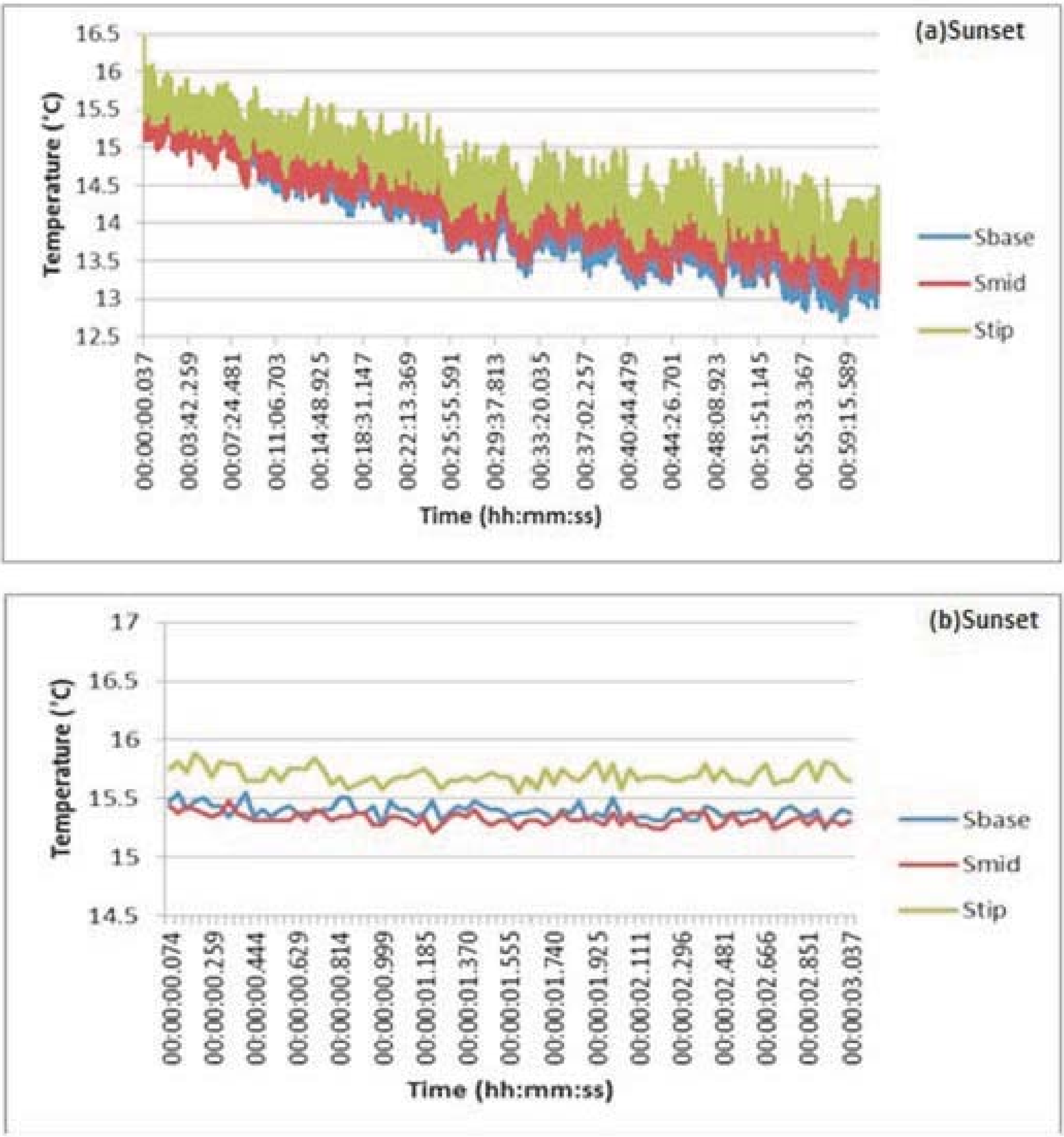

Figure 3:
Spine temperature gradients at sunset for *C. cinerea*
The temperature-time graph around sunset with readings for a spine's base (Sbase), mid-section (Smid) and tip (Stip):
(a) detailed graph for 1hr 45 minutes around sunset and (b) a three-second section of the detailed temperature-time data.

of the measuring area could be adjusted until its temperature reading matched the thermocouple reading. Even though the standard deviation of the emissivity measurement for *F. wislizenii* was low, the IR camera gave fluctuating readings for this species, making it problematic to select an emissivity.

It is known that backscattering is increased for rougher surfaces, increasing not only the measured spectral emissivity of an object but also fluctuation in this measurement [18]. Therefore, we suggest that the known surface microstructures on the spines of *F. wislizenii* could have caused the unstable readings on the IR camera. The surface scattering of

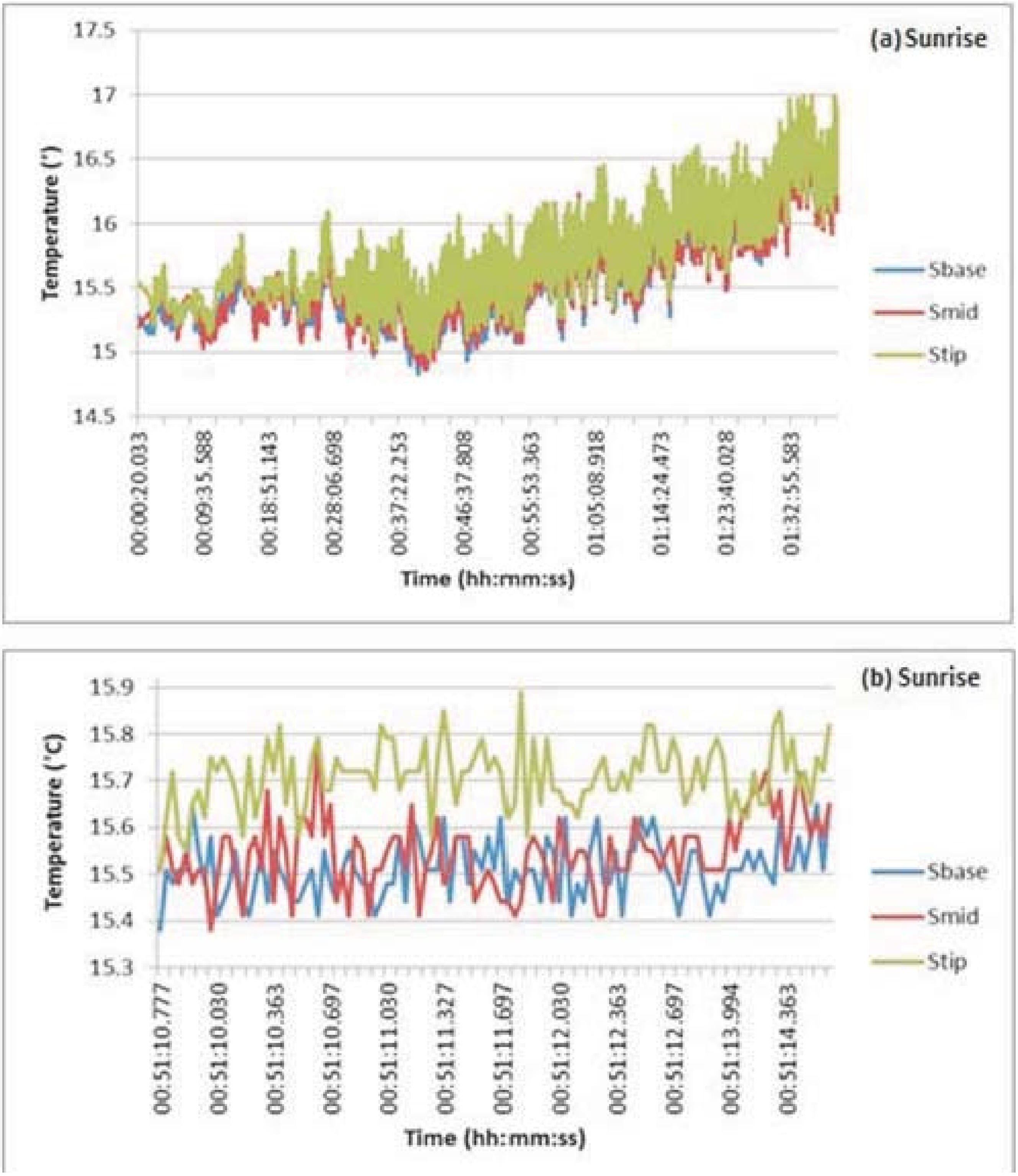

Figure 4:
Spine temperature gradients at sunrise for *C. cinerea*
The temperature-time graph at around sunrise with readings for a spine's base (Sbase), mid-section (Smid) and tip (Stip): (a) detailed graph for 1hr 45 minutes around sunrise and (b) detail of a five-second section of the temperature-time data.

Table 1
Mean spine emissivity for four species of cactus with the five measurements taken at the same point on the same spine (close to the attached thermocouple reference)

Emissivity	*C. cinerea*	*F. wislizenii*	*M. columbiana*	*P. mammulosa*
Measurement 1	0.963	0.89	0.99	0.93
Measurement 2	0.96	0.893	0.95	0.925
Measurement 3	0.973	0.87	0.98	0.925
Measurement 4	0.975	0.89	0.975	0.933
Measurement 5	0.973	0.89	0.99	0.925
Mean	**0.97**	**0.89**	**0.98**	**0.93**
St. Deviation	*0.007*	*0.009*	*0.016*	*0.004*

infrared due to the spine's microstructures is a consideration beyond the scope of this study.

Conclusion

For a single spine of *C. cinerea,* the tip always appeared hottest when placed outside and measured around the hours of sunrise and sunset. It is probable that the tip is warmer when placed outside to cool by nocturnal radiation due to its smaller surface area. These findings are in keeping with the 3D radiative cooling cactus spine simulations carried out by Yu et al. [17].

The emissivity of the spines of *F. wislizenii* was found to be the lowest of the four cactus species at 0.89 ± 0.009. This was the only cactus in this study whose spines did not show any sign of encouraging dew droplets to nucleate on their surfaces. However, even though its spines had the lowest emissivity of the four species, they were still found to be highly emissive. As such, we conclude that the absence of dew nucleation on the spines of *F. wislizenii* cannot be explained by a lower emissivity but must be due to other reasons such as surface morphology.

Even though limitations were found with this technology (i.e. within the optics and the thermal and spatial resolutions of the detector), in general these results indicate that infrared analysis is an important method which can assist in the comprehensive modelling of the moisture harvesting associated with cactus spines.

Acknowledgments

This research paper was funded by Fujitsu and supported by HPC Wales and Swansea University. Thanks are due to The Botanical Gardens in Singleton Park, Swansea, for donating two of the four species of cactus to this research project (*M. columbiana* and *P. mammulosa*) and thanks also to Jenny Childs for her assistance in the generation of this manuscript.

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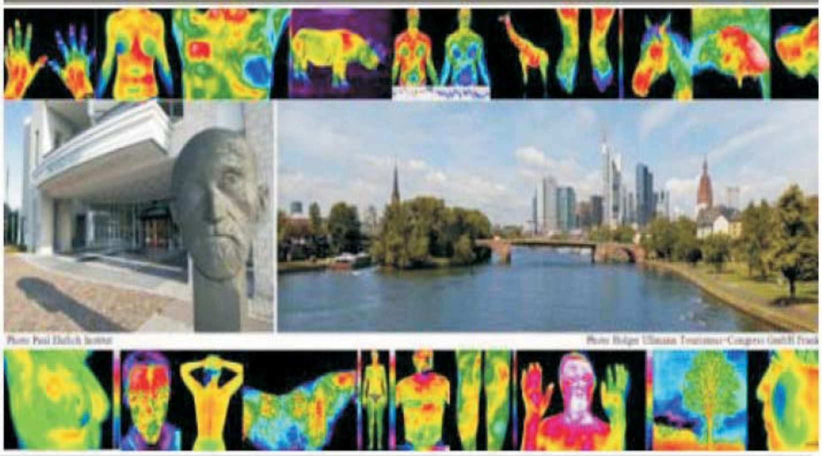

Guest editor: Reinhold Berz

Abstracts

Session 1
History of thermography and early medical equipment and applications

THE EVOLUTION OF INFRARED TECHNOLOGY IN HUMAN BODY TEMPERATURE

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The early history of medicine, shows that a number of physicians had reasons to study the temperature of the Human body, but attempts at measurement were not always successful. Even so, the clinical thermometer eventually became a routine tool, and became a world wide instrument for medicine. The fact that the human body radiates thermal energy as part of its natural thermoregulation was only exploited by later developments..The identification of "dark heat" by William Herschel (1800) subsequently called Infrared radiation was not available to the physician for study of the human body until technology brought in detectors. Here the story develops as a series of scientists found the way to use remote sensing of heat both to measure by bolometry and then through imaging technology.

In 1840 John Herschel, son of William Herschel, the German born musician and astronomer, created an experiment to investigate his father's observations. The image cause by sunlight on a carbon and alcohol mixture he called a thermogram. Yet nearly a 100 years passed before this concept could be used commercially. Much of the development of thermal detectors came from Germany England and Russia, followed by the USA and Japan.

By the 1950's infrared camera systems became a reality, though often slow scanning devices and limited in thermal and spatial resolution. Over the last 20 years, smaller, faster highly resolving systems have been de-veloped and relative cost has fallen. Despite the great innovations in detector technology, the advent of the computer has revolutionised the ability to manage the whole infra red imaging process. From better calibration image capture at speed, and image analysis, the advances in thermography have been phenomenal.

As a result, we have powerful technology to study human body temperature, although with infrared imaging we are limited to the imaging of skin temperature. This, nevertheless, can in some clinical applications be a significant influence on regional skin temperature, and in response to external challenges can be useful. Standardisation of protocol for image capture and for image analysis are now recognised to be of great im-portance. Reliable and reproducible results, a subjects sometimes in the past made by critics of the technique are the key to increased clinical acceptance. A thermal image taken today, bears little resemblance to those obtained over 50 years ago. However, many of the pioneering scientists of that time were often accurate in their predictions that thermography has a future in medicine as a non-invasive method of study of Human body temperature. We now also find that the clinical thermometer of the 19th century as being largely re-placed by the ear radiometer for tympanic membrane temperature.

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GERMAN CONTRIBUTIONS TO THERMOGRAPHY AND INFRARED IMAGING AND TO ITS MEDICAL USE

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The discovery of infrared radiation was done by the musician Wilhelm (William) Herschel from Hannover, Germany, and his son John Frederick, both living and working in Bath, England. They created the first "thermogram" in 1840.

German physicists like Gustav Kirchhoff (blackbody ca. 1860), Heinrich Hertz (electromagnetic waves, together with Maxwell), Max Planck (quantum physics), and Wilhelm Wien (Wien's law) formulated basic laws regard-ing infrared radiation.

It was in Leipzig (1868 to 1870), when Carl August Wunderlich was the first to introduce thermometry into hospitals. 60 years later, the first documented infrared image of a human subject (with eye glasses and a cup of water in his hand) was recorded in Frankfurt by Professor of physics Marianus Czerny (1929), using a machine called "evaporograph".

Figure 1:
First-ever infrared thermogram of a human subject, recorded 1929 in Frankfurt by Prof. Czerny

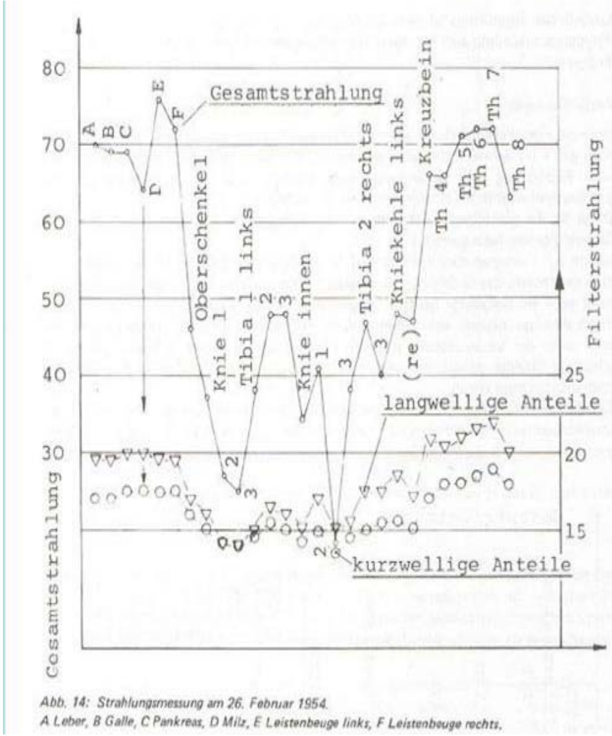

Figure 3:
One of the first medical “thermograms”, differentiating between short and long wave registration

The first documented and patented medial application of infrared techniques appeared 1952, when the two founders of our society (the physician Ernst Schwamm and the physicist Johann Reeh) presented their device for thermography.

It was in the year 1954, when Schwamm and Reeh founded the "Medizinisch-Physikalische Forschungsgemeinschaft des Unterlahnkreises", later called „Gesellschaft für Thermodiagnostik“ and „Deutsche Gesellschaft für Thermographie“. The suffix „und Regulationsmedizin“ was added later due to the dynamic regulation (cold challenge) tests widely applied. The early thermograms were temperatures recorded step by step and then plotted.

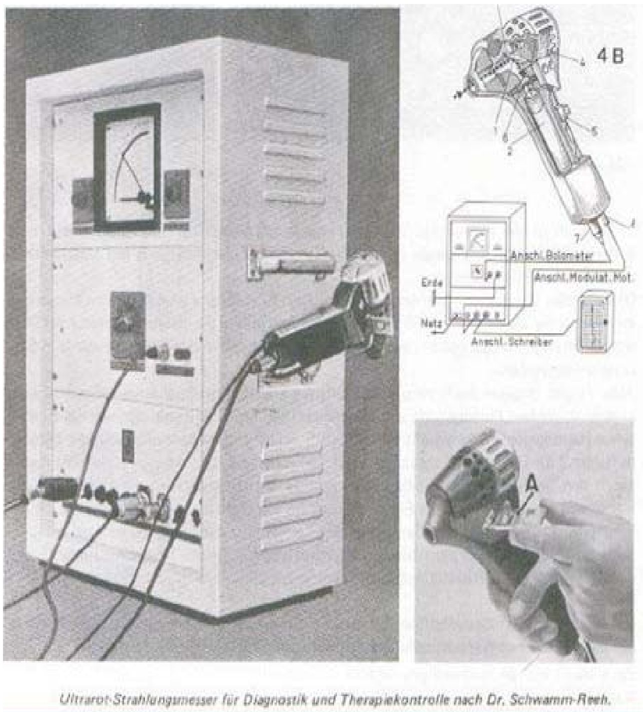

Figure 2:
Early device for medical thermography (ca. 1955)

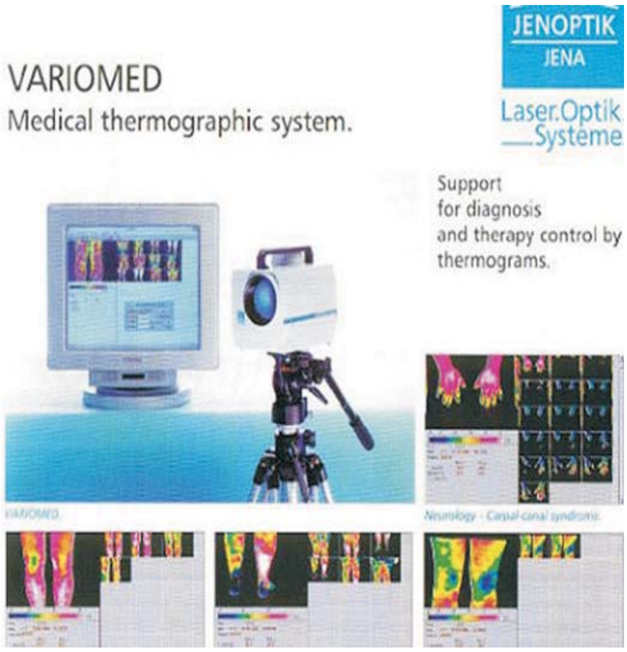

Figure 4:
The legendary 1990s Variomed made by Jenoptik, Carl Zeiss Jena, still with perfect measurement

After the discovery of liquid crystals (Otto Lehmann, Leipzig 1904), they were used in the 1970s also for medical applications.

Infrared cameras from Germany were legendary in the 1980 and 1990s, produced by Carl Zeiss Oberkochen and by Carl Zeiss Jena. The latter remained as Jenoptik, still producing cutting edge infrared cameras which often are called world class devices (but also in price high class). Since the 1990s, the famous HgCdTe detector devices (scanning systems, LN cooled) Variomed and VarioScan were state of the art (and beat some modern uncooled cameras), some are still in use.

Beside the many inventions and high tech productions, the main German contribution to medical thermography is provided by the "human capital", the physicians and other experts improving medical thermography for more than 60 years, joint together in the German Society of Thermography and Regulation Medicine, which has become global and international over time and therefore will be named "ThermoMed" in the future.

Session 2
Therapeutic thermal applications, thermal monitoring of therapy and interventions

THERAPEUTICALLY UV IRRADIATION OF THE BLOOD APPLIED TO PROBLEMS OF PERIPHERAL ARTERIAL BLOOD SUPPLY, CONTROLLED BY THERMOGRAPHY

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Autohaemotherapy is practised with success since more than 100 years. By irradiation of the blood with ultra-violet light the effects of the autohaemotherapy will be considerably changed and improved.

Since 30 – 40 years there are a lot of devices in the market and by way the method is widespread in clinics in Germany.

Preferred indications are all forms of oxygen deficiency of the organism and their consequences, especially troubles of the arterial circulation of periphery, heart, brain, loss of hearing, tinnitus, macular degeneration, and immune deficiency.

Case studies are presented together with lab results, infrared images and long term results.

THERMAL IMAGING AND CIRCULATING TUMOUR CELLS - WINDOWS ON BREAST HEALTH

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Thermal imaging and CTC testing can be considered as potential complementary biomarker technologies for the monitoring of breast health and the early detection and monitoring of breast dysplastic and neoplastic processes.

Breast cancer is a diagnosis, which can only be confirmed on cytological or histological examination. In the mammography screening randomized controlled trials (RCTs) that the Nordic Cochrane Centre reviewed in 2006, the average invasive breast cancer tumour size detected at mammography screening was16 mm, the size a tumour attains when it has undergone more than 30 doublings. By comparison the average size of tumours found as palpable lumps was 21mm, effectively one doubling older than 16mm.

Breast cancer doubling times vary with one large study showing 95% between 65 and 627 days. Even the most rapidly doubling of these 95% can be calculated as having been present for over 5 years and the slowest are so slow that they would not affect a woman in her lifetime. Mammography is considered to be able to detect breast cancer tumours once they have reached 10mm (Gotzsche P 2012).

There is therefore a critical window of time, of several years duration, available for intervention in the breast neoplasia process between the initiation of a neoplastic process and when it can be diagnosed as a breast cancer.

There are significant differential rates of breast cancer between countries (Ziegler et al 1993) and the identifi-cation of many environmental risk factors have lead to breast cancer being considered an environmental dis-ease.(Gray G et al 2009) When genetic predispositions are present, the risks associated with them are signifi-cantly modified by environmental risk factors. (Litton J 2012) Metastatic breast cancer recurrence rates are also modified by environmental factors such as exercise.(McNeely M 2006) Even those with BRACA 1 or 2 genes do not all develop breast cancer.(Litton J. 2012)

Periodic thermal imaging offers a means of supporting women to maintain breast health and to check if they are at an increased risk of breast cancer. (Chiatto S 1997

When thermal imaging detects persistently abnormally elevated breast temperatures and no tumour is de-tectable on anatomical imaging (mammography, ultrasound or MRI) there is a question as to why this is so. If a tumour is found conventional care model would be recommended in conjunction with breast health measures. General breast health measures to improve the breast tissue environment include avoiding in-flammation inducing and oestrogen inducing factors in the woman's lifestyle. This includes regular exercise, avoiding alcohol, maintaining ideal weight, the recommended intake of vegetables and fruit, avoiding oestrogen and xenooestrogens, addressing oral health, avoiding inflammation inducing foods, avoiding high levels of stress and obtaining adequate sleep, avoiding excessive electromagnetic radiation addressing key nutrient deficiencies in the diet such as iodine, selenium, magnesium and vitamin D, detoxification.

Several studies have demonstrated that persistent high grade thermal abnormalities in the breast with nega-tive anatomical imaging indicates a 30 to 40% risk of breast cancer being diagnosed within the next five years.(Gautherie M 1980)(Guidi A1996). As 5 years is within the lifespan of most of the rapidly growing tumours, the thermal changes maybe due to their presence. Given the observation that many invasive cancers large enough to be diagnosed on mammography do not progress it is possible that what have been consid-ered 'false positive' thermal images by many commentators could represent non progressive neoplasia. Environmentally induced tissue abnormality is a risk factor for neoplasia and altered breast physiology sufficient to create thermal changes may accompany this abnormality. The observation that breast thermal abnormalities often resolve with changes in the breast environment from applying breast health measures supports this view. (Personal communication Godfrey M 2012) Given the relationship of the environment as a trigger and a modifier of the breast neoplastic process, it maybe appropriate to consider neoplasia a marker of dysfunction in the breast environment.

There are no validated biomarkers for the presence of early breast neoplasia. This means that persistent abnormalities detected on thermal imaging of the breasts can not be tested to differentiate if they are caused solely by the presence of adverse environmental conditions, such as inflammation or relative oestrogen ex-cess or whether fibrocystic change, dysplasia or neoplasia is present as well. (Spitalier JM 1983) If the anatom-ical imaging is negative and thermal imaging remains positive then it would be valuable to have CTC testing validated as a biomarker for the presence or absence of a breast neoplastic process. CTC numbers can be monitored and may provide an indicator of progress and it would be valuable if a correlation with the thermal imaging results could be validated. Information from CTCs can indicate a greater likelihood of a neoplastic process when the neoplastic process is too small to be detected on anatomical imaging. (Pachmann K 2012) It is also possible to test the CTCs for their sensitivities to therapeutic agents. (Rüdiger, N. et al 2013) This infor-mation can offer guidance in regards to appropriate additional low risk treatments in addition to general breast health measures. These measures such as specific herbal medicines, intravenous vitamin C treatment and hyperthermia.

When DCIS is diagnosed histologically, it would be possible to trial a non- surgical, conservative approach of optimizing the breast health environment and monitoring breast health with thermal imaging. Studies would be useful to validate whether thermal imaging and or CTC testing are valid biomarkers to indicate the presence of neoplastic change in DCIS. If this validation was completed it would add confidence to thermal imag-ing's use in an active watch and wait approach, particularly if thermal abnor- malities can be cross validated with CTC testing.

Once an invasive breast cancer has been diagnosed, whether via screening or palpation, we know that many of the cancers detected will be very slow growing and will not be life threatening. Many of these make up the over-diagnosed group of screen detected cancers. (Jørgensen & Gotzsche 2009) Current policy means that low risk cancers are being treated the same way as high risk cancers. (Retsky M 2010) It maybe possible with CTC testing to obtain an indication of the metastatic potential of diagnosed tumours and of early breast neoplasia. It makes sense to improve the breast health environment for all of breast cancers in addition to any invasive treatments given. However if CTC testing can indicate which tumours have a very low metastatic potential there maybe the possibility of delaying invasive treatment, with the expectation that many of these cancers are self limiting and breast health measures may lead to their limitation or involution. These patients could then be followed with thermal imaging and CTC testing to follow their progress after breast health interven-tions. On the contrary if CTC testing was validated, it maybe possible for early breast neoplasia, demonstrating a high metastatic potential, and not responding to breast health lifestyle changes and low risk interventions maybe treated with more aggressive therapies.

Research is needed to validate thermal imaging and CTC testing as biomarkers providing windows on breast health and to correlate them. There are three clinical scenarios where research would be particularly valuable:

1. With persistently positive thermal imaging with negative anatomical imaging
2. In DCIS to support a breast health approach with a watch and wait policy and
3. With invasive neoplasia and cancers to differentiate those that are self limiting or which may become self limiting if supported by breast health measures from those that need more aggressive therapy.

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SHORT TERM EFFECTS OF LOCAL INFRARED IRRADIATION ON DIABETIC FEET AND LEGS – CASE STUDIES USING THERMOGRAPHY

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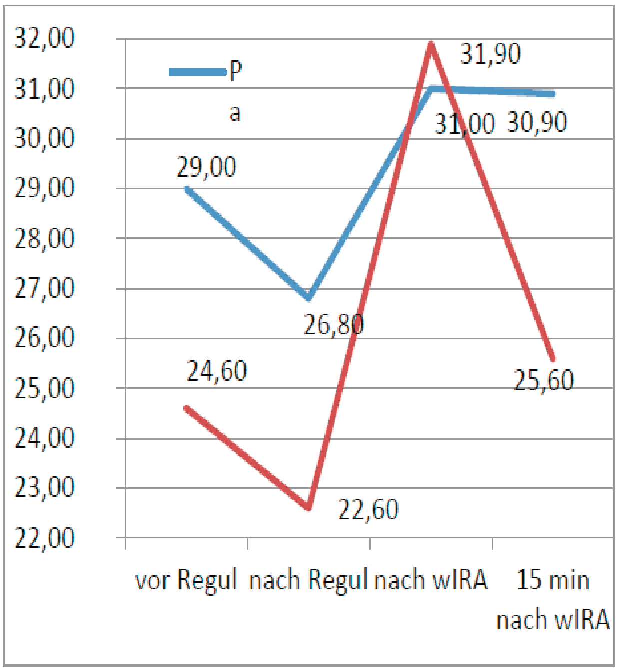
PREFACE: Infrared irradiation, especially when water filtered, has well known and documented positive effects on superficial as well as deeper tissue blood supply. IR(A) radiation has a sufficient penetration into the depth and therefore is suitable to increase blood flow and tissue supply of patients with diabetic feet. Infrared ther-mography can be used for monitoring the direct and immediate effects of IR(A) irradiation and also for follow up to verify positive alterations in patients with diabetic feet.

METHODS: Two elderly patients with diabetic feet syndrome (male 76 yo and female 71 yo) were treated with water filtered IR(A) – wIRA after being 15 minutes exposed to a mild cold challenge. This cold challenge was leading to a decrease of the temperature of feet and toes. Thermography measurement of the distal lower limb before and after cold provocation test (regulation test) was recorded. Then 30 min of wIRA 750 W irradiation of the forefeet and distal lower limb was applied. Immediately after irradiation and 15 min later, a follow up thermography measurement of the same region was recorded.

RESULTS: In the female patient, the coldest spot (toe 1 right foot) was getting remarkably colder following the initial cold stress. After 30 minutes of wIRA application, the region was 2 °C warmer, and 15 minutes later still keeping the same warm temperature. In the male patient, the coldest spot (digit 2 left foot) also was getting 2 °C colder following the initial cold stress. After 30 minutes of wIRA application, the region was 8,5 °C warmer, and 15 minutes later still 1 °C above the initial temperature and 3 °C above the temperature following the initial cold stress. Both patients demonstrated a remarkable heating up during and immediately after wIRA irradiation. There was no stealth effect of wIRA irradiation to be seen. Infrared A (wIRA) irradiation leads to increased blood circulation within the coldest area, and this increase remains for at least 15 minutes at cool ambient temperature.

CONCLUSION: Infrared thermography is very suitable to demonstrate positive short term effects of IR(A) – wIRA irradiation on the blood supply in the feet of older patients with diabetic feet syndrome. Further examinations with more patients and including long term studies are necessary to verify the positive and sustainable effect of a series of IR(A) irradiation.



HIGH RESOLUTION INFRARED THERMOGRAPHIC IMAGING OF BREAST AND BOTTLE FED INFANTS DURING FEEDING- A PILOT STUDY

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BACKGROUND: Many studies show advantages of breast over bottle feeding, containing e.g. immunologic components supporting host defense. Little is known, however, about temperature differences generated by both mother and baby regarding both methods of feeding. Here we demonstrate preliminary data on thermographic temperature measurements taken during breast and bottle feeding.

METHODS: 15 pre- and full term healthy newborns were measured during breast (n=12) or bottle feeding (n=6) with a high resolution thermography camera (FLIR Systems, SC 660). 3 infants were both, breast and bottle fed. Temperature was measured at different spots forming a line (L) or an area (A): L1: thermo-line between infant cheeks, lips and breast/bottle teat; A1: sucking area; A2: infant face; A3: breast; A4: bottle teat; A5: bottle. Differences between groups were assessed using the Wilcoxon-Mann-Whitney U-test for non-normally distributed data.

MEASUREMENTS AND RESULTS:
Gestational age was (Median/Min/Max) 39/30/42 weeks, birth weight 3073/1490/3890g, age: 3/1/30 days.
40% were female, 66% of the bottle fed infants were fed their mothers' milk. The mean infrared temperature of breast and (bottle) fed infants was:
Max temp. L1: 36.6/35.8/37.5°C (35.3/34.7/36.6°C), $p < 0.01$;
Mean temp. L1: 35.2/34.6/36.1°C (32.4/30.6/33.7°C), $p < 0.01$;
Min temp. L1: 34.1/32.6/35.1°C (30.1/25.7/32.4°C), $p < 0.01$;
Mean temp. A1: 36.3/35.6/37.4°C (33.6/31.1/35.2°C), $p < 0.01$;
Mean temp. A2: 35.1/33.6/36.6°C (34.5/34.1/36.5°C), $p = 0.25$;
Mean temp. A3: 35.5/34.7/36.5°C; A4: (30.9/26.3/33.3°C) and A5: (32.6/28.1/35.1°C).

CONCLUSION: Our preliminary data show significantly lower infrared temperatures over the areas of interest during sucking in bottle fed compared to breastfed infants during feeding. Further research is needed to evaluate whether similar differences can be shown for the milk consumed by the infant and, if so, whether infants drinking colder milk have to expend additional energy to warm it up.

CHANGE OF BODY WARMTH DISTRIBUTION IN PATIENTS WITH ANOREXIA NERVOSA AFTE R INPATIENT TREATMENT?

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BACKGROUND. Anorexia nervosa (AN) is one of the most dangerous psychiatric illnesses, which is associated with refusal of a normal body weight, a distorted body perception, self-induced underweight, numerous medical complications and physiological changes. With regard to changes in body warmth distribution many patients with AN centralize blood perfusion and therefor have cold extremities. The interaction between health and body warmth can be traced back in the history of medicine to Hippocrates, but has hardly been investigated in AN so far.

METHODS. As part of an evaluation study we investigated the efficacy of a multimodal inpatient therapy based on the principles of anthroposophic medicine. The body warmth distribution of young patients with AN (n = 21; mean age = 14:58; SD age = 1.80) was measured with a infrared camera (FLIR SC660) at baseline and after six weeks of treatment in addition to other psychophysiological parameters. We expected an increase in general body warmth (body core temperature measured at the inner ocular angle) and of the warmth radiation especially in the extremities.

RESULTS. We gained significant increase in body warmth radiation (pre post analysis) at tip of the nose ($p = .018$ *); palm ($p = .044$ *); instep ($p = .002$ **) and marginal significant results at the inner ocular angle - roughly equivalent to the body core temperature ($p = .054$). In the areas of the entire head, lower arms and legs, respectively, a trend towards a significant increase was found.

CONCLUSIONS. The data provide preliminary evidence that the body warmth distribution changes by treatment of AN with an increase of the core temperature and an increase of warmth radiation in the periphery. As an indicator for a successful therapy thermography might be a useful in addition to conventional psychophysiological measurements.

USE OF CTC ASSAYS AS A DIAGNOSTIC AID - SOME CLINICAL EXPERIENCE

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Circulating tumour cells (CTCs) are malignant cells in the blood stream which have originated from a primary tumour site. They have the potential to differentiate and metastasize, but as they have stem-cell-like properties they can also remain quiescent if the 'microenvironment' supports this. They are increasingly of interest both for aiding the diagnosis of malignancy, and also for monitoring disease progression.

There are different methods for detecting and monitoring CTCs. I have worked with RGCC (Research Genetic Cancer Centre) in Greece since 2005 and have been using their assays for CTCs since 2007. Their method of quantifying and characterising CTCs is Flow Cytometry. The strength of this method is that it uses 'negative selection' (analysing all the cells that are left after removing the known CD45+ve blood cells) as this reduces the likelihood of false negatives. It also allows for further characterisation of the cells by immuno-phenotyping.

There is a consensus view from research to date that in breast cancer cases a CTC count of 5 CTCs/7.5mls of blood or higher correlates with an increased risk of relapse/disease progression. There are similar references for other common malignancies. RGCC also incorporates a number of 'prognostic' markers into the test result in addition to the cell count eg Nanog, SOX2 and OCT4, and C-MET which provide further information about how the cells are behaving and offer information about the risk of progression.

I use CTC assays as part of a screening strategy eg where there is a strong family history of cancer or increased risk of malignancy, and to help differentiate between benign and malignant conditions eg the likelihood of a breast lump being malignant if the patient is refusing a biopsy; and to help differentiate between prostatitis and prostate cancer. I also use them for monitoring, particularly of 'minimal residual disease'. Formal diagnosis requires histology, but clinically I find these assays increasingly useful for the information they add.

I have found CTC screening helpful in a number of cases alongside MammoVision thermal imaging and consider this to be an interesting screening combination, worthy of further research. Of note, I have cases of confirmed DCIS where patients have CTCs (malignant breast cells) in their blood stream and I am wondering if in these patients have (had) an invasive focus of disease that has been missed, or whether malignant cells have been released into the circulation by the biopsy process (and/or surgery). The worrying thing is that these cells persist and have malignant potential and we do not yet know their significance in DCIS cases, where the assumption often is that if the patient undertakes surgery, and radiotherapy if recommended, there is a good chance of 'cure'.

Session 3 Thermography in various medical fields

SPECIAL DEVELOPED AND PATENTED ANATOMY SCREENING AND INTERPRETATION SOFTWARE IN CLINICAL PRACTICE WITH HELP FROM FULLY AUTOMATED ROBOT

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Over the past 15 years Dr. Carol Chandler has developed special thermography anatomy screening software with an anatomical overlay compliment for use in clinical practice. The software was developed purely from her own personal clinical experience as well as the experience of hundreds of users. Increased knowledge of thermal physiology together with correlation of patient symptoms and clinical outcomes has provided vital information for continuing updates to the software application.

The greatest industry challenge over the years has been the need to standardize the imaging technique. For accurate clinical evaluation it is necessary that follow-up screening positions be exactly comparable to the previous screening. That challenge has been addressed with the use of positional overlays to assist the technician.

The software also utilizes unique patented compliment anatomical overlays of the various organs, vertebra, muscles, dents, lymphatic system and meridian references to support technicians, medical interpreters and patient reporting / consultations.

In addition, there is a separate application specifically for interpretation or assessment viewing for the medical professional on a separate computer, with full control of image assessment features.

The automated reporting features save the doctors time and ensures secure data exchanges between medical professionals, clinics and hospitals.

In addition there is also a fully automated robotic computer controlled camera stand available for ultimate privacy imaging. Dr. Chandler also offers educational serves that includes reference manuals, classroom training and online instructional seminars for thermography technicians, interpreters and medical physicians.

NEW STANDARDS FOR FEVER SCREENING WITH THERMAL IMAGING

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In recent years, pandemic influenza virus infections have caused concerns about the ever- increasing mobility of populations, especially in air travel.

Some use of infrared imaging for fever screening has been made since 2006 in international airports, most of which have not used optimal technique. For this reason the International Standards Organisation produced two documents in 2008 and 2009 (ISO TC121/SC3-IEC SC62D) 4,5

The final documents were published as ISO TC 121/SC3-IEC SC62D Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening in 2008. This was followed by a technical report especially written for organisations purchasing and deploying thermal imaging cameras for screening. ISO/TR 13154: 2009 ISO/TR 80600 Medical Electrical Equipment- Deployment, implementation and operational guidelines for identifying febrile human using a screening thermograph.1

These documents, focus on the minimal requirements for a radiometric camera (i.e. capable of measurement) that is required to measure with the optimal certainty the small area at the inner corner of the human eye, with at least 9 pixels.. The second document is a guide to the responsible authority that has to implement the standard for screening. The need for quality assurance, regular calibration checks, training and documentation are all described. One other important issue is the need for clinical studies to evaluate the concept of temperature measurement from the face for fever detection. To investigate the usefulness of the new standard for thermal imaging, we have studied a group of children in a pediatric hospital setting.

402 children at the Pediatric Clinic in Warsaw were checked for fever by three different methods. The nurse using a clinical thermometer under the armpit (axilla for5 minutes). Thermal imaging (22-23°C ambient) using a FLIR infrared camera SC640. with regions around the inner canthi (i.c.) measured for temperature. Both inner ear measurements (tympanic membrane) with a clinical radiometer were recorded .

RESULTS: A total of 402 children were examined between 2006 and 2011. The majority of children attending the hospital were not febrile, they were compared with those known to have a clinically defined fever, and examined prior to medication.. Of this group 350 (85%) were found to be free from fever, and 52 (15%) cases of definite fever were recorded. There were 192 males and 210 females

AFEBRILE	Mean °C	Std deviation	Number
Eyes: inner canthus	36.48	0.49	354
forehead	36.44	0.65	326
axilla	36.3	0.59	347
ear	36.12	0.71	178

Table 1 temperature data - non fever group

FEBRILE	Mean °C	Std deviation	Number
Eyes: inner canthus	38.9	0.84	52
forehead	34.7	0.86	52
axilla	38.9	0.68	52
ear	37.4	1.41	24

Table 2 temperature data - fever group [49% male 51% female]

These data showed the existence of a linear relationship between the measurements between sites in the fever cases. This is highest when comparing the inner canthus eye measurements by thermography and axilla temperature measured by the clinical contact thermometer.

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Ring EFJ, Jung A, et al. New Standards for Fever Screening with Thermal Imaging Systems. J.Mech. Med. Biol. 2013 113(3) 01350045

A NEW WAY OBSTETRIC CARE WITH THE USE OF INFRARED THERMOGRAPHY THE HEAD OF THE FETUS DURING THE FINAL STAGE OF CHILDBIRTH

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In 2012 we have developed a method of express-diagnostics of hypoxic damage of the cerebral cortex of the fetus and obstetrical helping with a thermal imager. The method is based on the following regularity revealed by us: hypoxia and ischemia decreases the intensity of radiant heat in tissues.

METHODS: Thermography conducted in a maternity hospital in the physiological delivery in 35 pregnant women admitted for urgent delivery. The control group included 20 women, with the re-birth, having healthy children, born in time. In addition, the criteria for selection of the control group pregnant women is high stability of their fetuse to intrauterine hypoxia, confirmed in 30 - 32 weeks of pregnancy results of Gauskhneht test (more than 30 seconds). Another group of women studied consisted of 15 pregnant women who have previously had a successful physiological birth with the birth of live fetuses in the project schedule. Additional selection criterion in this group was the low stability of births of their fetus to intrauterine hypoxia, confirmed in 30 - 32 weeks of pregnancy results of Gauskhneht test (less than 10 seconds). Other than that, there was a pregnant woman entwined cord around the neck and chest of the fetus. Infrared thermometry was performed using thermal imager ThermoTracer TH9100XX (NEC, USA) in the temperature range 26 - 36 °C. The temperature of the air in the delivery room is in the range 24 - 26°C.

RESULTS: The results showed that in the final of childbirth and immediately after them in the absence of symptoms of placental insufficiency and there is a high stability of the fetus to hypoxia the temperature in area of the sagittal seam skull never drops below the skin temperature in neighboring areas. It is established that in normal pregnancy and in normal physiological delivery heads of live fetuses in thermovisor portrayed mainly in yellow-orange-red colours. In addition, in normal the scalp of fetuses before birth has a high temperature. But the fetuses, were born in meconium waters, haved a low temperature in scalp and in body of newborn. Moreover, the normal on the surface of the parietal part of the head of the fetus can be detected local hyperthermia area where the temperature may be 0.5 - 4° C above the surrounding surface of the head. This zone has an elongated shape and is located over the sagittal seam of skull.

In the group, consisting of 15 pregnant women with signs of placental insufficiency and with low adaptation of fetuses to hypoxia the dynamics of temperature of the visible surface of the head over the bearing-down stage of labor in 10 fetuses had no fundamental differences from the dynamics of the temperature of the fetuses in the norma. But the other 5 fetuses in second period of physiological childbirth demonstrated short periods of reduced temperature. The duration of these periods ranged from 30 to 120 seconds.

Analysis of the circumstances surrounding the emergence of local hypothermia in zone of sagittal seam showed that the immobility of fetuses in the period between attempts lead to the conservation and the progress of this local hypothermia in the head. On the other hand, active movement of the fetus through the birth canal, caused by an extraordinary vain, attempts women, to increased the temperature after 2 - 3 seconds in all 5 of the fruits of this group.

It is assumed that the lack of oxygen leads to temperature reduction in the process of oxidative metabolism in the mitochondria of the brain, which promotes cooling the scalp fetus during labor in the presence of air at room temperature.

THERMAL IMAGING - A BIOMETRIC APPROACH FOR EVALUATION OF LOCAL SIDE EFFECTS AFTER VACCINATION

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Paul-Ehrlich-Institute, Federal Institute for Vaccines and Biomedicines

BACKGROUND: Vaccines are a heterogeneous class of medicinal products containing antigenic substances capable of inducing specific immunity against infective agents or toxins, or against other antigenic substances. In contrast to other biological and chemical medicinal products used for the treatment of diseases are vaccines a preventive measure usually given to large cohorts of healthy subjects. Thus, a high standard of safety is expected. However, data about the safety profile must rely on clinical studies and are mostly based on subjective reports by the probands. Infrared imaging is here proposed as a supplementary approach to quantify the local reactivity after a vaccination in a manner that is not influenced by subjective reporting.

OBJECTIVES: Development of an experimental protocol, that is appropriate to describe the local thermal response at the injection site. This has to consider an optimum timeframe, the variability of the local thermal emission, questions regarding the thermal left-right symmetry and biometric aspects. Finally the reactivity of a vaccine should be described by a biometric approved parameter, derived from the increased local thermal response at the injection site.

RESULTS: The concept of Infrared-thermography was proved by more than 160 participants of the yearly influenza vaccination campaign in 2012/13 and 2013/2014. Nearly 40% of all subjects showed a pronounced thermal reaction. Apart from this, 25-30 % displayed no signs of any thermal response. Foregoing, frequent vaccination and the age led to a certain higher thermal response. Subjective pain reporting after influence vaccination was weak by the majority of participants.

CONCLUSION: Imaging by thermography shows an increased local blood flow at the injection site and allows a clear quantitative description. This clear signs of inflammatory response can be interpreted as a marker for the reactivity of the vaccine. Even if clear figures are available to describe the thermal response, the general low reactivity of influenza vaccines, and the not well specified "pain signals makes it difficult to evaluate, how far thermal imaging may finally contribute in a general assessment of the reactivity. Apparently, investigations in more reactive vaccines should follow.

ACKNOWLEDGEMENT The authors would like to thank the participants of the study for their time and effort in contributing in the study. The thermal survey was arranged in cooperation with Sabine Wicker, University Hospital Frankfurt, Goethe University, Occupational Health Service.

Session 5 Thermography in breast health and breast diseases

MAMMOVISION - AN INTEGRATIVE BREAST CANCER PREVENTION AND DIAGNOSTIC METHOD

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For the diagnosis and therapy of breast cancer there are international standards. For the standardized therapy there are corresponding manuals of the big breast tumor centers, e. g. in Germany the breast cancer diagnosis manual of the Tumorzentrum Munich.

All experts agree in the fact, that the breast cancer early detection should be improved. The breast cancer incidence is increasing, especially in countries where the breast cancer rates were much lower before. Today we know, that - when detected - breast cancer has been grown for more than ten years and very often there are already micro metastases.

In the year 2005 we started with the breast infrared radiography MammoVision. This is a new standardized complementary method. Changes in the female breast tissue can show characteristic changes in the infrared spectrum. MammoVision means a standardized measurement of the infrared spectrum of the female breast in two steps: Before and after cooling down at room temperature. If MammoVision shows irregular results we always can control and compare the result with the results of other technical methods, especially of our Ultrasound CT (Multi Slide Imaging) and of our mammography.

MammoVision is no replacement method but a very interesting complementary method. A lot of further studies will be necessary to assess more extensively the benefits and limits of this method.

THERMAL IMAGING TO ASSESS BREAST HEALTH IN WOMEN UNDER AGE 35 - AN ONGOING PILOT STUDY FROM 2012

Mike Godfrey

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PURPOSE: To determine whether there was thermographic evidence of impaired breast health in young women many years before breast screening becomes routinely available.

COHORT involved: To date, 138 women aged from 17 to 34 have had breast thermograms.

FINDINGS: Only 57/138 had normal breasts defined as BIRAS 1 or 2. A further 48 were equivocal i.e. BIRAS 3 with 30 having BIRAS 4 and 3 with BIRAS 5. Therefore, a significant percentage of young women have asymptomatic thermal and/or vascular abnormalities in one or both breasts. Some observational evidence indicates that this can be associated with oral contraception.

CONCLUSION: Breast thermal imaging is a clinically worthwhile investigation in younger women and further large-scale investigations appear warranted.

THE STANDARDIZED RECORDING AND EVALUATION PROCEDURE OF MAMMOVISION

Reinhold Berz, Julian Pablo Berz

PREFACE: In history and still recently, there was and is a variety of procedures applying thermal measurement of the female (and male) breast. This lack of standardization was leading to a project, funded by the German government over four years (2001 to 2005), aiming at a protocol for preparing, conducting, and evaluating thermal breast measurement. The name of this protocol and standardization is MammoVision, and this method is applied in many places in several countries around the globe. Thousands of patients and tens of thousands of examinations have been conducted meanwhile.

AIM OF MAMMOVISION: In order to compare examinations (intra-individual, inter-individual, follow up etc.), all measurement has to be conducted under the same protocol. The patient's preparation is as important as the ambient conditions (20 °C ambient temperature +/- 2 °C, adaption of the patient, no drugs or tight cloths/bras). Trained staff conducts the examination following always the same routine, given by audio-visual signals of the computer (program EXAM). A multi patented recording process ensures optimized and repeatable distance and angles between IR camera and each breast. Medically tested and CE certified IR cameras are used only (predominantly German produced Jenoptik - formerly Carl Zeiss Jena - devices). A special cold challenge is also applied, with measurement before (comfort temperature) and after ("regulation temperature") the challenge. After measurement, the software EXAM (as a part of MammoVision) is used to arrange the pictures, to select the perfect contrast, to apply the patented grid architecture over each breast, and to evaluate the temperatures inside the grid and its sub areas (sectors). Following the accumulated knowledge of best practice studies and results over decades, a semi automated evaluation (including the trained doctor's evaluation of the vascular patterns) leads to a BIRAS rating, comparable to the BI-RADS of radiologists. BIRAS is used as a risk indicator or, even better, as an indicator for the health status of the female breast.

PRACTICAL DEMONSTRATION: The examination and evaluation procedures are presented; typical examinations and ratings are demonstrated.

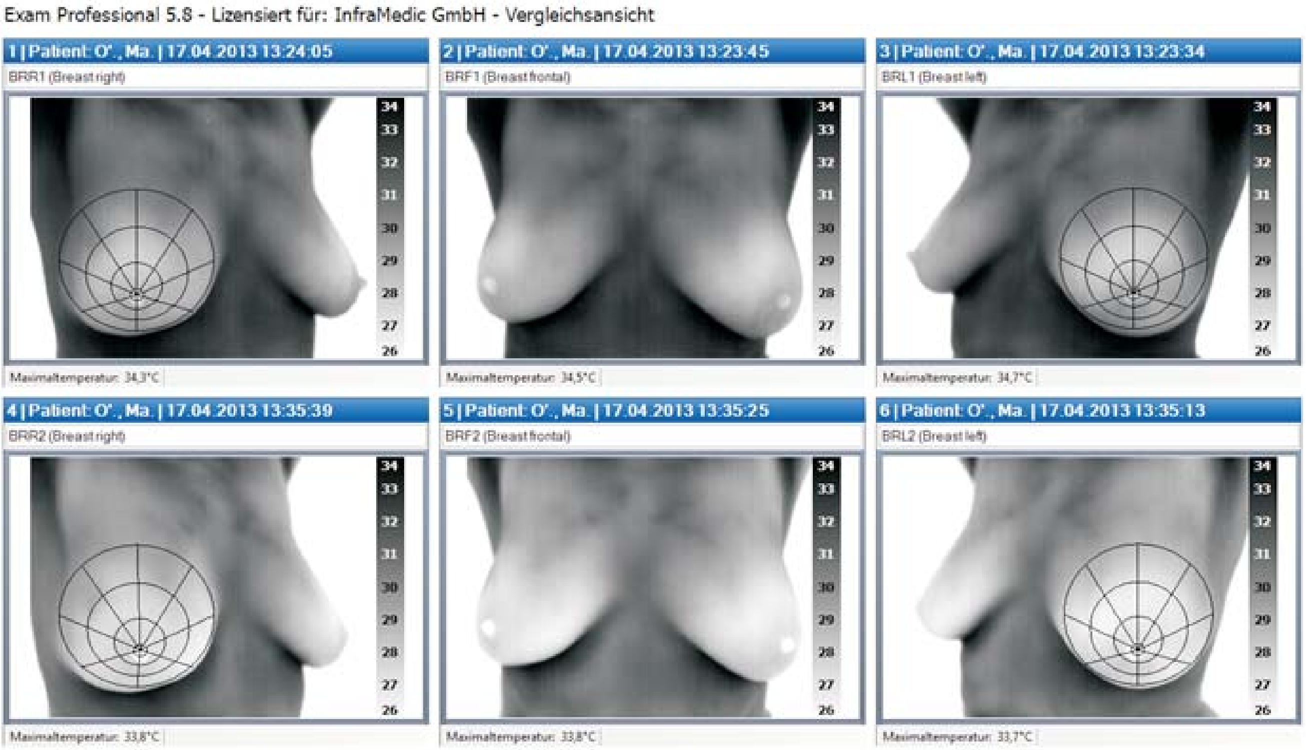

Figure 1:
MammoVision of healthy breasts without vascular pattern (no increased breast metabolism)

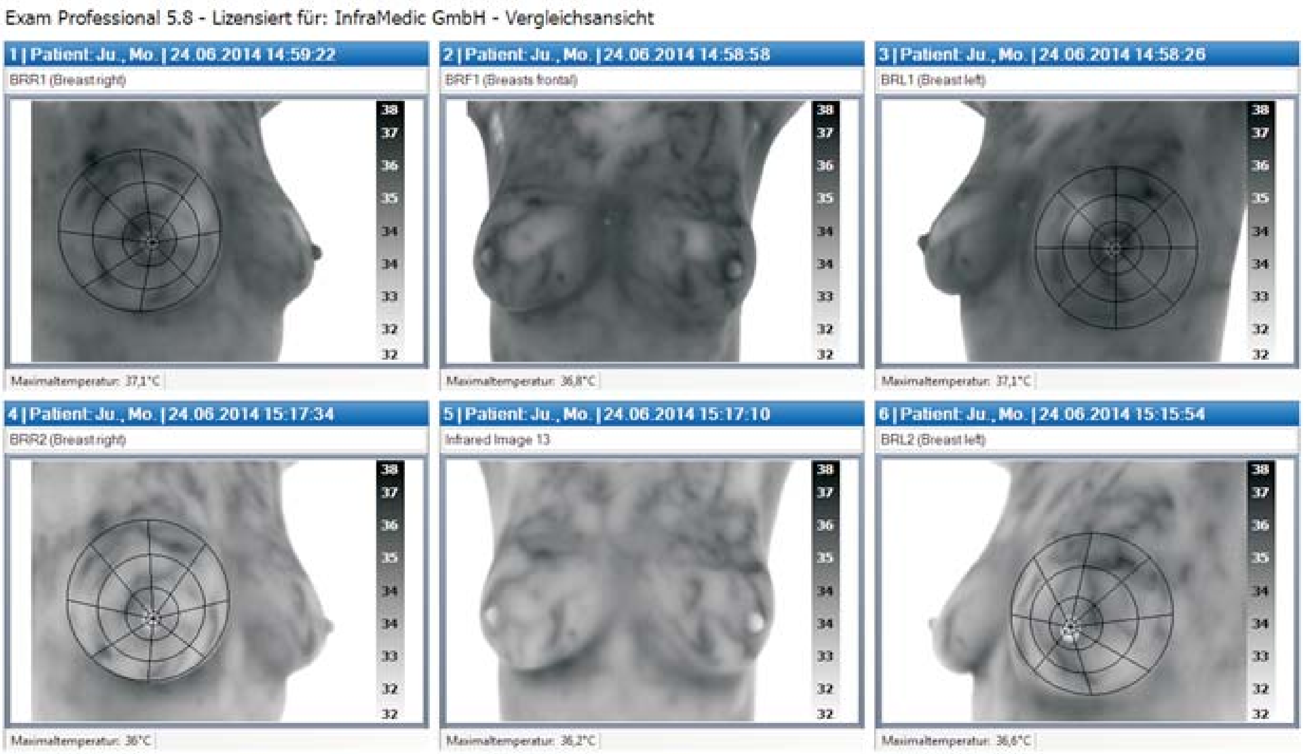

Figure 2:
MammoVision of healthy breasts with intensive vascular pattern (increased breast metabolism)

EFFECT OF DIET AND LIFESTYLE ON IMPROVING BREAST HEALTH - VERIFICATION BY THERMOGRAPHY

Philip Getson

Thermographic Diagnostic Imaging, Marlton; NJ; USA

The role of providing objective data in the form of thermographic imaging will illustrate how effective various diet and lifestyle modifications are in improving breast health will be offered in the form of pre- and post imaging of women who have undertaken these steps toward healthy living.

AN OVERVIEW OF THERMOGRAPHIC LEGAL CASES THROUGHOUT THE WORLD AND RECENT ANTI-MAMMOGRAPHY ARTICLES

Philip Getson

Thermographic Diagnostic Imaging, Marlton; NJ; USA

Unfortunately there continues to be a link in the public eye between thermography and mammography

As thermography continues to grow in popularity worldwide and as more and more negative press regarding mammography comes forth in the world press, there is an even greater emphasis on information regarding the legal climate in which we find ourselves.

It is my intent to present the most recent data on legal issues regarding thermography worldwide as well as to provide an update on recent mammographic-related medical literature.

IODINE AND THE BREAST

Mike Godfrey

BOP Environmental Health, Greerton,Tauranga, New Zealand

Iodine levels have markedly decreased over the past decades with most populations now being significantly deficient due not only to a lack of iodine but also due to competitively impaired uptake by chlorides, fluoride and bromides the other more reactive halogens.

Whilst iodine is recognised for thyroid metabolism, little medical awareness exists in its role in breast health. However, Iodine has been well documented as an effective treatment for fibrocystic breasts.

This presentation describes underlying factors for deficiency and iodine's essential role in breast health.

THE USE OF INFRARED THERMOGRAPHY IN THE ARCADIA CLINIC FOR INTEGRATIVE MEDICINE AND CANCER TREATMENT

Christian Büttner

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In the Arcadia clinic in Bad Emstal, Germany, we work with methods of an Integrative Medicine. Our main focus is on health and not on diseases. We have integrated many additional and very helpful diagnostic tools into our work, such as Dark Field Microscopy, Heart Rate Variability (HRV), Bio Impedance Analysis (BIA), Infrared Thermography and many others.

Before looking more closely at the special use of Infrared Thermography, we need to look at the reason why we make diagnoses at all. There are three main reasons. The first is scientific interest; the second is to have a solid basis for every possible therapy; and the third is to help the patients live a better and more joyful life. Especially the last point, which is the most important one for the patient, has to be reintegrated into our work!

It is most important for every therapist, to learn how to make a good diagnosis and how to bring it to the patient in order to help the patient live a better life.

Since October 2010 we mainly use Thermography for our cancer patients. During that time Thermography has become a very helpful tool to make a diagnosis, to control the results of a treatment and to check the situation of the patient in the process of healing. Since this year, after the move to our new clinic, we have more and more patients that also come to us to use Thermography as an alternative to Mammography, that has turned out not to be the perfect tool for screening of breast health.

I will discuss the results from Thermography pictures of different patients to show how useful this diagnostic tool can be in our daily work and how useful it is to help the patients live a better life with more responsibility for their own health.

THE ROLE OF REGULATION CAPACITY IN THE DEVELOPMENT AND TREATMENT OF NEOPLASTIC CONDITIONS

Daniel Beilin,

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Tumor disorders are most often the result of a trigger-factor in the presence of a disturbed terrain. Often this is wors-ened by aberrations of drainage organs over time or dental and other focal infections, creating tissue loading of triggering factors that may be benign or become pathogenic. Medicine continues to neglect the whole-body electrochemical and neurological dys- regulation factors that can be reflected in functional tests such as Darkfield Microscopy and Regulation Thermometry. If we can visualize, identify and remove blocks to the functional Regulation System, the tissue matrix will have a new opportunity for functional enhancement. With the introduction of historically verified algorithms, the new expert software called "AlfaVue" has been integrated into Regulation Thermometry, enhancing our understanding of the cancer terrain. This lecture reviews several cases whereby systemic factors and dynamics of tumor disease were identified, enabling the physician to include these key systems in their therapeutic approach instead of merely focusing on the localized event. The functional image-synthesis will be shown as a method for visualizing the regulation system, and then compared to infrared camera thermography and other imaging methods.

THERMOGRAPHY AND BREAST CANCER

Mike Godfrey

BOP Environmental Health, Greerton,Tauranga, New Zealand

A number of cases are presented showing the varied role thermal imaging can play in both earlier detection and when other standard investigations are inadequate. A case is presented where thermal imaging contributed to monitoring ongoing interventions. A case is also presented where notwithstanding a normal thermogram; bilateral mastectomy was performed following diffuse micro-calcifications being identified on mammography.

IDENTIFYING BREAST HEALTH RISKS AND MONITORING EARLY INTERVENTION AND TREATMENT USING MAMMOVISION

Gerson A. S. Machado [1,2]

[1] InfraMedic Mörfelden-Walldorf, Germany;

[2] Machado Business Development, Belo Horizonte, Brazil

BACKGROUND AND OBJECTIVES: Countries with 70% of breast cancer related deaths have < 10% of screening. In this work we evaluate the feasibility of a universally-deployable method based on detoxification, nutrition and parallel multi-modality interventions including infrared thermography with MammoVision (TM) by InfraMedic (TM) and hyperthermia, for the fast identification and reversal of breast health risk factors.

METHODS: A group of 15 volunteers ranging in age from 31 to 82 participated in a 2-day intensive detox and nutrition programme including custom smoothies, supplements, lymphatic drainage, IR sauna, localised hyperthermia and breast massage to identify and reverse BIRAS risk levels monitored with MammoVision.

RESULTS: In all subjects breast regulation imaging improved visibly in one day (maintaining improvement for over a year so far, if lifestyle improves). In about 70% of cases BIRAS ratings reduced substantially including cases of BIRAS 4 to BIRAS 1 in one day. Cases where BIRAS did not reduce rapidly were associated with high aureolar heat, known viral infection and emotional factors, some of which improved over time by repeating the programme. Simply by becoming more breast aware and empowered, women can take control of their breast health and take proactive action to preempt breast disease.

Session 6 Hyperthermia

ONCOTHERMIA A NEW FORM OF HYPERTHERMIA

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BACKGROUND - OBJECTIVE: Heat is applied in medical practice from the dawn of the medicine. The technical difficulties to deliver heat deeply into the body blocked its wide application. New hope and intensive research was when the electromagnetic energy delivery became a real option. D'Arsenoval was pioneering the energy-delivery by electric current in the late 19 century, and the radiative applications became popular when the microwaves were discovered in the middle of the 20 century. Oncothermia synergizes the two approaches unifying the electrical field and the very locally applied temperature, [1]. Our objective is to present the basic developments and results of this kind of hyperthermia in oncology.

METHODS: Hyperthermia needs to overheat the malignant cells, and makes lethal damage by this action. However, the local or regional deep-heating is a complex task in human body due to the technical and physiological difficulties. Tech-nically the overheating of the surfaces and the focusing in depth causes the major problems, while in the physiology the homeostatic feedback, i.e. the intensive blood-flow reaction which tries to cool down the heated volume. This latest makes a competition between the thermal damage and the support of the malignancy by blood-supply. Oncothermia heats up selectively the cellular membrane of malignant cells on high temperature avoiding the physiological feedback control being effective. This effect is made by special properties of the applied electric field (RF-current) and its impedance matching [2], [3]. The cell-damage by high temperature is completed with the action of electric field which is anyway considered seriously in the literature for a long time [4], and is intensively applied in the clinical practice [5], [6]. Actions of the modulated electric field are applied for various accepted clinical trials [7], [8].

RESULTS: Oncothermia has multiple levels of proofs, the method was developed from basic laboratory to the clinical practice [9], including molecular biology research in-vitro and in-vivo [10], [11], preclinical applications in veterinarian [12], and human [13] therapies. It is a widely applied, popular therapy in onco-lo gical hyperthermia [14], and it has multiple clinical studies too. Presently oncothermia has 62 clinical trials altogether involving more than 3700 patients from five countries (Germany, Hungary, Italy, S. Korea, and China). These trials cover 19 lesions: Bone (metastatic); Breast; Colorectal; Gliomas; Head & neck; Brain (metastatic), Kidney; Liver (metastatic); Lung (NSCLC); Lung (SCLC), Pancreas; Cervix; Ovary; Prostate; Soft-tissue sarcoma; Stomach; Urinary-bladder; and Uterus. Average number of patients in the studies is 53, by lesions 116. Maximal patient number in a study (Phase III) was 311 (NSCLC). The average oncothermia enhancement ratio (ratio of the median survival of responders to non-responders) was 5.1. The comparison with the large databases was made in multiple clinics relations, showing extremely large (minimum 20%) enhancement of the 1st year survival percentages. Presently four randomized clinical studies are in progress in various university hospitals (advanced breast, ovary, cervix and liver) and multiple preclinical studies are also proceeded in various university research centers.

CONCLUSIONS: Oncothermia is a new hyperthermia therapy using all the standard advantages of the conventional heating and plus uses the electric field improving the classical effects. It has good clinical achievements in the clinical studies, making stable basis of the clinical applications in various advanced primary and metastatic malignancies.

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SURVEY AND CONTROLLING OF INFRARED IRRADIATION LOCAL HYPERTHERMIA BY THERMOGRAPHIC SYSTEM HEATCONTROL

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PURPOSE: Local hyperthermia can be applied by electromagnetic fields of lower frequency and longer wavelength, or by infrared (IR) irradiation. IR irradiation is used to heat tumour tissue, often in preparation of irradiation with ionizing radiation. The penetration depth of IR irradiation can be increased by applying a water filter (infrared A, IRA). Nevertheless, IR and also IRA irradiation causes heat deposit primarily in the skin. Therefore, local hyperthermia bears a risk of skin burns, especially when there are scars within the irradiated zone. To avoid skin burns, combined with a maximum of heat deposit in the deeper tissue, was the objective to develop the system HeatControl.

METHODS: HeatControl is a computer program that controls the intensity of an IR irradiation source by either switching the device "ON" or "Off", or by increasing or decreasing the electric power intensity that powers the IR bulb of the irradiation device. This is the "efferent" arm of HeatControl. The other arm ("afferent") is provided by signals of a thermal medical infrared imaging device (medically approved IR camera). This IR camera covers the area where the local IR hyperthermia is applied. All temperatures in this particular area are carefully monitored and compared to an upper and a lower threshold modified by the medical operator. The upper threshold represents the temperatures that can lead to skin burn, while the lower threshold provides the maximum of possible heat energy load in the tissue (figure 1 and 2)

RESULTS: More than 30 patients have been treated applying the system HeatControl, which managed the intensity of hyperthermia heat deposit in cancerous tissue. Based on this local hyperthermia heat load, the malignant cell seemed to be much more vulnerable when later exposed to subtle and mild ionizing irradiation. The efficiency of the IR hyperthermia treatment could be remarkably enhanced. No skin burns have occurred during all therapy applications. The latest development stage of HeatControl enables more than one IR local hyperthermia device to be actively controlled, covering different areas of surveillance and irradiation, e.g. both breasts of a woman simultaneously. The system HeatControl is easy to use for the medical operator.

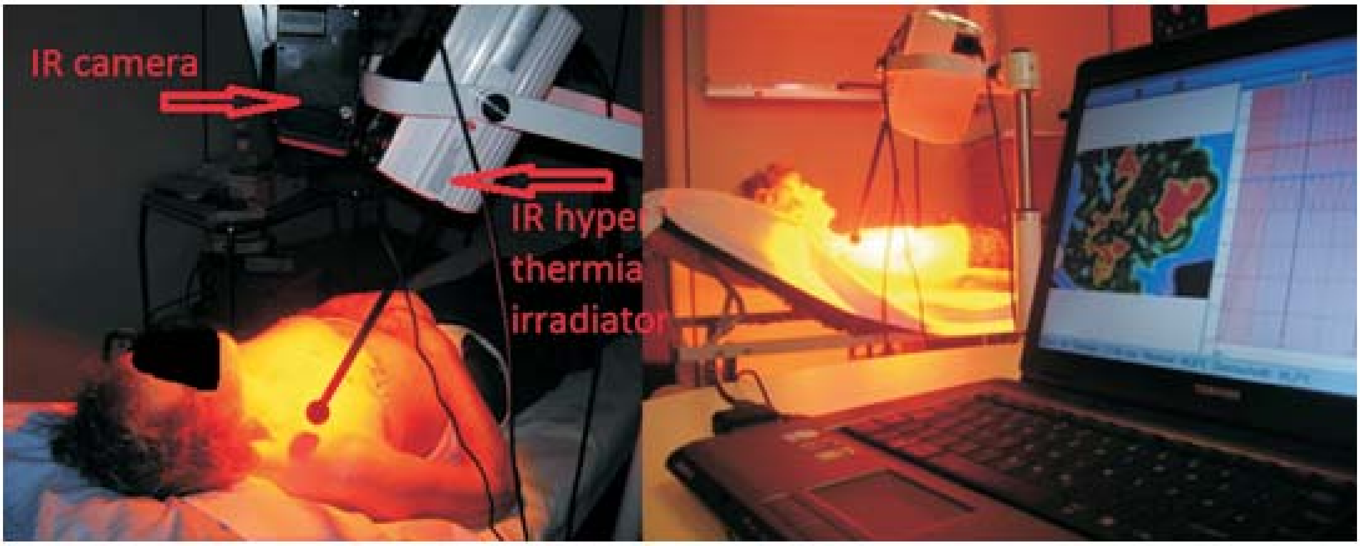

Figure 1:
fixed IR camera and IR hyperthermia irradiator (left), screen with IR image and intensity graph with thresholds (right)

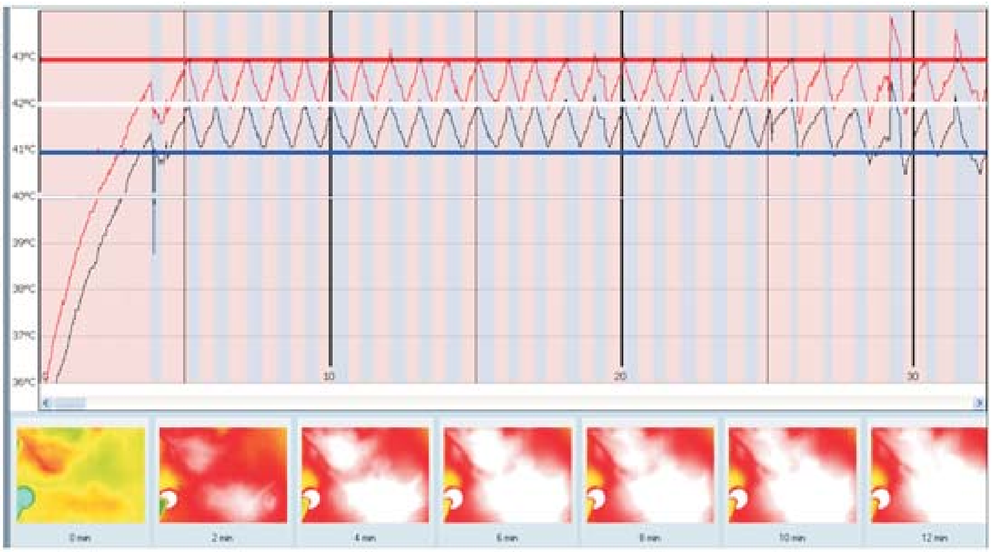

Figure 2:
complete HeatControl screen with IR image and intensity graph with thresholds (upper threshold = red, lower threshold = blue), maximum temperature = oscillating red, minimum temperature = oscillating blue)

Session 7 Thermography applied to vascular and musculoskeletal diseases

APPLICATION OF THERMOGRAPHY IN THE DIAGNOSIS AND TREATMENT MONITORING OF THE COMPLEX REGIONAL PAIN SYNDROME TYPE I (CRPS I)

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Military Institute of Medicine, Warsaw, Poland.

Algodystrophic syndrome entity (type I) has not fully known pathogenesis and course. It is characterized by severe pain of the distal part of limb, oedema, vasomotor dysfunction and impaired efficiency. These symptoms occur after trauma, thoracic surgeries, myocardial infarction, stroke, peripheral nerve damage, less common in the course of venous or arterial thrombosis. Pathomechanism of the disease is unclear, but the most important factor of its pathogenesis seems to be a disorder of the autonomic nervous system. Limb pain and swelling, in the typical cases, are accompanied by vasomotor disturbances, restricted mobility, increased sensitivity to pressure and temperature changes. The course of the disease can be divided into three periods: I- acute period, II- dystrophic period, III- atrophic period. Apart from the vasomotor form, we can distinguish paralytic form (after a stroke) and toxic (drug-induced). The majority of patients has emotional lability, hyperreactivity and a tendency to anxiety and depression. Imaging studies are useful in the diagnosis. The effectiveness of treatment depends on the period in which the diagnosis is made. The sooner patients are treated, the outcomes are better. Analgesics and sympatholytics are used in this therapy. Good effects of decongestants, anti-inflammatory medications and stimulating bone calcification treatment are obtained after the application of an alternating magnetic field of low frequency, low-energy laser, whirpool limbs massage, affected limb exercise. We present a case of 42-year-old man with algodystrophic syndrome, in which the diagnosis was made in the advanced second of the disease. Pharmacological treatment and physiotherapy had beenused for 3 months and led to a significant improvement, which is well illustrated by the thermographic examination.

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DIFFERENCES IN SKIN TEMPERATURE RESPONSES DURING THREE DIFFERENT (-135°C) WHOLE BODY CRYOTHERAPY EXPOSURE DURATIONS IN ELITE RUGBY LEAGUE PLAYERS

J. Selfe, J. Alexander, J. Costello, K. May, N. Garratt, S. Atkins, S. Dillon, H. Hurst, M. Davison, D. Przybyla, A. Coley, M. Bitcon, G. Littler, J. Richards

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BACKGROUND: Growing ever popular within elite sports, Whole Body Cryotherapy (WBC) is the therapeutic application of extreme cold air for a short duration. Minimal evidence is available for determining the physiological effects of WBC, including observation of skin surface and core temperature changes, in particular across specific pre-determined regions of interest. This study aimed to investigate the effects of three different (-135°C) whole body cryotherapy exposure durations on skin surface and core body temperatures in a group of elite rugby league players.

METHODS AND RESULTS: 14 male professional first team super league rugby players were exposed to 1, 2 and 3 minutes of WBC at -135°C. Each WBC exposure was separated by seven days, and followed a competitive league fixture. Via ingestion of a core temperature pill, core body temperature was recorded pre, immediately post and 20 minutes post WBC. Non-contact, digital infrared thermal imaging measured skin surface temperature (Tsk). Tsk was measured pre, immediately post and every five minutes post WBC exposure, up to 20 minutes. Regions of interest were defined by attaching wooden markers to specific anatomical landmarks. Four regions of interest were defined; anterior triangle of the neck (A), torso (B), lower abdomen (C) and the back (D).

Significant reductions (p=<0.05) in mean Tsk were noted after each exposure duration. Average Tsk over time demonstrated significant differences (p=<0.05) between pre and immediately

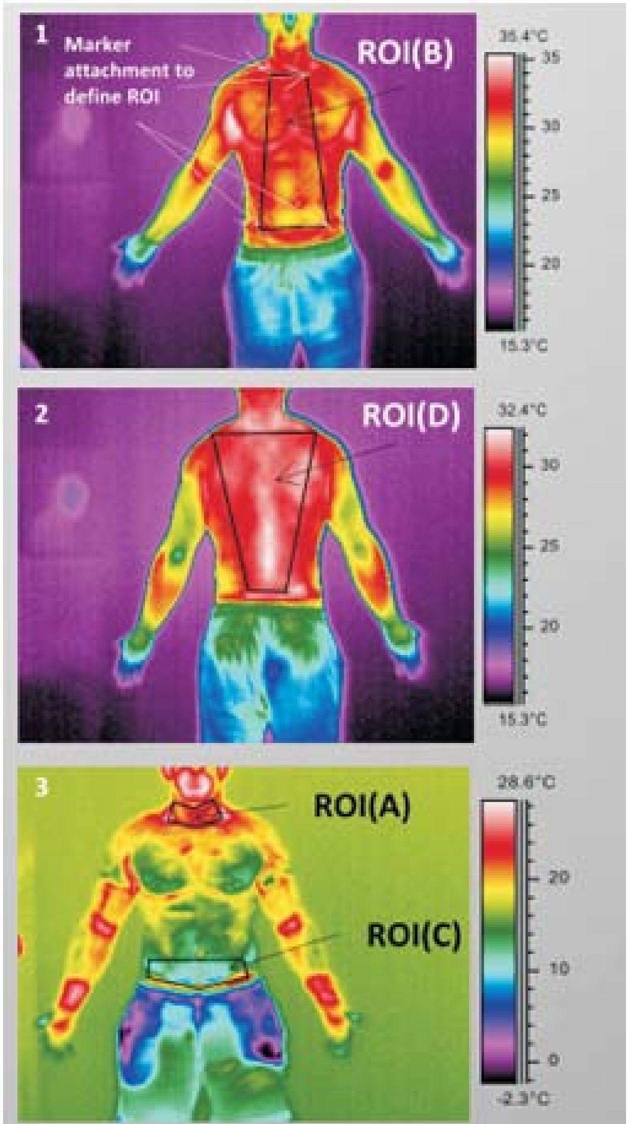

Figure 1. Pre WBC exposure (anterior), 2. Pre WBC exposure (posterior), 3. Post WBC exposure (anterior).

post exposure time points, for each exposure. When comparing regions of interest significant differences (p=<0.05) were found in mean Tsk. When comparing average Tsk of lower abdomen with A, B and D, significant differences (p=<0.05) were determined. No significant differences were noted between B and D. No Significant differences were noted in core temperature.

DISCUSSION AND CONCLUSION: In all four regions of interest, Tsk was reduced following all exposure durations of WBC. The effectiveness of WBC in reducing Tsk has been demonstrated in previous studies; in the current study the lowest Tsk recorded was 12.1°C, in the lower abdomen following a 3 minute exposure of WBC. This demonstrates the ability of WBC to achieve skin cooling within a desired therapeutic range, which is a key claim of WBC, as part of a recovery method within elite sport. The pattern of change and differences in average Tsk across C against A, B and D was interesting. In particular vascular shunting to protect vital organs in areas A and B could be a suggestion as to why Tsk differed following WBC exposures. Core temperature did not significantly fluctuate following exposures of WBC. However, a small rise was observed in all exposures, illustrating a relationship with the drop in Tsk, and the body's ability to maintain the function of vital organs. A phase of rewarming occurred following WBC exposures with post mean Tsk at 20 minutes not reaching pre exposure mean Tsk. Although lower limb Tsk was not measured in this study, these findings may have implications for clinicians deciding when it is safe to return an athlete to functional tasks following WBC, to reduce the risk of potential injury.

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THE PREDICTIVE VALUE OF THERMOGRAPHY IN CRPS

Philip Getson

Thermographic Diagnostic Imaging, Marlton; NJ; USA

Thermography offers the best and perhaps the only diagnostic tool for the confirmation of the clinical diagnosis of CRPS.

All patients that we have studied have undergone a full body thermal analysis even if there are only symptoms in one limb. I have found significant sympathetic dysfunction 6-12 months before the onset of clinical symptoms in other body regions. The implications of such findings and their potential clinical ramifications will be discussed.

USE OF DYNAMIC THERMOGRAPHY IN DIAGNOSING FROSTBITE AND NON-FREEZING COLD INJURIES IN THE NORWEGIAN ARMED FORCES

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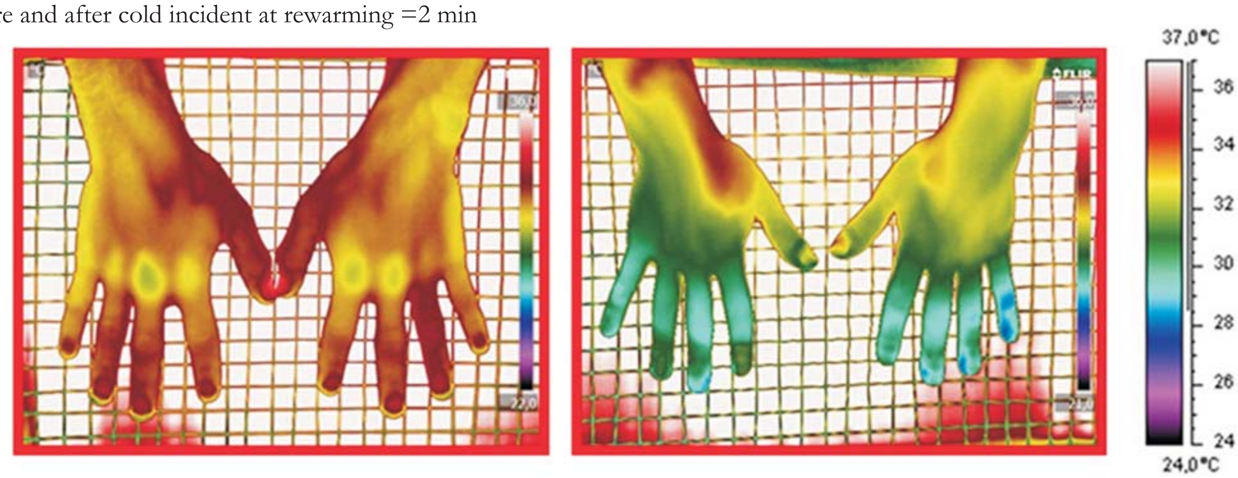
The Norwegian armed forces experience annually a substantial number of frostbite and non-freezing cold injuries (NFCI) during winter training. An additional challenge is that the military personnel fail to report cold- and frost-damage during training, due to a fear that reporting such incidents may have a negative effect on their military career. Thermography might contribute to diagnose changes in micro-vascularization, although validity and reliability in using thermography for large-scale studies remains uncertain. The main objective of the project is to investigate whether standardized thermography can identify subjects prone to frostbite and NCFI before their military service and thereby prevent frostbite and NFCI during winter training. The main study will involve 3-400 Norwegian soldiers during the next 3 years. A pilot study has tested the methodology and study design. In order to obtain valid data it is important that the thermographic imaging take place under standardized and stable study conditions. Following the recording of control images, the hands were subjected to a standard cooling procedure involving immersion in 20°C water for 1 minute. This was followed by a spontaneous rewarming period during which thermal images were continually recorded (figure 1). The majority of soldiers had normal rewarming profiles. However, ca. 10% of the soldiers had recovery profiles that indicated a disturbance of microcirculation in their fingers, of which they were unaware of. Thermographic surveys at the start of the military service that show pathological heating patterns might indicate an increased risk of cold and frost damage during winter training. Based on these preliminary results we suggest that thermography may be a potentially reliable method for identifying individuals with high risk for cold and frost damage.

Figure 1
Before and after cold incident at rewarming =2 min



CONSENSUS REGARDING INTERPRETATION IN THERMOGRAPHY OF HANDS?

Norheim AJ[1], Mercer J[2].

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[2]Medical Imaging Research Group, Faculty of Health Sciences, University of Tromsø, The Arctic University of Norway, Tromsø Norway

During the next 3-4 years, a study among 3-400 Norwegian conscripts will take place in an attempt to monitor frostbites and non-freezing cold injuries in hands/fingers among the Norwegian soldiers. The challenge is a questionable validity and reliability in the interpretation of the Thermographic images, as there, to date, not are published any well-defined standard for this procedure. This project is an attempt, trying to reach consensus regarding interpretation of normal thermal images obtained by DIRT. A panel of 10 experts in Thermography will be included in an e-mail Delphi process. The scientific Delphi technique is 'a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. The format is working at a distance, with all communication by email through a moderator. There are separate stages, shortlisting and judging, each consisting of an initial round that elicits panelists' comments on the entries, followed by one, two or three rounds in which panelists nominate their preferred entries. The number of rounds depends on how quickly a consensus emerges. The experts will interpret and comment a set of thermal image-series from rewarming patterns in presumptive healthy persons. Likewise, the experts will interpret a set of thermal image-series from rewarming patterns in patients with frostbites. The anonymous individual response are summarized, in terms of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are also encouraged to revise their earlier answers in light of the anonymous replies of other members of their panel. Finally, a pre-defined stop criterion (e.g. number of rounds, achievement of consensus, and stability of results) and the mean or median scores of the final rounds determine the results. The aim of this project is trying to define what is normal rewarming, and when does a thermal image become pathologic. The aim is to reach a common agreement regarding standardized normal rewarming pattern. This process will through the Delphi process, gain scientific knowledge to strengthen the acknowledgement and understanding towards thermography as method and scientific tool. Each participant contributes by E-mail where they interpret a set of thermal image-series. The interpretation by questions/statements is an attempt to objectify the interpretation. This is not a time-consuming work, and the responding procedure should not take more then 10-15 minutes at each Delphi round, presumable 2-3 rounds over a few weeks. The Delphi process will be described in scientific papers. After the data collection, all participating experts are invited to contribute to become co-authors, according to the Vancouver rules of common authorship.

THERMAL RESPONSE AFTER COLD-WATER PROVOCATION OF HANDS OF HEALTHY YOUNG MEN: A TEST-RE-TEST INVESTIGATION

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INTRODUCTION: In healthcare, and predominantly in medical research, noninvasive methods like infrared thermography have been used for decades to study circulation to the skin of the feets, hands, and fingers. Despite this, there is no consensus on procedures for various types of examinations, and the reliability of different methods has not been thoroughly evaluated. The aim of the present study was to determine the repeatability of an infrared thermography method for evaluating the thermal response of hands provoked by cold water.

MATERIALS AND METHODS: In 26 healthy young men, the response of hand/finger-skin temperature to cold water provocation was measured twice on two consecutive days. An infrared thermography camera, connected to a computer, was used and data were processed in real time. The software divided each hand into 18 predefined regions of interest (ROI). The average temperature in each ROI was calculated and stored every 10th second. Baseline hand/finger-skin temperature before cold-water provocation was recorded for two minutes. The bare hands were then immersed in water at 10°C ± 0.5°C for 30 seconds and carefully dried. Thereafter, the rewarming was measured every 10th second during 15 minutes.

RESULTS: The baseline, cooled, and final hand-skin temperature showed a correlation of $r = 0.6\text{-}0.8$ ($P < 0.001$) between the two days. No significant difference in rewarming speed between the two days was found. After a fast initial rewarming (approximately 1.5°C/min), the quick rewarming process ceased, and the baseline temperature was not reached during the 15 minutes of measurement.

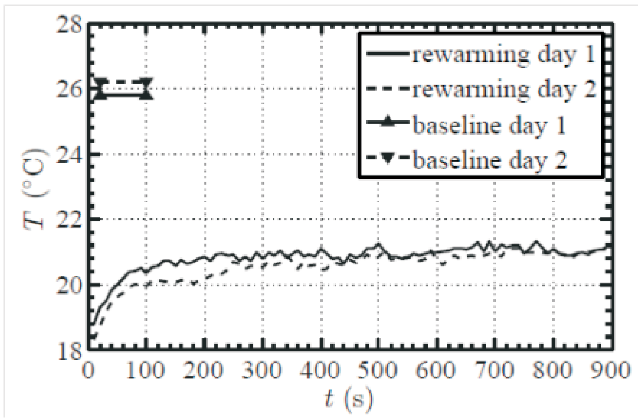

Figure 1.
The rewarming process of hand/finger-skin median temperature measured on 52 hands. The solid lines represent day one, and the dashed lines represent day two. The mean was calculated from all hands' 18 ROI temperatures into a single mean for each hand. The temperature measurement during rewarming was performed from baseline (time -1), cooled (time zero), to end of measurement (900 seconds).

The hand/finger-skin temperatures were found to be slightly lower on day 1 than on day 2.

DISCUSSION: For the group studied, we found a positive significant correlation of the measurements between the two consecutive days. Despite this, there was a difference in temperature between day 1 and day 2 that could be explained by an intra-individual biological variability which may not be controllable. In spite of this we found the method repeatable. The findings that the hands do not reach the baseline temperature during the 15 minute rewarming process may have several explanations (e.g., cooling water too cold, cooling time too long, cold intolerance among the participants). All this needs to be more thoroughly investigated, not least in order to learn how long the rewarming process should be measured in order for the subjects to reach full recovery.

THE EFFECT OF ORAL UPTAKE OF NICOTINE ON SKIN BLOOD PERFUSION OF THE FACE AND HANDS IN SNUS USERS AS DETERMINED BY THERMOGRAPHY

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In recent years the number of people using cigarettes in Norway has significantly declined, with intake of nicotine being replaced by smokeless tobacco (ST) products such as snus placed in the oral cavity. While health risks from smoking cigarettes are well known little is known about health risks of using ST. The main aim of this thesis was to compare the effects of oral use of snus with nicotine (SN+) and snus without nicotine (SN-) on skin perfusion in the hands and face in young habitual users of snus. Skin perfusion was indirectly monitored by measuring changes in by skin temperature using infrared thermography. The main finding in this thermography based study was the demonstration of a strong decrease in skin perfusion through the uptake of nicotine in snus, presumably due to the vasoconstrictive effect of nicotine (Fig.1). While similar responses are known from cigarette smoking, to our knowledge this study is the first to show this for habitual users of snus containing nicotine. A secondary finding is that nicotine uptake in users of snus has no effect on the skin temperature of the inner canthus of the eye, which will be of interest to those using thermography for fever detection in pandemic screening situations. The clear negative physiological effects of using snus containing nicotine demonstrated in this study justify advising patients to avoid using snus containing nicotine prior to surgery and in the immediate period after surgery. In this study the number of participants was small and further studies comparing different age groups and subjects with different habits regarding the amount and frequency of snus usage are needed to shed more light on the physiological effects of using snus and similar smokeless products containing nicotine.

Fig. 1. Infrared thermal images of the hands of a habitual snus user before (left) and 30 minutes after (right) placing 2 pouched packets of snus containing 16 mg of nicotine under the upper lip of the oral cavity.

ANALYSIS OF THERMOGRAPHIC EVALUATION IN PATIENTS ADMITTED IN REHABILITATION CLINIC IN THE LAST 5 YEARS (2009-2014) - A RETROSPECTIVE STUDY

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In the 3 rd clinic of National Institute of Rehabilitation are hospitalized every month about 100 patients.

Of all patients admitted in the clinic about 60% are patients with neurological sequelae (after stroke, spinal cord injury, various neurosurgical interventions) remaining patients have orthopaedic pathologies 20% (prosthetic, post-traumatic sequelae-fractures) and aprox 20% from plastic surgery.

Patients are clinically and functionally assessed on admission, subsequently investigated from laboratory and imaging point of view.

We found that after general clinical examination a large number of patients have disturbances of thermal equilibrium in the periphery (especially patients with associated risk factors-smoking, obesity, and diabetes).

This was seen especially in patients with neurological deficits of central and peripheral type.

In this context, in 2009 the clinic began using thermography as auxiliary method for assessing peripheral circulation on selected categories of patients.

For these evaluations we used Thermacam thermograph, and evaluations were made according to the Glamorgan protocol.

The most common types of pathology analyzed were;

-hemiplegia / hemiparesis

-tetraparesis

- neurological peripheral deficit of the upper limbs, mainly, and of the lower limb.

-polineuropathy(diabetic, exposure to toxic substances).

In our clinic there is a special interest for the treatment of patients with

In the period January 2009- July 2014 we performed a total number of 1464 thermographic evaluations for different types of pathology.

From the cases evaluated in the clinic at this time, I will turn to the case of a young patient with a complex injury to the leg (by accident on the sport field)-

Thermography was performed daily, before and after treatment, recording potential differences in thermal skin reaction in the context of rehabilitation and readaptation to the effort.

Dynamic of thermal reactivity was recorded graphic and statistical analyzed.

Thermographic evaluation can be a very useful diagnostic imaging method that can be performed quickly, is noninva-sive and can contribute to evaluation of temperature control of patients undergoing rehabilitation program.

Session 8 Thermography in various medical fields II

SKIN CANCERIZATION FIELD AND VIDEO-T HERMOGRAPHY - A NEW EVALUATION METHOD?

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There is evidence that patients with chronic exposure to UV usually develop skin precancerous or cancerous lesions in photo-exposure areas.
This observation, lead to concept of "Skin Cancerization Field": this hypothesis suggests how a tumour area can have an increased probability to become the site of another cancer.

We have yet demonstrated how high resolution Video- Thermography applied in particular area as aged hairless scalp, can improve differential diagnosis between basal cell carcinoma and actinic keratosis, revealing some peculiar patterns about different type of skin cancers; in particular:

-Hot spots with quick thermal recovery time on Actinic keratosis

-Cold spots on site of Basal Cell Carcinomas (BCC)

In this work, we would discuss about the presence of higher thermal gradient area, in which we found the largest number of actinic keratoses (AK), while BCC not responded to this peculiar criteria.

We sustain that - if this preliminary data are confirmed - Video Thermogrphy, could represent a "non invasive in real time method", that may be observe a target "dangerous" area, that could be treated before the arising of "skin cancerous lesions".

INFRARED THERMOGRAPHY SKIN AT THE INJECTION SITE AS A WAY OF TIMELY DETECTION INJECTION DISEASE

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In 2013 we opened injection disease and described its etiology, pathogenesis, clinical course options, outcomes, prevention and treatment [1,2]. It is established that today there is no specific solutions of drugs for injection, produced exclusively for safe injections introduction into the inside each individual tissues of a human body. Therefore, in the veins, muscles, skin, subcutaneous fat, and other tissues of the patient administered drugs, formulated for injection inside unknown what kind of fabric. However, our intuition tells us that most likely, this tissue is venous blood. So while injecting high-quality solutions for injection inside other tissues may be irritation, local inflammation and damage which may be identified through monitoring of the dynamics of local temperature of the skin at the injection site by infrared thermography. The method is based on the following regularity revealed by us: drugs with high aggressiveness cause the formation in the skin at the injection zone long-term local hyperthermia.

METHODS: Experiments were carried out on 20 pigs, which have carried out monitoring of a condition of the tissues of the skin and subcutaneous fat after subcutaneous injection of solutions 40 drugs before and after reconstitution with water. Dynamics of tissue condition with the introduction of these drugs was estimated in different years on the eye, with the help of the ultrasonic device Aloka SSD-900 and through determination of the dynamics of temperature by ThermoTracer TH9100XX (NEC, USA) in the temperature range 26 - 36 °C. The temperature of the air in the delivery room is in the range 24 - 26°C.

RESULTS: The results showed that the observation of forecast of the local drug interactions is sufficient to determine the dynamics of local tissue temperature for 10 minutes after the start of their interaction with the drugs. It is established that the drugs have annoying and/or cauterizing an action, cause, and medication, deprived of pharmaceutical aggression, not a cause in this period of time the local hyperthermia in places of local interactions. Therefore, the registration of the dynamics of the local temperature tissue in places of local interactions of medicines, implemented for the first 10 minutes after injection of drugs solution, can claim the role of a universal indicator of express-diagnostics of the pharmaceutical tissue damage to the introduction of drugs. Injection site appears bruise pharmaceutical irritation and local non-infectious inflammation of skin and soft tissues, a new disease, which received the name of "Injecting disease of skin and subcutaneous fat". Established that the cause of the disease is interstitial physical-chemical burn, which cause the medicine with high pharmaceutical aggression. Proposed original methods and tools for rapid diagnosis, prevention and treatment of injection disease.

CONCLUSION: It is shown that many drugs has high pharmaceutical aggression, so their injections cause the disease of skin and soft tissue, which was named injecting disease. Established that the thermal monitoring the local temperature in the injection site has a high prognostic value for the diagnosis and treatment of injection disease.

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NON-CONTACT THERMAL AND MULTISPECTRAL IMAGING, A CLINICAL DIAGNOSTIC TOOL FOR MONITORING TISSUE PERFUSION AND OXYGENATION, APPLIED IN CLINICAL TRIALS

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Non-contact imaging using video cameras, thermal cameras or multi-spectral cameras can be applied to retrieve diag-nostic information from patients.

Near infrared (NIR) light has been used for more than 3 decades to study blood concentration and oxygenation changes in tissue. NIR light penetrates more deep into tissue then visible light and is nearly not attenuated by skin pigmentation. NIR illumination with normal or multispectral cameras can detect subtle changes in blood content at each heartbeat, multispectral imaging by combining different NIR wavelengths the tissue blood oxygen saturation changes over large areas can be imaged. Thermography for measuring absolute surface temperatures is recently re-discovered because of the new generation thermal cameras. Modern thermal cameras have become small and practical without special cooling systems and calibration procedures and have a high image and temperature resolution (<0.1 K).

All these techniques can be used to study localized differences in tissue characteristics (e.g. tumor) or dynamic changes in the tissue (e.g. perfusion, oxygenation and temperature changes).

Thermal imaging can be useful to image physiological processes, perfusion, inflammation, friction and breathing. Tem-perature changes can be induced or provoked to observe dynamic changes to differentiate between healthy and ab-normal responses.

In our medical center several medical specialists have become interested in the potential of thermal imaging and vari-ous feasibility studies have started:

-Cardiology: prediction of spasm of artery in arm.

-Urology: cause of impotence after radical prostatectomy

-Anesthesiology: effectiveness of anesthetic block and pain treatment, non-contact monitoring of vital functions

-ENT surgery: harvesting and quality of reperfusion of skin flap.

-Plastic surgery: perfusion quality of skin flap for breast reconstruction, effectiveness of cryo treatment of hypertrophic scars, burn wound skin transplantation

-Dermatology: objective and sensitive imaging of allergic reactions

Clinician appreciate the technology real-time presenting of the thermal images or analyses. Thermal imaging can helps to improve the treatment or can become a new diagnostics tool. To replace the present golden standard more valida-tion studies with large patient groups have to be done.

Session 9 Proteomic approach in diagnosis and therapy

PROTEOMIC APPROACH IN DIAGNOSIS AND THERAPY

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The functional proteomic profile (fpp) is a lab-based method in complementary medicine (CAM) with 40 years of experience and a database of more than 2 million patients.

When a disease is developing genes react with information transported through proteins i.e. the proteins change prior to any detectable clinical symptoms.

Disrupting the protein structure through biochemical reagents leads to a precipitation. This change of serum density is photometrically determined. The deviation of the reaction tests can be used as infra clinical meta diagnosis. Four different groups of serum protein tests are identified giving you a systemic overview over the patient's complete health status. Following the diagnostics the computer puts together an individual therapy plan squared with the profile out of a therapeutical arsenal of 600 medications.

Session 10 Veterinarian applications of thermography

CONCEPTS IN THERMOGRAPHY FOR REFINEMENT AND REDUCTION IN ANIMAL USE FOR TESTING OF BIOLOGICALS

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Latest technical developments in high resolution Infrared Thermography (IR) provide further prospective opportunities for its use in biomedical research [1]. Five experimental settings, to reduce the burden in animal experiments by IR-thermography are presented: (1) Safety testing of vaccines in target species, (2) Pyrogenic assay on rabbits,(3) thermometry in guineapigs, (4) mice model to investigate oral Ovalbumin allergy and (5) tumor modeling.

RESULTS: Vaccination of pigs with Gonadotropin-releasing-factor-analogon causes a significant increase of the surface temperature at the vaccinated side, indicating a high reactivity. IR-Thermography to replace pyrogenic assay on rabbits underlies a higher variability, comparing to rectal thermometry. Thus, only pronounced pyrogenic activity can be de-tected by this method. Thermal studies in guinea pigs are helpful in monitoring the decrease of body temperature. However, thermoanalysis of skin reactivity is lesser recommended. Mice model to study clinical aspects of food allergy seems to be a prospective application in thermal monitoring. Evaluating the tumor status in nude mice by IR-thermometry allows earlier detection of efficacy in therapeutic intervention and provides the opportunity for advanced human endpoints.

CONCLUSIONS: In general, IR-thermography provides several concepts in reducing the burden for animals involved in biomedical studies. Otherwise, limits by the animal physiology, due to thicker skin, the fur and metabolic properties in small laboratory animals must be considered [2,3].

ACKNOWLEDGEMENTS: This research was supported in part by M. Bernau, P. V. Kremer and A.M. Scholz, from the Livestock Center Oberschleissheim, Veterinary Faculty of the Ludwig-Maximilians-University Munich, Germany and by E. Balks, F. Mohs, J. Hermanns, M. Toda, U. Salge-Bartels from the Paul-Ehrlich-Institut, Federal Institute for Vaccines and Bio-me dicines Langen, Germany

This research project is funded by the German Federal Ministry of Education and Research (grant -number 0316009A).

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DYNAMIC THERMOGRAPHIC MONITORING OF HORSES DURING MOVEMENT

A von der Wense

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A major issue of horses is the complex of lameness without diagnostic clearing. Often veterinarian routine examinations cannot point at the cause of the lameness. Full body thermographic examinations of horses standing still are a first approach to get a survey regarding the thermal patterns of a horse. In some cases, further examinations are needed.

Additional to thermographic stills of horses, dynamic analysis applying thermal video records can be very useful. By thermal video sequences of horses during movement, a localization of heat patterns may pinpoint to muscular compensations or other problem structures. By identifying those problems, further additional veterinarian examinations can be indicated.

Summarizing thermal video recording is a useful and additional method to analyze musculoskeletal problems of horses during movement.

INFRARED THERMOGRAPHY OF THE UDDER OF COWS AFTER EXPERIMENTALLY INDUCED MASTITIS WITH ESCHERICHIA COLI

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The aim of this study was to evaluate the course of thermographic patterns of the udder surface temperature after experimental infection with Escherichia coli. Five clinically healthy cows were used in this study. During a period of 48 hours thermographic pictures (ThermaCAM® B20 HS, Flir Systems®, Danderyd, Schweden) of the caudal aspect of the udder were taken every 2 hours to determine minimal (minT), maximal (maxT) and mean (meanT) temperatures in each picture. Udder and milk were examined clinically and microbiologically for signs of mastitis before inoculation, 12 and 24 hours post inoculation (pi). 24 hours after beginning of the trial the right hind quarters were infected by inoculation of 2 ml of a suspension of E. coli in physiological saline (250 CFU/ml). As a control 2 ml of physiological saline were injected in the left hind quarter of the respective animals. The effect of mastitis on udder surface temperature was analysed with a mixed model (MM; using Proc Mixed) taking animals and repeated measurements into account.

After inoculation both hind quarters showed an elevation in surface temperature, which was more pronounced in maxT ($p < 0.001$ at 13, 15 hours pi, right and left quarters) than in meanT ($p< 0.001$ at 13, 15, 17 hours pi, only at left quarter) compared to values measured 24 hours before (ΔmaxT (mean± SD) at 13 hours pi: infected quarter: $+1.98 \pm 0.59$ °C; uninfected quarter:

+1.93 ± 0.62 °C). Comparing meanT between hindquarters the difference was greatest at 13 hours pi and temperature was lower (-0.89 ± 0.65 °C) as at the infected quarter (s. Fig. 5). Differences between meanT and maxT in hindquarters were not significant at any time-point.

CONCLUSION: After experimental infection of the udder with E. coli significant changes in udder surface temperature due to inflammation can be measured by thermography. The method could be an additional tool in automated mastitis detection.

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THERMOGRAPHIC EVALUATION OF DERMATOME PATTERNS IN VARIOUS ANIMAL SPECIES

Ram C Purohit, J. Schumacher, D.D. Pascoe, D.F. Wolfe, M.Caldwell, T. Passler, Irma Wensink.

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Painful conditions associated with peripheral neurovascular and neuromuscular injuries are easy to confuse with spinal injuries, injuries associated with cervical, thoracic, and lumbar-sacral areas. Other conditions such as oste-oarthritis, tendonitis and others musculoskeletal diseases may also be confused with neurovascular conditions. There-fore infrared thermography studies were done to map the sensory-sympathetic dermatome patterns of cervical, thoracic, and lumbosacral regions in horses, bovine and other animal species. May clinical cases of cervical, thoracic and lumbosacral injury were evaluated using thermography and other diagnostic methods to document spinal injuries.

Animals with nerve compression had cooler thermal patterns, away from the site of injuries and that correlated with dermal nerve innervations patterns. In cases of acute injury , thermal patterns may be warmer than normal at the site of the injury. Elucidation of dermatome (thermatome) patterns provided spinal injury location for the diagnosis of back injuries in horses, cattle, dogs and other animal species.

The cutaneous circulation is under sympathetic vasomotor control. Thus peripheral nerve injuries and nerve com-pression can result in skin surface vascular changes that can be detected thermographically. Inflammation and nerve irritation may result in vasoconstriction, causing cooler thermo grams in area of skin supplied by the nerve. In horses, cattle, dogs and other animal species with suspected neurovascular or neuromuscular injury we administered intravenously a small dose of acepromazine (alpha blocking drug) to demonstrate that the cooler area due to the nerve compression showed increased heat (thermal patterns). The alpha blocking drug acepromazine caused vaso- dilation and increased blood flow in about 10 minutes in skin supplied by compressed nerve, thus providing the evidence of the presence of nerve compression due to inflammatory reaction. Neurogenic inhibition can be diagnosed through the administration of alpha-blocking drugs, which causes vasodilation of blood vessels to cause an increased blood flow and increase skin temperature within the dermatome supplied by that nerve.

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SEVERITY ASSESSMENT AND STRATIFICATION BY AN AUTOMATED, CONTINUOUS NON-CONTACT INFRARED MONITORING SYSTEM IN MODELS OF INFECTIOUS DISEASE

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INTRODUCTION: Animal studies are non-replaceable to understand disease mechanisms and to establish new diagnostic and therapeutic targets, but are often burdening the animals and extremely labour intensive. An automated system - monitoring animals automatically and continuously, free of additional stress and manipulation - allows evaluation of health status, treatment effects as well as prediction of clinical course/outcome and will thereby overcome current limitations.

METHODS: We evaluated a non-contact automated system recording temperature and activity profiles of multiple animals simultaneously by a thermographic camera system in a rodent model of severe infection and inflammation. An underlying database and central software, combined with artificial intelligence and web service access for remote control, records the characteristics of the animals over time. Sham treated controls and mice undergoing peritoneal infection with different degree of severity with and w/o antibiotic rescue therapy were investigated.

RESULTS: The system was able to monitor various animals simultaneously, with easy access for remote control by external computers and mobile devices. Sham mice demonstrated a circadian rhythm in surface temperature and activity with a variation of 5.2 K. In the most severity group (100% mortality/24h, no antibiotic rescue) the combination of temperature and activity allowed prediction of death ~ 18h before this event. This was also true for mid-grade, semi-lethal sepsis (50% mortality rate/ 48h, no antibiotic rescue). A clear discrimination between survivors and non-survivors was achieved. Using activity and temperature profile for stratification, antibiotic rescue (meropenem) was able to identify the time point of intervention and to change outcome until a distinct degree of prediction. All animals undergoing infection demonstrated a characteristic (time) trajectory of both parameters, indicating disease progression and providing objective evidence for assessment of severity. The system allowed non-subjective decision making for euthanasia in survival analyses and pre-mortal tissue sampling of animals predicted going to death. It reduces harm and numbers of animals, enables humane endpoints and advances animal research towards a more "clinical study scenario". For pharmaceutical pre-clinical studies animals can be enrolled at a uniform severity grade.

CONCLUSIONS: Automated, continuous non-contact infrared monitoring offers the opportunity to fulfil 3R standards by reducing numbers and suffering of animals, allows definition of a uniform state of a progressive disease and improves quality of data by stratification.

THERMOGRAPHIC EVALUATION OF TESTIS AND SCROTUM IN VARIOUS ANIMAL SPECIES

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The testicular temperature of most mammalian species must be below body temperature for normal spermatogenesis. The testes of most domestic mammalian species migrate out of the abdomen and are retained in the scrotum, which provides the thermal environment for normal spermatogenesis. Disruption of the normal thermal patterns and gradients of the scrotum is directly related to testicular degeneration.

Results of animal studies conducted at Auburn University over 30 years on the thermoregulation of the testis and scrotum in bulls, stallions, bucks, dogs and llamas will be presented. Purohit et.al (1-4) used thermography to establish normal thermal patterns and gradients of the scrotum in bulls, stallions, bucks, dogs and llamas. The normal thermal patterns of the scrotum in all species studied thus far is characterized by right to left symmetrical patterns, with a constant decrease in thermal gradients from the base of the scrotum to the apex. In the bulls, bucks, and stallions, a thermal gradient of 4-6 degrees Celsius was noted from the base to its apex. A gradual decrease in temperature from the base to the apex was demonstrated by concentric bands representing gradual cooling patterns, which demonstrated the function of a vascular counter current heat exchange mechanism in the testis. Normal scrotal infrared thermal gradients and patterns in dog and llamas are unique to their own species and may vary from other animals.

Various clinical conditions and factors can cause disruption of thermoregulatory mechanism in the scrotum and testis, thus causing depression of spermatogenesis. Inflammation of one testicle increased ipsilateral scrotal temperature of 2.5 - 3.0 C. In a case of both inflamed testes, there was an overall increase of 2.5-3.0 C temperature along with the reduction in temperature gradients from the base to the apex was seen in cases of testicular degeneration. Lack of thermal symmetry and change in temperature gradients were seen in both acute and chronic cases of testicular degeneration. The disruption of the normal thermal patterns and gradients of the scrotum is directly related to testicular degeneration. This may cause transient or permanent infertility in the male. It is well established that increases in scrotal temperature above normal causes disruption of spermato-genesis., affects sperm maturation, and contributes toward sub fertile or infertile semen quality. Early diagnosis of pending infertility has a significant impact on economy and reproduction in animals. Thermography has been efficacious for early diagnosis of acute and/or chronic testicular in humans and many animal species.

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Session 11 Outlook on future issues of medical thermography

TRENDS OF NEW INFRARED DETECTOR TECHNOLOGIES EXPAND THE POSSIBILITIES OF THERMOGRAPHY.

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With its 3.1 megapixels in IR-format this worldwide unique infrared system gives a new definition to the premium segment of uncooled thermographic medical cameras.

The application of thermography in human medicine is versatile and efficient:

Infrared camera systems provide a detailed picture of the body temperature's distribution in an efficient way

Flexible use of thermography for various disease patterns

Imaging of smallest temperature differences in high resolution

Frame rate up to 240 Hz

Real-time capability

Fixed an portable Camera version I

Image format: (2,048 x 1,024) IR pixel; optomechanical MicroScan feature; High-resolution 5.6" TFT display with (1,280 x 1,024) pixel and inclinable colour viewfinder

Important notice !

The abstracts have not been reviewed by the editorial board of Thermology international. The responsibility for correct content of this congress proceedings is with the guest editor Prof Dr Reinhold Berz.

Conferences and Meetings in 2015

21st -23rd March 2015

XIX National Congress of the Polish Association of Thermology in Zakopane, Poland

*Conference Venue:*Hotel Hryny, Pilsudsjiego str 20

ABSTRACT DEADLINE February 15th 2015

ajung@wim.mil.pl or a.jung@spencer.com.pl

Abstract form will be published in Thermology International and in Acta Bio-Optica et Informatica Medica

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Prof. Sillero Quintana PhD (Spain)
Prof. Adriana Nica MD,PhD (Romania)

Registration fee for non Polish participants will be paid in cash on arrival at the conference.

Registration by e-mail is required before March 1st to ensure hotel reservation. After registration number is issued, delegates are committed to payment of the fee.

Registration includes
welcome dinner Friday 20th
lunch and accomodation..
Extra night + breakfast + 70 €
Accompaning person – 200 €

20th–23th April 2015

SENSING TECHNOLOGY+ APPLICATIONS in Baltimore, Maryland, USA

Venue: Baltimore Convention Center

The Symposium SENSING TECHNOLOGY + APPLICATIONS (COMMERCIAL, INDUSTRIAL, AND CONSUMER SENSORS) is focused on commercial sensing and imaging topics and further development of technologies with consumer applications.

–TECHNOLOGIES
- 3D Imaging and Visualization
- Data Visualization
- Fiber Optic Sensors
- Hyperspectral Imaging
- Imagery and Pattern Analysis
- Information Systems and Networks
- **IR Sensors and Systems**
- Next-Generation Robotics
- Next-Generation Sensors and Systems
- Polarization
- Spectroscopic Sensing
- Terahertz Devices and Systems

Thermographics
- Wireless Sensing

APPLICATIONS
- Automotive/Transportation
- Communication/Networking
- Energy Harvesting
- Environmental Monitoring
- Harsh Environments
- **Healthcare/Medical Devices**
- Infrastructure
- Manufacturing
- Ocean Sensing
- Oil, Gas, Petrochemical
- **Pharmaceutical/Biotech**
- **Sensing for Agriculture and Food/Water Safety**

A preliminary programme is available at
http://spie.org/Documents/ ConferencesExhibitions/ DSS15-Advance-lr.pdf

6th-10th July 2015

QIRT – ASIA 2015 in Mahabalipuram, Chennai, India
Venue Hotel Radisson Blu Resort Temple Bay, Mahabalipuram (50 kms from Chennai City)

SCOPE OF THE CONFERENCE
QIRT-Asia 2015 will cover, but will not be limited to, the following topics:
·IR scanners and imaging systems for quantitative measurements.
·Data acquisition, image and signal processing.
·Integration of thermographic systems and multispectral analysis.
·Calibration and characterization of IR cameras, emissivity determination, absorption in media, spurious radiations, 3D measurements
·Certification and Standardization.
·Ultrasound thermography, eddy current thermography, photothermal methods and thermal effects induced by elastic waves or mechanical stresses, etc.
·Application of IR thermography to radiometry, thermometry and physical parameters identification in all fields such as: industrial processes, material sciences, thermo-fluid dynamics, energetics, non-destructive evaluation, cultural heritage, environment, medicine, biomedical science, food production…

Information: Secretariat, QIRT-Asia 2015
Radiological Safety Divison
IGCAR, Kalpakkam
Tamilnadu - 603102
Email: info@qirtasia2015.com
Tel: 044-27480352, Fax: 044-27480235

7th-10th July, 2015

19TH INTERNATIONAL CONFERENCE on THERMAL ENGINEERING AND THERMOGRAMMETRY (THERMO)
in Budapest, Hungary

MAIN TOPICS

The structure of the sessions will be fixed after receiving the papers, but the topics will cover the following fields:

General thermal engineering; theory of measurements; thermal informatics, thermo-CAD and its applications; advanced thermodinamics and the new tendencies associated: industrial energy management and process control systems; practice of thermal engineering; infra-red imaging science & technology: thermogrammetry, micro- and nanoscale thermal phenomena and sensing techniques, thermal defectometry; applied thermo-optics; thermophysical properties; heat and mass transfer; cooling of electronic components; heat exchangers; combustion; thermophysics of the environment; building services; environmental aspects of energy use; thermo-ergonomy and thermo-psychology; thermo diagnostics; system analysis in thermo-biology; IR-imaging in biomedical and bio-engineering applications; remote sensing through IR-imaging, multi-disciplinary topics.

TECHNICAL ISSUES

The language of conference and abstracts is English. Together with oral presentation of papers a poster session will be organized.

Duration of each presentation will be limited to 15 minutes and additional time for discussion will also be provided. The English translation of lectures not read in English should be submitted at the registration desk on the spot. LCD projector and computer with Windows OS for Microsoft Power Point format presentations is available. (Please note, that using your own computer is not allowed.)

Those intending to attend the conference are kindly invited to send an Application & Registration Form to the address listed later, under "INFORMATION".

EXHIBITION

During the conference an exhibition of scientific and industrial instrumentation will be organised. Exhibitors from the field of temperature measurement and control, thermal properties, IR-imaging, anemometry, industrial energy control, heat loss detection equipment etc. are welcome.

VENUE

The conference is hosted by
the Budapest University of Technology and Economics (BME, Budapest, XI. Budafoki út 4., Hungary) located near the Hotel 'Gellért' and the Danube. More information about the conference place and hotel accommodation will be sent after the arrival of the Registration Form at
www.mate-net.hu .

CALL FOR PAPERS

The photocopy-ready papers(for CD-ROM presentation) of max. ten A4 format pages to be presented on the conference are to be submitted before 15 February, 2015. To assist the work of the Scientific Committee the authors are kindly requested to point out the aim, method and results of their work in the summary to be provided according to the typing instructions.

Notification of the acceptance of abstracts will be forwarded to the authors until 30 December, 2014. The full text of all accepted papers will be included the CD-ROM Proceedings to be presented to the participants at the Conference.

INFORMATION

Application & Registration Forms and abstracts/papers should be sent to:

Dr. Imre BENKÕ, MATE Secretariat,
E-mail: ibenko@freestart.hu

2nd September, 2015

Medical applications of human thermography
(Pre-Congress Course) in Madrid

Venue: Faculty of Physical Activity and Sport Sciences (INEF de Madrid).

Further information: see pages 36 & 37
OR CONTACT
Manuel Sillero:
Phone +34-687044034
email: eatmadrid2015@gmail.com

3rd - 5th September; 2015

XIII EAT CONGRESS in Madrid

Venue: Faculty of Physical Activity and Sport Sciences (INEF de Madrid)

Further information:

See pages 38-40
www.eat2015.info or www.europeanthermology.com

Medical applications of human thermography

(Pre-Congress Course)

Date: Tuesday, 2nd September de 2015.
Duration: 8.5 hours.
Venue: Faculty of Physical Activity and Sport Sciences (INEF de Madrid).

A certificate of attendance to 8,5 lecture hours will be provided by the Technical University of Madrid (UPM) and the European Association of Thermology (EAT).

Organize:

More info: Manuel Sillero: +34-687044034
eatmadrid2015@gmail.com

INSCRIPTION PROTOCOL

+ The inscription will be on-line in the link:

https://docs.google.com/forms/d/1ZHj4Uc3ipkSiG268n2OnZ1pqd4re8qRADMpgVFgZEuU/viewform?c=0&w=1

NOTE: This link will be available only until 30th of July. After this date, any inscription will be done in cash at the reception desk. Please, notify your interest (see below).

VERY IMPORTANT: The inscription will confirmed when the on-line inscription form is completed and sent, and after a proof of the payment is received in the email:

eatmadrid2015@gmail.com

FURTHER INFORMACIÓN:
Mobile: +34-687044034 (Manuel Sillero)
eatmadrid2015@gmail.com

COURSE FEES

	Until 1st of July	After 1st of July
EAT MEMBERS	180 €	220 €
NON EAT MEMBERS	220 €	260 €

+ **Course fee includes the lunch and the coffee breaks in the INEF's cafeteria.**

+ Inscriptions on the day of the course will be possible only in case of vacancies. Please contact with the organization first. Mobile +34687044034 (Manuel Sillero) or eatmadrid2015@gmail.com.

IMPORTANT: The minimum number of attendants will be 10. If the 1st of July the number is below this limit, the course maybe cancelled and the attendants will be contacted to be informed about the cancelation.

COURSE VENUE

Faculty of Physical Activity and Sport Sciences (INEF Madrid).

C/Martín Fierro, nº7 – 28040 - Ciudad Universitaria, Madrid, Spain

PAYMENT

1st) Transfer the congress fee to the account:
IBAN: ES74-0065-0100-12-0031000262;
SWIFT: BARCESMM (Barklays Bank)

Important information for the bank transfer:
Sender: Name and surame of the attendant.
Reciever: UPM-OTT
Concept: P131110231 + Name + ID or Passport number (Example: P131110231 Manuel Sillero 52XXX794Z)

2nd) Send the proof of payment to the email:
eatmadrid2015@gmail.com

Organizers: Technical University of Madrid (UPM) and the European Association of Thermology (EAT)

INTRODUCTION

One of the objectives of the European Association of Thermology is to promote the adequate use of thermography in all their application fields.

It is a tradition on the EAT Congresses to organize a training course oriented to those who want to get introduced into the fundamentals of thermography or to anyone who want to extend or review his/her knowledge about thermography.

This year the course has been focused on the medical applications of human thermography. Any professional related with human health is kindly invited to participate in this basic course instructed by acknowledged members of the EAT.

We look forward to seeing you in Madrid in September 2015

Manuel Sillero Quintana
Director of the course.

OBJECTIVES

+ To understand the fundamentals of Physics and Physiology affecting the Human Thermography.

+ To get an introduction about the Medical Applications of Thermography.

+ To introduce the attendant to the protocols for the appropriate data collection, analysis and interpretation of the human thermal data.

COURSE PROGRAM

Tuesday, 2nd of September 2015.

8:30 Late registration and accreditation.

9,00 Opening *(Dr. Manuel Sillero)*

9:10 **Principles of physics of Infrared Thermography** *(Dr. Ricardo Vardasca)*

10:10 **Physiological concepts applied to Thermography** *(Dr. James Mercer)*

11:10 COFFEE BREAK

11:30 **Infrared thermography in medicine** *(Dr. Francis Ring)*

12:30 **Provocation test used in medical thermography** *(Dr. Kurt Ammer)*

13:30 LUNCH BREAK.

15:00 **Infrared image analysis and Reporting** *(Dr. Kurt Ammer)*

16:00 SHORT TECHNICAL BREAK.

16:15 **Practical Session: TermoINEF Thermal Imaging Protocol** *(Members of the TermoINEF research team)*

16:45 **Practical Session: Thermogram Recording practice** *(Several teachers of the course)*

17:45 COFFEE BREAK

18:15 **Practical Session: Data collection and Reporting with ThermaCam Reporter** (*Dr. Manuel Sillero*)

19:15 **Examples of medical data interpretation.** *(Several teachers of the course)*

20:15 Closing and distribution of certificates (Manuel Sillero).

VERY IMPORTANT: In the practical sessions the students will record each other, so that, during the evening session the student should wear shorts and light clothes to facilitate the data collection.

COURSE INSTRUCTORS

Prof. Dr. Francis Ring
University of South Wales, United Kingdom

Prof. Dr. Kurt Ammer
University of South Wales, United Kingdom
EAT Treasurer, Austria

Prof. Dr. James Mercer
University of Tromsoe, EAT President, Norway

Dr. Ricardo Vardasca
University of Porto, Portugal

Prof. Dr. Manuel Sillero Quintana
Technical University of Madrid, Spain.

Members of the TermoINEF
(Research team of the Sports Department)
Technical University of Madrid, Spain.

Note: Lectures and practical training will be in English.

ACADEMIC CERTIFICATE

A certificate of attendance to 8,5 lecture hours will be provided by the Technical University of Madrid (UPM) and the European Association of Thermology (EAT).

European Association of Thermology

Physical Activity and Sports Faculty (INEF). U.P.M.

XIII European Association of Thermology Congress

XIII EAT CONGRESS
madrid
3rd-5th September 2015

Thermology in Medicine:
Clinical Thermometry and Thermal imaging

FINAL ANNOUNCEMENT AND CALL FOR ABSTRACTS

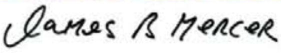
More info: www.eat2015.info and www.europeanthermology.com

The EAT and the Faculty of Physical Activity and Sports Sciences (INEF) have the pleasure of inviting you to participate in the XIII EAT Congress in Madrid between the 3rd and 5th of September, 2015.

The target of this Congress is integrating professionals and researchers from different fields who are working daily with medical thermography, introducing the latest advances in infrared technology and the new applications arising from them.

The Congress will appeal not only to end-users of medical thermography but also to researchers and developers. The congress will focus on free communications and posters in the areas of Human Applications, Animal Applications, and Engineering.

We look forward to seeing you in Madrid in September 2015.



Manuel Sillero Quintana.
Chairman of the Organizer committee.

James Mercer
President of the AET.

COMMITTEES

Manuel Sillero-Quintana (SPA). Congress Chairman

ORGANIZING COMMITTEE

Prof. Dr. Kurt Ammer (AUT)
Prof. Dr. Kevin Howell (GBR)
Prof. Dr. Anna Jung (POL)
Prof. Dr. James Mercer (NOR)
Prof. Dr. Francis Ring (GBR)
Dr. Ricardo Vardasca (POR)

LOCAL ORGANIZER COMMITTEE

Mr. Javier Arnaiz (SPA)
Prof. Dr. Pedro J. Benito (SPA)
Prof. Dr. Joao Carlos Bouzas (BRA)
Prof. Dr. Javier Calderón (SPA)
Dr. Ismael Fernández-Cuevas (SPA)
Prof. Dr. Ignacio Refoyo Román (SPA)
Dr. Pedro M. Gómez (SPA)
Mr. Sergio Piñonosa (SPA)
Prof. Dr. Antonio Rivero (SPA)

EAT SCIENTIFIC BOARD (*)

Prof. Dr. Kurt Ammer (AUT)
Prof. Dr. Imre Benkö (HUN)
Dr. Marcos Brioschi (BRA)
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Prof. Dr. Anna Jung (POL)
Prof. Dr. Arcangelo Merla (ITA)
Prof. James Mercer (NOR)
Prof. Dr. David Pascoe (USA)
Prof. Dr. Adriana Nica (ROM)
Prof. Dr. Francis Ring (GBR)
Dr. Ricardo Vardasca (POR)
Prof Dr. Hisashi Usuki (JPN)

XIII EAT CONGRESS 3rd to 5th September 2015, Madrid.

PROGRAMME (by 23rd of January 2015)

	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00
Wednesday 2-9-15	PRE-CONGRESS COURSE More info: www.eat2015.info													
						Late Registration and Accreditation at the Hotel Florida Norte								
Thursday 3-9-15	Late Registration and Accreditation at INEF	Session 1-1 Technical Applications		Coffee Break	Session 1-2 Technical Applications	LUNCH (INEF)	Session 1-3 Animal Applications		Coffee B.	Session 1-4 Animal Applications		EAT Meeting		
Friday 4-9-15	Late Registration and Accreditation at INEF	Session 2-1 Biomedical Applications		Coffee Break	Session 2-2 Biomedical Applications	LUNCH (INEF)		VISIT TO A PINTORESQUE CITY AND GALA DINNER (*)						
Saturday 5-9-15	Late Registration and Accreditation at INEF	Session 3-1 Biomedical Applications		Coffee Break	Session 3-2 Biomedical Applications	LUNCH (INEF)	Closing Ceremony and EAT Awards							

(*) Note.- The bus will depart from the Florida Norte Hotel around 15:30. The visit will be from 16:30 or 17:00 to 20:00 and the dinner from 20:00 to 22:00 arriving 23:00 to the hotel.

The scientific committee will receive submission for abstracts for free communications and posters in the areas of "Biomedical Applications", "Animal Applications" and "Technical Applications". Abstracts submission will be on-line (https://docs.google.com/forms/d/15lUVW6GsKsBwx8fHQ7yqAON7xrl9dubEGerZlegVaM0/viewform?c=0&w=1&usp=mail_form_link). Note: Prizes will be awarded for the best communications, best posters and best student presentation. The authors of best communications will be invited to submit an extended version of their abstracts for publication in Thermology International.

The Scientific program (regularly updated) can be found on the official web page of the EAT Congress: www.eat2015.info .

REGISTRATION

All the registrations will be on-line in the link: https://docs.google.com/forms/d/1ROydAdol3e3Q-Xx4vmRRV0ZQiXikq8g3OJgaUpADdcc/viewform?c=0&w=1&usp=mail_form_link

KEY DATES

10th October 2014. Opening of abstract submission and registration.

Abstract submission. The deadline has been extended to 26th of February.

27th March 2015. Acceptance notification to authors.

17th April. End of Early bird registration.

REGISTRATION FEES

	Early Registration (Until 17-4-15)	Late Registration (Until 31-7-15)	Last-minute Registration (After 31-7-15)
EAT MEMBER (1)	300 €	360 €	400 €
Non EAT member (1 &2)	350 €	410 €	450 €
1-day registration (2)	125 €	150 €	170 €
Student (3)	150 €	200 €	240 €
Accompanying person (4)	200 €	260 €	300 €

(1) Full inscription include registration pack, coffee breaks, lunches, Galla Dinner, and 10 tickets for public transports (metro and bus).
(2) Annual EAT fee = 50 € (including one year subscription to the journal Thermology International). To get information about how to apply to the EAT as ordinary or extraordinary member, visit http://www.europeanthermology.com (membership).
(3) 1-day registration will include registration pack and coffee breaks and lunch of the day. **Gala Dinner not included.**
(4) A certificate with ECTS credits will be provided by U.P.M. Gala Dinner not included.
(5) Accompanying person registration will include 2 one-day excursions (9:00 - 16:00) with lunch (3rd and 5th of September) and Gala Dinner.

ACCOMODATION

Hotels in Madrid are quite full in early September. For this reason, the organizers of the EAT Congress have reserved 100 rooms for participants at the **Hotel Florida Norte******, which will be the official hotel of the congress. The special fees for the attendants are:

· 35.35 € (incl. 10% VAT) per person in double bed room including breakfast (buffet).
· 59.35 € (incl. 10% VAT) single room including breakfast (buffet).

The Florida Norte Hotel is about a 25 minutes walk or a 5-10 minute bus ride to the venue. The city centre is a 10 minute walk from the hotel.

VERY IMPORTANT. In the registration form the participants have to indicate whether or not the will stay in the Hotel Florida Norte (organizers will inform to the Hotel). If they choose to use the Hotel Florida Norte, they have to reserve the hotel themselves writing and email to reservas.florida@celuisma.com. Alternatively the hotel can be booked on-line at http://www.celuisma.com/en. NOTE: If you indicate in the booking form that you are an attendant of the EAT Congress you will be charged the special congress rate and NOT the fee indicated on their website.

TRAVEL INFORMATION

There is a train service directly from Madrid Barajas airport (Terminal 4) to Príncipie Pío Station (35 minutes, about 2.50 €; one train each 30 minutes), where the official hotel is located.

There are also metro and buses from the Airport to the city center (40-50 minutes, about 5-6 Euros). A taxi from the Airport could be another option but a little bit more expensive. In 2014 the fixed fee for a taxi from the Airport to any place in the centre of Madrid is 30€.

The radial structure high-speed (AVE) and regional trains and buses allow travel to Madrid from the most important cities of Spain. Furthermore, Madrid has an excellent underground system, a frequent bus network and many reasonably priced taxis for local transportation.

We encourage our attendees to use the public transport. A 10 ticket bonus will be provide to all the attendants with a 3-days registration at the Reception Desk in the Hotel FLORIDA NORTE.

TECHNICAL OFFICE

For any enquire, you can contact the office of the congress by email eatmadrid2015@gmail.com or by phone: +3491336-4021 or -4081, +34687044034 (mobile).

XIII EAT CONGRESS 3rd to 5th September 2015, Madrid.