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Repeatabilty of Hot Spot identification

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Which articles in Thermology international are peer reviewed and which are not

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Peer review is the gold standard that provides the guarantee of scientific quality in scholarly journals. The advantages and deficiencies of the peer review process have discussed in the literature [1,2], but an alternative process of better performance is not yet in sight.

Peer review is a required process for original articles and reviews before they are published in Thermology international, and this quality tool became necessary in 1993 when the journal name was " Thermologie Österreich" and selected to become the official publication organ of the European Association of Thermology [3]. The following sentence "*All manuscript (i.e. review and original article) will be read by two independent reviewers"* appeared in the "instruction for authors" for the first time in number 4, Volume 4 (1994) in Thermologie Österreich. As consequence of the review process about 50% of the paper submissions in the last 5 years have been rejected because the did not met the minimum quality standards required for publication. Some of these papers have been published in other journals after text revision based on the report of reviewers for Thermology international.

But not all articles, published in Thermology international have passed a peer review. Announcements of conferences and meetings, the section "News in Thermology", and Conference Abstracts do not enter the review process. Consequently, this material is not listed in Embase. It is assumed, that the members of the scientific conference boards have already applied some quality check of their conference presentations. Only changes of the English were made occasionally in abstracts published in Thermology international.

This journal shows the abstracts of an upcoming meeting in South Carolina, scheduled for April 30. This collection of summaries of presentations includes an "Update of Guidelines for Neuromuscular Thermography", which failed to pass sucessfully the review process of Thermology international. One of the main points of criticism was discussed in an editorial published at the time of the manuscript submission.[4] Unfortunately, the authors have not responded to the arguments provided, and therefore it has to be stated, that the Guideline on Neuromuscular Thermography on page 62-to 65 of this issue is not a refereed version. Different to the original version [5], the editor of this journal does not agree with the contents and conclusion of this updated guideline.

Nevertheless, this paper is published, as one of the functions of the journal is to document the activities of all thermology societies which use "Thermology international" as official publication organ. In this conflict between service for the member societies and the committment to publish papers with agreed scientific back ground, disclosure of the reasons for publication was the only solution.

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Repeatability of Identification of Hot Spots in Thermal Images is influenced by image processing

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SUMMARY

BACKGROUND: Hot spots are regarded as diagnostic signs in thermal images of patients suffering from tennis elbow or fibromyalgia. However, the reliability of the identification of hot spots is not well known and may be poor.

OBJECTIVE: The aim of this study to investigate how precisely hot spots can be identified from thermal images.

METHODS 2 studies were conducted. In study A , 32 images recorded from fibromyalgia patients in the view upper back were reviewed. Hot spot were identified in three ways. Firstly, the uncompressed continuous colour scale was used and hot spots were identified by eyes and the identified area was accepted as a hot spot when the temperature difference to the surrounding areas was greater than 0.5 degrees- Secondly, the colour scale of the thermal images was compressed in order to increase the contrast between cool and warm areas and hot spots were identified in the same way as in the uncompressed thermal images. Thirdly, two isotherms were generated at temperature levels 1 degree apart and combined with a stepwise compressed colour scale. The mean temperature of hot areas within the isotherm at the higher temperature was determined and compared to the mean temperature of the surroundings of the hot spot. These temperature measurement procedures were repeated two days later.

In study B, a set of 3 isotherms, 0,5 degrees apart, was used for hot spot identification. Moving this set over the total range of temperature within a thermal image, can easily detect hot spots as the temperature difference between the 1st isotherm with the lowest threshold and the 3rd isotherm with highest threshold is at least equivalent to the chosen temperature between the isotherms.

This approach was tested in a set of 10 thermal images previously used for testing of the reproducibility of hot spot identification. All images were evaluated twice on different days by the same reader, who was blinded at the second evaluation to the results of the first reading,

The findings were statistically analyzed with respect to method of hot spot identification and time of investigation.

RESULTS: The mean number of hot spots varied by the method of identificaton with lowest numbers in uncompressed images and highest numbers in isotherms. Reliabilty, based on ANOVA (values beween 0.87 and 0.73) and Single Measure Intraclass Correlations were highest for compressed images, followed by non compressed images and isotherms.

In study B, the reproducibility of hot spot identification was moderate to good (Single Measure Interclass Correlation: 0.699; 95% confidence interval: 0.138 to 0.917, Reliability Coefficient alpha: 0.807). The reproducibility of hot areas was poor (Single Measure Interclass Correlation: 0.14; 95% confidence interval: -0.162 to 0.580, Reliability Coefficient alpha: 0.413)

CONCLUSION: Reproducibilty of Hot spot identification vary with respect of the method of image processing

KEY WORDS: Hot spot, reproducibility, thermal image

DIE REPRODUZIERBARKEIT DER IDENTIFIKATION VON HOT SPOTS IN WÄRMEBILDERN VON DER BILDBEARBEITUNG AB

HINTERGRUND: Hot spots in Wärmebildern von Patienten mit Tennisellbogen oder Fibromyalgie gelten als diagnostisches Zeichen. Allerdings, ist das Maß der Zuverlässigkeit der Erkennung von Hot spots nur wenig bekannt und ist möglicher Weise gering.

FRAGESTELLUNG: Das Ziel dieser Studie war es zu ergründen, mit welcher Präzision Hot spots in Wäremebildern identifiziert werden können.

METHODE: Es wurden 2 Studien durchgeführt. In der Studie A wurden 32 Wärmebilder des oberen Rückens durchgesehen, die von Fibromyalgiepatienten stammten. Hot spots wurden auf drei unterschiedliche Weisen identifiziert. Bei der ersten Methode wurde eine nicht komprimierte Farbskala verwendet, und Hot Spots wurden visuell ausgewählt und als Hot Spot akzeptiert, wenn die Temperatur der ausgewählten Fläche um 0,5 ° höher war als der umgebenden Fläche. Bei der zweiten Methode wurde die Farbskala komprimiert, um den Farbkontrast zwischen warmen und kühlen Arealen zu verstärken, Hot Spots wurden auf die gleiche Weise wie bei der nicht komprimierten Farbskala bestimmt. Bei der dritten Methode wurden zwei Isothermen im Abstand von 1 Grad genefriert und mit einer gestuften und komprimierten Farbskala kombiniert. Die mittlere Temperatur der warmen Fläche innerhalb der Isotherme mit höherer Temperatur wurde bestimmt und mit der durchschnittlichen Temperatur der umgebenden Fläche des Hot Spots verglichen. Alle Temperaturmessungen wurden nach 2 Tagen wiederholt.

In Study B wurde ein Satz von 3 Isothermen im Abstand von 0,5 Grad für die Erkennung der Hot Spots genutzt. Wenn man einen solchen Satz von Isothermen über den gesamten Temperaturbereich bewegt, sollten Hot Spots leicht erkannt werden, da die Temperaturdifferenz zwischen der Isotherme mit der niedrigsten Temperatur und der Isotherme mit der höchsten Temperatur gleich dem gewählten Temperaturabstand ist.

Die Ergebnisse wurden hinsichtlich der Methode der Hot Spot Bestimmung bzw. des Untersuchungszeitpunktes statistisch analysiert.

ERGEBNISSE: Die durchschnittliche Zahl der Hot Spots variierte in Abhängigkeit der Bildbearbeitung, wobei die meisten Punkte mit Isothermen und die geringste mit der unkomprimierten Farbskala gefunden wurden. Die Zuverlässigkeits-Koeffizienten zeigten in der ANOVA Werte zwischen 0.87 und 0.73 und die höchsten Interklassen-Korrelationens wurden für unkomprimierte Wärmebilder, und dann für die komprimierte Farbskalen und Isothermen gefunden.

Die Reproduzierbarkeit der Hot Spots Entdeckung war in Studie B mäßig bis gut (Interklassen-Korrelation: 0.699; 95% Vertrauensintervall: 0.138 bis 0.917, Zuverlässigkeits-Koeffizient Alpha: 0.807). Die Reproduzierbarkeit der warmer Flächen war gering (Interklassen-Korrelation: 0.14; 95% Vertrauensintervall:l: -0.162 bis 0.580, Zuverlässigkeits- Koeffizient Alpha: 0.413)

SCHLUSSFOLGERUNG: Die Reproduzierbarkeit der Bestimmung von Hot spots variiert in Abhängigkeit der durchgeführten Bildbearbeitung.

SCHLÜSSELWÖRTER: Hot spot, Reproduzierbarkeit, Wärmebild

Thermology international 2011, 21 (2) 40-46

Introduction

In 1977, German authors reported in their description of the normal back thermogramm hot circular areas up to 2 degrees warmer than the surrounding tissue with sharp or gradual transition to the adjacent skin [1]. Cold and hot areas of rhomboid or oval shape with vertical or horizontal axis were also described. No pathological findings were related to these thermal inhomogenities.

Usually, hot spots are evaluted qualitatively as a spot of different colour or gray shade on a thermal image. It may be defined quantitatively by any area that is at least 0.5° warmer than its surroundings [2] or 1°C warmer than the contralateral side [3].

Hot spots in thermal images from patients suffering from locomotor disorders were previousley related with myofascial trigger points [3], tender tendon insertions [2, 4] and tender points of fibromyalgia patients [5,6] as tenderness in defined body sites is a required diagnostic feature of fibromyalgia.

The value of thermography for the detection of myofascial trigger points was discussed ambiguously. While Fischer & Chang [3], Diakow [7] and Kruse & Christiansen [8] described at leas ta moderate relationship between increased temperature and decreasedthreshold for pressure pain over myofasial trigger points, reported Swerdlow & Dieter [9] a high rate of both false negative ands false positive findings. Radhakrishna & Burnham, using a hand held radiometer, were also unable to establish a relationship between skin temperature and pressure threshold in a group of patients with either myofascial pain or fibromyalgia [10].

However, hot spots can also be detected in thermal images recorded in other fields of medicine such as dermatology, senology, phlebology or plastic surgery. Hot spots in dermatology are related to local inflammation as in allergy [11], various herpetic lesions [12,13,14], active psoriatric plaques [15] or localised scleroderma [16].

The vascular architecture and the anatomy of blood vessels, particulary of perforating vessels explain most of hot spots detetcted on the skin surface with an thermal imager, especially after a cooling procedure. In plastic surgery, mapping hot spots with thermography can help to choose the best site for harvesting free perforator flaps [17]. In phlebology, incompentent perforating veins are characterised by increased skin temperature and reflux on the venous Doppler examination [18, 19]. Cooling was previously a required procedure in breast thermal imaging and hot spots of high intesity (3° C warmer than the surrounding tissue) was labeled as a sign of malignancy [20]. Increased temperature, easily detected after conductive cooling was also reported for skin melanomas [21].

However, a previous study reported a poor inter-rater repeatability of hot spot identification in thermal images of fibromyalgia patients with reliability coefficients between 0.047 and 0.36 and single measure intraclass correlation between 0.15 and 0.20 [22]. This study was based on visual identification of hot spots in thermal images stored and processed with the AGEMA CATS software.

Aim of this paper is to clarify, if different ways of image processing performed with the software package CTherm may increase the inter-rater repeatability of hot spot identification.

Method

2 studies were conducted to investigate the reproducibilty of hot spot identification.

Study A

Thermal images recorded with an AGEMA 870 infrared scanner from patients with suspected fibromyalgia have been converted to the CTHERM format. 32 images of the standard view "Upper back" were selected and hot spots in each image were counted in three different ways.

Any visually identified area suspected to have a higher temperature than 0,5 degrees as the surroundings was checked by spot temperature measurements

Originally, a comparison of mean temperatures of the hot spot with the area around the hot spot was indented . However, this approach appeared as very time consuming and impossible to apply for small hot spots.

Therefore, hot spot identification was performed in thermal images after the following image processing:

A. Without image processing using the uncompressed continuous colour scale (Figure 1)

B. After compressing the continuous colour scale (usually to temperature range of 5°C) (Figure 2)

C. After creation of two isotherms one degree apart and combining the isotherms with a compressed stepwise colour scale (0.5 ° each colour, Figure 3 and Figure 4))

In A and B, spot temperatures of the hot spot were taken and compared to spot temperatures in the area surrounding the hot spot. A temperature difference of 0.5°C or more comfirmed the hot spot. The mean temperature of hot areas within the isotherm at the higher temperature was determined and compared to the mean temperature of the surroundings of the hot spot. These temperature measurement procedures were repeated two days later. The number of hot spots was counted in each image and the results of the two assessments was analysed statistically

Study B

The first isotherm with the highest threshold was set when at least one spot was enclosed in the upper range of temperature, Then, 3 isotherms, 0,5 degrees apart were generated. Moving such a set over the total range of temperature within a thermal image, can easily detect hot spots as the temperature difference between the 1st isotherm with the lowest threshold and the 3rd isotherm with highest threshold is at least equivalent to the chosen temperature between the isotherms.

This approach was tested in a set of 10 thermal images previously used for testing of the reproducibility of hot spot identification. All images were evaluated twice on different days by the same reader, who was blinded at the second evaluation to the results of the first reading.

Statistical analysis

Mean number of hot spots and 95%confidence interval of the mean were determined. The reliability coefficient alpha and intraclass correlation coefficient were calculated for Study A and B. For the three sets of isotherms, reliabilty of hot spot count was calculated separately for hot spots in the upper and the lower range of temperature. SPSS 10.0 for Windows was used for all calculations.

Results

Study A

The highest number of hot spots as found with the combination of a compressed colour scale and isotherms. The

Table 1
Reliabilty coefficient and intraclass correlation coefficients for hot spot count in study A

Study A	Reliability Coefficient alpha	Intraclass Correlation Coefficient (ICC)	95% confidence interval of ICC
Uncompressed scale, first count versus uncompressed scale,second count	0.81	0.66	0.41to 0.82
Compressed scale, first count versus compressed scale,second count	0.93	0.87	0.75to 0.93
Isotherms, first count versus Isotherms scale,second count	0.78	0.64	0.38 to 0.81
Uncompressed scale, first count versus compressed scale, first count	0.89	0.79	0.62 to 0.89
Uncompressed scale, second count versus compressed scale, second count	0.88	0.78	0.60 to0.89
Uncompressed scale, first count versus isoherms, first count	0.83	0.71	0.49 to 0.85
Compressed scale, first count versus isoherms, first count	0.93	0.86	0.73 to 0.93
Unompressed scale, second count versus isoherms, second count	0.88	0.68	0.44 to 0.83
Compressed scale, second count versus isoherms, second count	0.89	0.80	0.63 to 0.90

Table 2
Reliabilty coefficient and intraclass correlation coefficients for hot spot count in study B

Set of three isotherms	Reliability Coefficient alpha	Intraclass Correlation Coefficient (ICC)	95% confidence interval of ICC
Hot spots; first versus second count	0.81	0.70	0.14 to 0.92
Hot spots at high temperature, first versus second count	0.98	0.94	0.73 to 0.99
Hot spots at low temperature; first versus second count	0.97	0.93	0.76 to 0.98
Hot areas; first versus second count	0.41	0.14	-0.16 to 0.58
Hot spots & hot areas; first versus second count	0.77	0.60	0.06 to 0.88

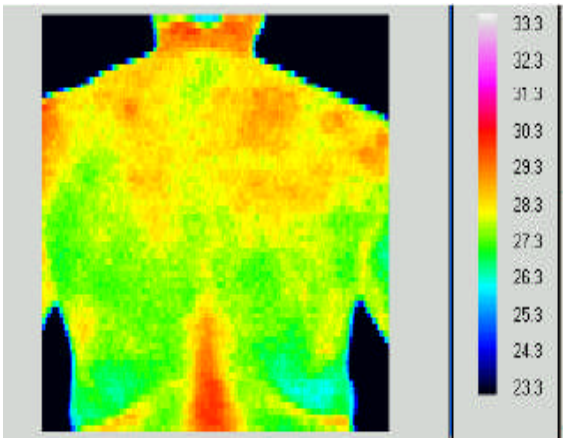


Figure 2
Uncompressed continuous colour scale
First count:10 hot spots, Second count:12 hot spots

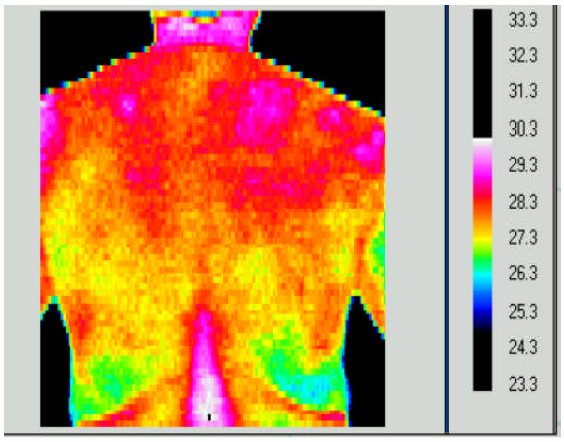


Figure 3
Compressed continuous colour scale
First count:14 hot spots, Second count:17 hot spots

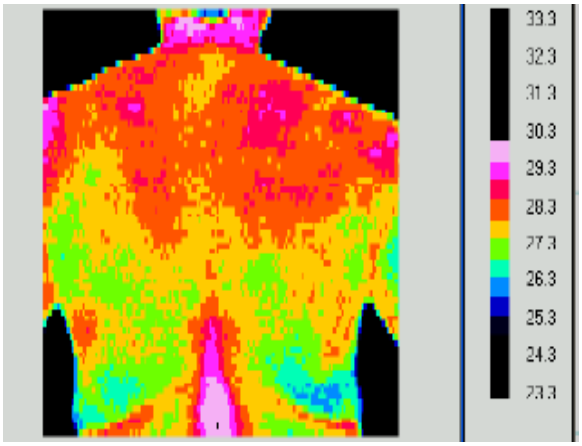


Figure 3
Compressed stepwise colour scale

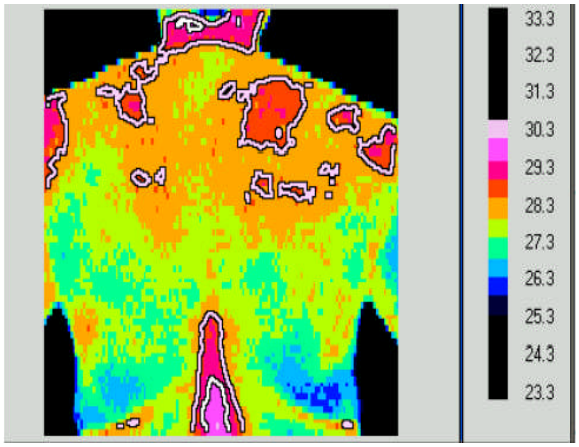
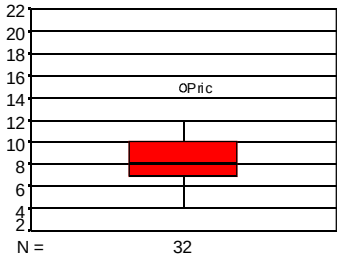
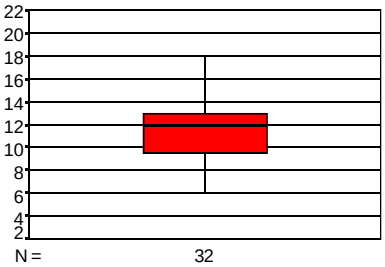


Figure 4
Compressed stepwise colour scale plus isotherms
First count: 18 hot spots, Second count: 22 hot spots

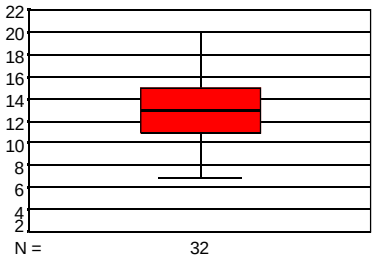
Figure 5
Number of hot spots (median, 95% CI (confidence intervall)



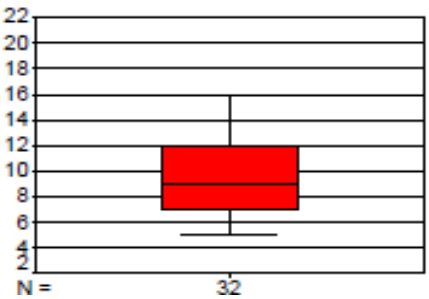
Uncompressed, 1st count
median:8, 95% CI 7.56 to 9.32



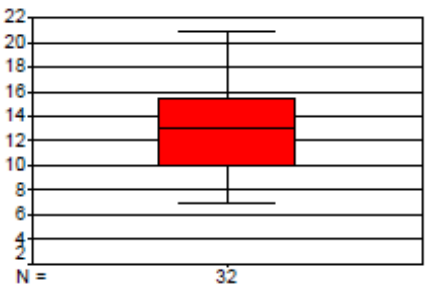
Compressed, 1st count
median:12, 10.45 to 12.37



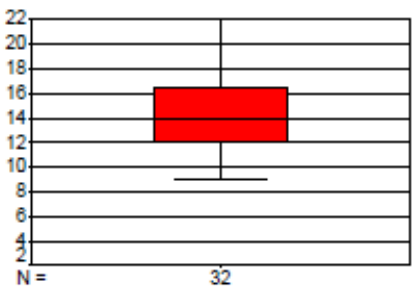
Isotherm , 1st count
median: 13; 95% CI 12.20 to 14.23



Uncompressed, 2nd count
median:9; 95%CI 8.40 to 10.54

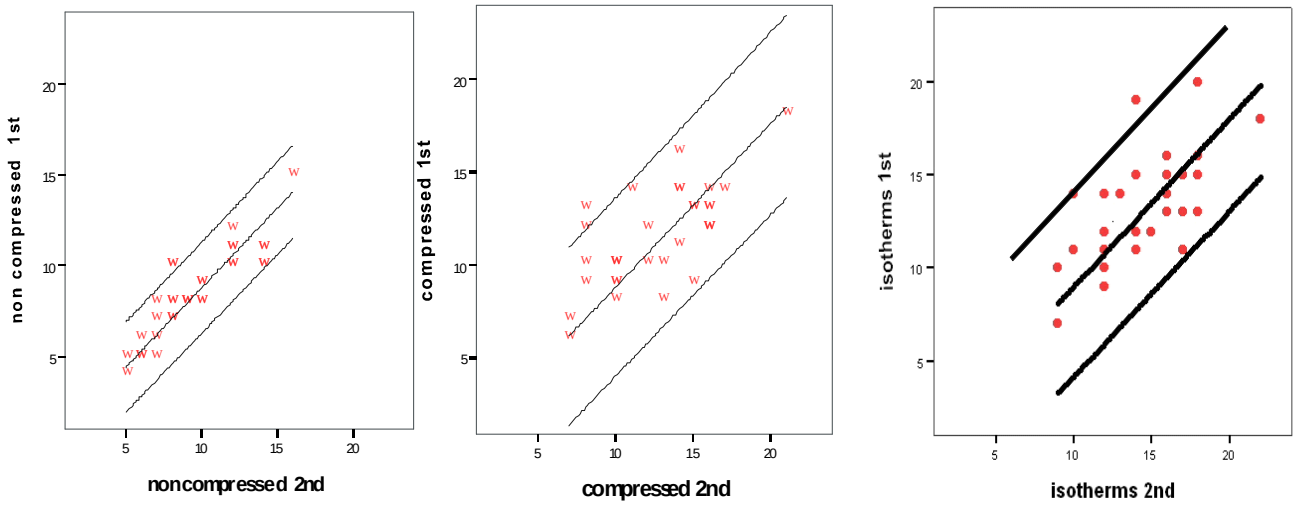


Compressed, 2nd count
median: 13, 95%CI 11.31 to 13.82



Isotherms, 2nd count
median: 14, 95% CI 13.39 to 15.55

Figure 6
Scatterplots of identifies hot spots in the first agianst the second count. (Study A)



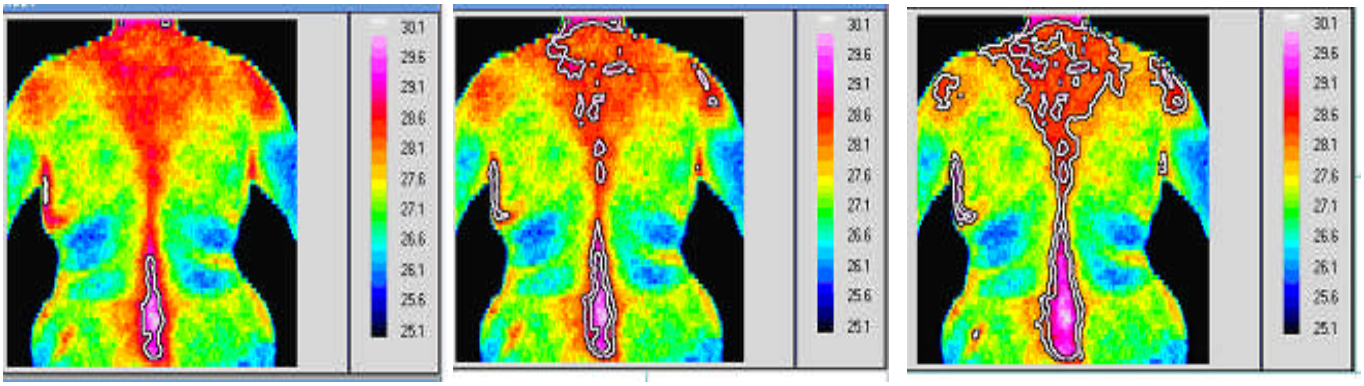


Figure 7
3 isotherms method in study B,

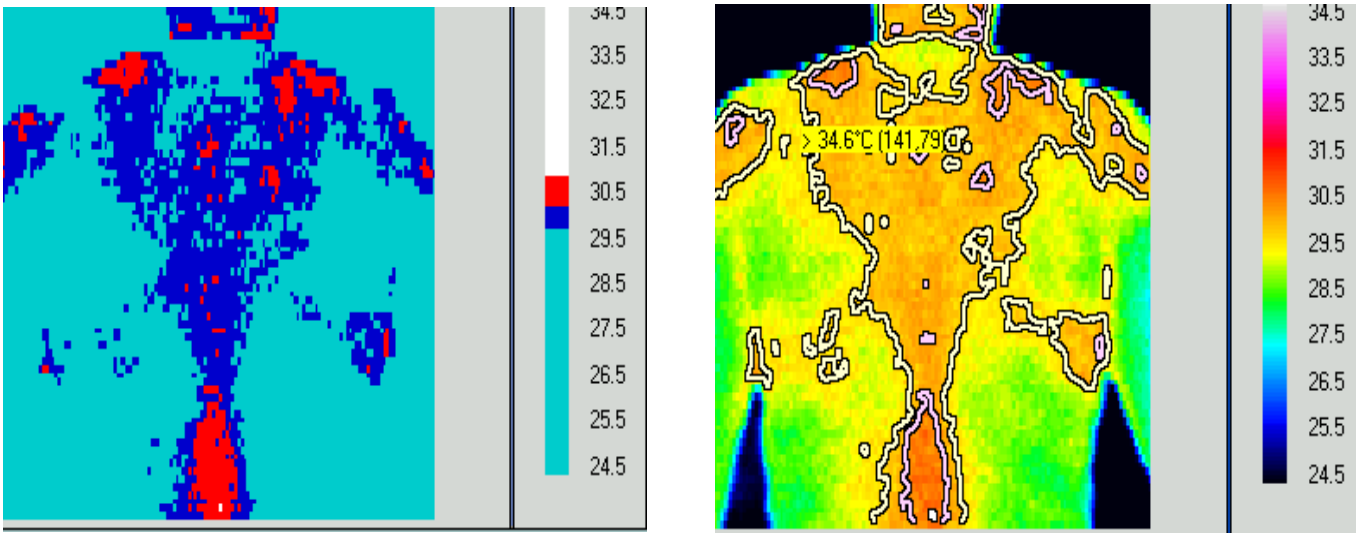


Figure 6
Thermal image colour coded hot spots and the same image with a set of 3 isotherms

smallest number of hot spots were identified in the uncompressed image (Figure 5). The smalles range of variation of hot spot count was detected with the uncompressed colour scale (Figure 6)

Reproducibility of each of the three methods was moderate to good (table1). Reliability coefficient and intraclass correlation within the groups was best for the compressed scale and worst for isotherms. The reproducibilty across the groups was best between the compressed scale and isotherms., but lowest between the uncompressed sale and isotherms.

Study B

A set of 3 isotherms detected the highest number of hot spots. The first count obtained on average 17.4 ± 8,3 hot spots, the repeated count 2 days later resulted in a mean number of 17.3 ± 7.9 hot spots. Table 2 shows the reliability coefficients and the intracalss correlation for hot spots, hot areas and the combination of hot spots and hot areas.

The reproducibility of hot spot counts in the range of high temperature was slightly better than the count of hot spots in low temperature range.

Discussion

While the median number of hot spots varied in study A in different image processing, the mean number of hot spots detected with the set of isotherms was nearly identical in both sets of evaluation. Nevertheless, the reliabilty coefficient of the hot spot count with a set of isotherms was of the same magnitude as with uncompressed colour scale or isotherms in study A. Hot area identification obtained a low grade of reproducibility

The rather disappointing low grade of reproducibility of the 3 isotherm method may be caused by several causes.

Firstly, the maximum size of a hot spot and the minimum size of a hot area were not cleary defined. This might have caused false classifications of big sized hot spots as hot areas and vice versa. Small hot spots and large hot areas may have been missed particularly when the isotherms were very irregular in shape.

The threshold for the isotherms with the highest and the lowest temperature differed between the two readings, although the reproducibilty of hot spot counts at either end of the temperature range was very good and better as the reproducibilty throughout the full range of temperature.

Finally, very small hot spots may have been overlooked, particulary in the range of lower temperatures and when located close to an irregular shaped isotherm.

Counting hot spots may be easier when the area between isotherms is colour coded instead of marking the edge of the isotherms (figure 8). Automatic combination of isotherm definition and colour scale manipulation function might improve hot spot identification. Furthermore, after definition of three isotherms a locking mechanism is proposed to allow movement of all isotherms through the total range of temperature within the thermal image.This would increase the comfort in using the software.

Conclusion

Compared to the first attempt to determine the reproducibility of hot spot count within thermal images from fibromyalgia patients [21], both investigated methods showed a marked inprovement in the grade of repeatability. However, the obtained reproducibility of hot spot identification might not be sufficient to recommend hot spot count as an outcome measure for trials in fibromyalgia patients. This is caused by the high variabilty of temperature distribution in most of the typical tender sites in fibromyalgia.

In the case of epicondylitis, however, hot spots are closely related to low threshold for pain at pressure [2, 22] and have proved to be responsive outcome measures for physical therapy [22] and radiofrequency microtenotomy [23]. Only one other clinical study used infrared thermography in a low level laser trial for myofascial pain syndrome [24 and reported decrease of skin temperature and increase of pressure pain threshold after irradiation with low level laser..

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Thermography guided Irradiation using Water-filtered Infrared-A (wIRA) and Radiotherapy on Recurrent Breast Cancer - First Experiences and Temperature Analysis

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SUMMARY

PURPOSE: The response of cancerous tissue to ionizing radiation is significantly increased by local hyperthermia, as shown in many randomized clinical trials. However, there is a lack of data regarding hyperthermia dose application and administration. The risk of thermal skin overload and severe burns is always present when trying to reach the maximum of therapeutic tissue heat. To solve this problem, new equipment for safe and self controlling local hyperthermia was designed, including a high precision and high resolution medical infrared thermography unit.

METHODS: In addition to electron radiotherapy (linear accelerator), local hyperthermia was applied to women with inoperable recurrent breast cancer who were classified as resistive to further therapy. Due to the depth of the cancerous clusters (1 to 2 cm), water-filtered Infrared-A (wIRA, 800 - 1400 nm wavelength) irradiation was chosen to transfer the heat into the target tissue. The advantage of wIRA is that the heat is deposed in a depth of 1 to 2 cm below the skin. The infrared radiation wavelengths that lead to skin burns are mostly filtered.

To monitor the wIRA irradiation, to control the amount of heat radiation from the heat source and to avoid heat overload and burden of the skin, the whole equipment is controlled by a computer in combination with a specialized medical infrared thermography unit. The whole irradiated area is continuously monitored by the temperature measurement unit with a permanent real time measurement data stream to the computer. An adjustable skin burn avoiding upper threshold limits the wIRA irradiation. Another lower threshold ensures the maximum of available therapeutic heat deposit.

RESULTS: Eight patients have been treated with this new device. The equipment worked well within the expected range. Although the thermal pattern of the irradiated area was very inhomogeneous (scars etc.), no heat burden or skin burn sign occurred. The system was perceived as comfortable and reliable for patients and physicians. Compared to the previous standard method (without infrared thermal measurement unit) the efficiency of the wIRA therapy could be remarkably enhanced. The equipment kept the skin temperature reliably below the critical limits.

CONCLUSION: Thermography guided wIRA irradiation of women with inoperable recurrent breast cancer is a crucial advantage and superior to infrared irradiation without thermal monitoring. Due to the inhomogeneous heat pattern, the measurement device must ensure high accuracy, stability, thermal and spatial resolution. Simple medical contact or infrared thermometers will not be able to recognize hot spots within the irradiated area. Further developed equipment will control more than one wIRA unit and provide exact infrared dose information.

KEY WORDS: Water-filtered infrared-A (wIRA), infrared thermography, breast cancer, hyperthermia, temperature measurement, infrared irradiation.

THERMOGRAPHIE GESTÜTZE BESTRAHLUNG MIT WASSER GEFILTERTEM INFRAROT A UND RADIOTHERAPIEFBEI WIEDER AUFTRETENDEN BRUSTKREBS- ERSTE ERFAHRUNGEN UND TEMPERATURAUSWERTUNG

ZWECK: Zahlreiche randomisierte klinische Studien haben gezeigt, dass die Epfindlichkeit von Krebsgewebe auf ionisierende Strahlung durch lokale Hyperthermie erhöht wird. Allerdings besteht ein Mangel an Daten über die Durchführung der optimalen Hyperthermie-Dosis. Das Risiko einer Überwärmung der Haut und von schweren Verbrennung besteht beim Versuch einer maximalen therapeutischen Überwärmung immer. Für die Lösung dieses Problems wurde eine neues Gerät zu sicheren und selbst kontrolliertem lokalem Hyperthermiebehandlung entwickelt, das auch eine zuverlässige und hochauflösenden Infrotkamera beinhaltet.

METHODE: Zusätzlich zur Elektronen-Strahlentherapie (Linearbeschleuniger) wurden Frauen mit inoperablen, Therapie resistenten, rezidivierenden Brustkrebs mit lokaler Hyperthermie behandelt. Angesichts derLoklisation der Krebszellen 1-2cm unterhalb der Oberfläche wurde ein Wasser gefilterter Infrarot A Strahler (wIRA, 800 - 1400 nm Wellenlänge) für die Hyperthermie des Zielgewebes ausgewählt. Der Vorteil von wIRA liegt darin, dass dadurch eine Überwärmung 1-2 cm unterhalb der Haut erzielt werden kann, da die Infrarotstrahlen, welche an der Haut zu Verbrennungen führen können, bereits gefiltert werden.

Die gesamte Hyperthermieeinheit wird durch einen Computer in Verbindung mit einer speziellen medizinischen Infrarot-Thermographie Einheit kontrolliert, um die wIRA Bestrahlung zu überwachen, indem die Gesamtheit der Wärmestrahlung von der Wärmequelle kontrolliert wird, um einen zu große Wärmebelastung der Haut zu vermeiden. Das gesamte bestrahlte Areal wird kontinuierlich durch die Temperaturmesseinheit überwacht, die in Echtzeit einen andauernden Datenstrom dem Computer zuführt. Die wIRA Bestrahlung wird durch eine einstellbaren oberen Grenzwert eingeschränkt, um Verbrennungen zu vermeiden. Ein zweiter unterer Grenzwert erlaubt die maximal mögliche Wärmeaufnahme.

ERGEBNISSE: Acht Patientinnen wurden mit diesem neuen Gerät behandelt. Das Gerät funktionierte erwartungsgemäß sehr gut. Obwohl das thermische Muster des bestrahlten Gebiets sehr inhomogen war (Narben usw.) wurde keine Wärmeüberladung oder Verbrennungen beobachtet.Das System wurde als angenehm und zuverlässig von Patienten und Ärzten wahrgenommen. Im Vergleich zur bisherigen Standardmethode (ohne Infrarot basierter Temperaturmesssung) konnte die Wirksamkeit der wIRa-Therapie deutlich erhöht werden. Mit dieser Therapieienheit wurden kritische Temperaturgrenzwerte nie erreicht oder überschritten.

CONCLUSION: Die Thermographie gestützte wIRA Bestrahlung von Frauen mit inoperablen, wieder auftretenden Brustkrebs stellt einen entscheidenden Fortschritt dar und ist der Infrarotbestrahlung ohne Temperaturüberwachung überlegen. Auf Grund der inhomogenen Wärmeverteilung an der Hautoberfläche, muss die Messeinheit einen hohen Grad von Stabilität und Messgenauigkeit sowie hohe thermische und räumliche Auflösung garantieren. Einfache Kontaktthermometer oder Infrarotradiometer können heiße Zonen innerhalb des bestrahlten Gebiets nicht entdecken. Weiter entwicklete Therapiegeräte werden mehr als eine wIRA Bestrahlungserinheit überwachen können und eine exakte Dosis der Infrarotstrahlung zur Verfügung stellen.

SCHLÜSSELWÖRTER: Wasser-gefiltertes Infrarot-A (wIRA), Infrarot -Thermographie, Brustkrebs, Hyperthermie Temperaturmessung, Infrarotbestrahlung.

Thermology international 2011, 21: 47-53

Introduction

Breast cancer still is the most common malignant disease of women in developed countries. Despite medical effort (surgery, radiotherapy, chemotherapy), many women with inoperable recurrent breast cancer have to be classified as resistive to further therapy. Additional ionizing irradiation like electron therapy (linear accelerators) is limited due to severe side effects. To increase the response of cancerous tissue to ionizing radiation significantly, local hyperthermia can be applied, as shown in many randomized clinical trials[1,2,3].

The cancerous infiltrated tissue thickness of women after breast surgery is in the range of a few centimeters. To increase the temperature of the cancerous tissue, water-filtered infrared A (wIRA) can be applied. But Infrared irradiation, especially if not water-filtered, can lead to severe burns of the skin (Figure. 1). Therefore therapeutic infrared irradiation uses wIRA for local hyperthermia, deposing heat into cancerous tissues and avoiding an intolerable thermal burden of the body surface (skin) by filtering the long wave infrared B and C.

Methods

The wIRA equipment - Heater

To shift heat into the cancerous infiltrated tissue without burning the skin, wIRA equipment of Hydrosun® Medizintechnik, Muellheim, Germany, was chosen (Fig. 2, radiator type 501 with a 750 W 3000 K halogen bulb, a 10 mm water cuvette and standard orange filter). The water-filtered (visible) red light and (invisible) infrared spectrum ranges from 550 to 1400 nm (Fig. 3) with approximately 185 mW/cm² total irradiation intensity wIRA +VIS; with approximately 140 mW/cm² water-filtered infrared-A (wIRA) and approximately 45 mW/cm² visible light (VIS) at a distance of 25 cm.

The wIRA hyperthermia source is posed perpendicular ca. 25 cm above the irradiated cancerous infiltrated area. A Stick limits the distance to the skin.

The wIRA equipment - medical infrared thermography measurement unit

For medical applications it is not suitable to use infrared cameras designed for industrial purposes. Due to the Medical Devices Directive (MDD, Directive 93-42 EWG) in Europe, only special calibrated thermography devices that can guarantee high accuracy, stability over time, thermal sensitivity and spatial resolution can be used. Those latest generation medical infrared cameras provide a thermal sensitivity of better than 30 mK, an accuracy of 250 mK or better, an overall homogeneity of all 76'000 or 110'000 thermal sensors of at least 250 mK and a superior stability

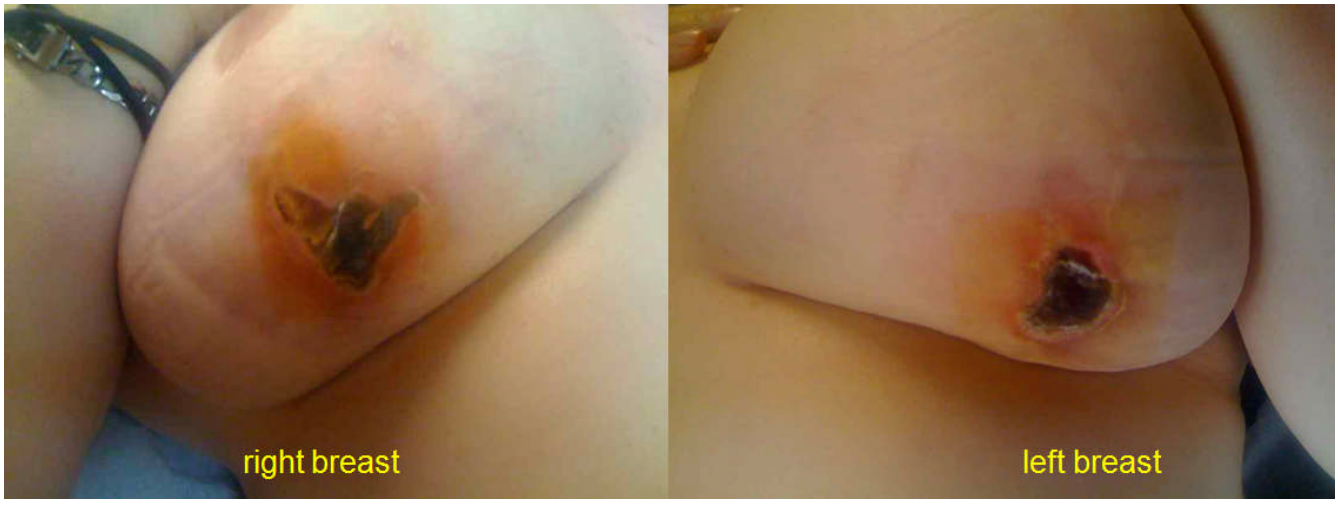

Figure 1:
Skin burns at both breasts after therapeutic infrared irradiation without thermographic monitoring

(avoiding thermal drift). In this system Jenoptik devices were integrated (formerly Carl Zeiss Jena), either as VarioCam HR head or as VarioCam HR with display, battery etc. These cameras are medically certified and comply with the European MDD.

The high spatial resolution of 384x288 thermal detector elements (>110'000 sensors) is crucial for a very detailed recording of the thermal pattern of the irradiated area. Infrared cameras with lower spatial resolution could miss small hot spots with an increasing hazard of local heat overload leading to severe skin burns. Another important feature of infrared cameras designed for medical measurement is the detector size. A pitch of 35 µm can catch twice as much infrared photons for measurement than detectors with 25 µm pitch. Therefore the sensitivity and accuracy of 35 µm pitch based infrared cameras is clearly better and should be preferred.

Additionally there is a need for a high aperture (f= 1/1,0) and for lenses made of pure Germanium with a transmissivity of more than 99 per cent. Industrial designed infrared cameras with a lens aperture of f=1/1,3 or f= 1/1,4 have, together with 25 µm detectors, only 25 per cent of photons for thermal measurement.

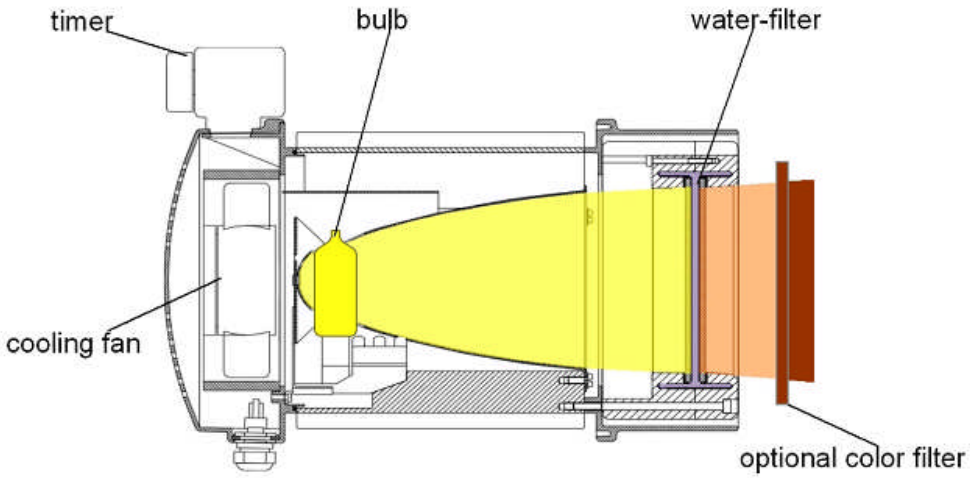

Figure 2
Cross section of a water filtered infrared-A radiator

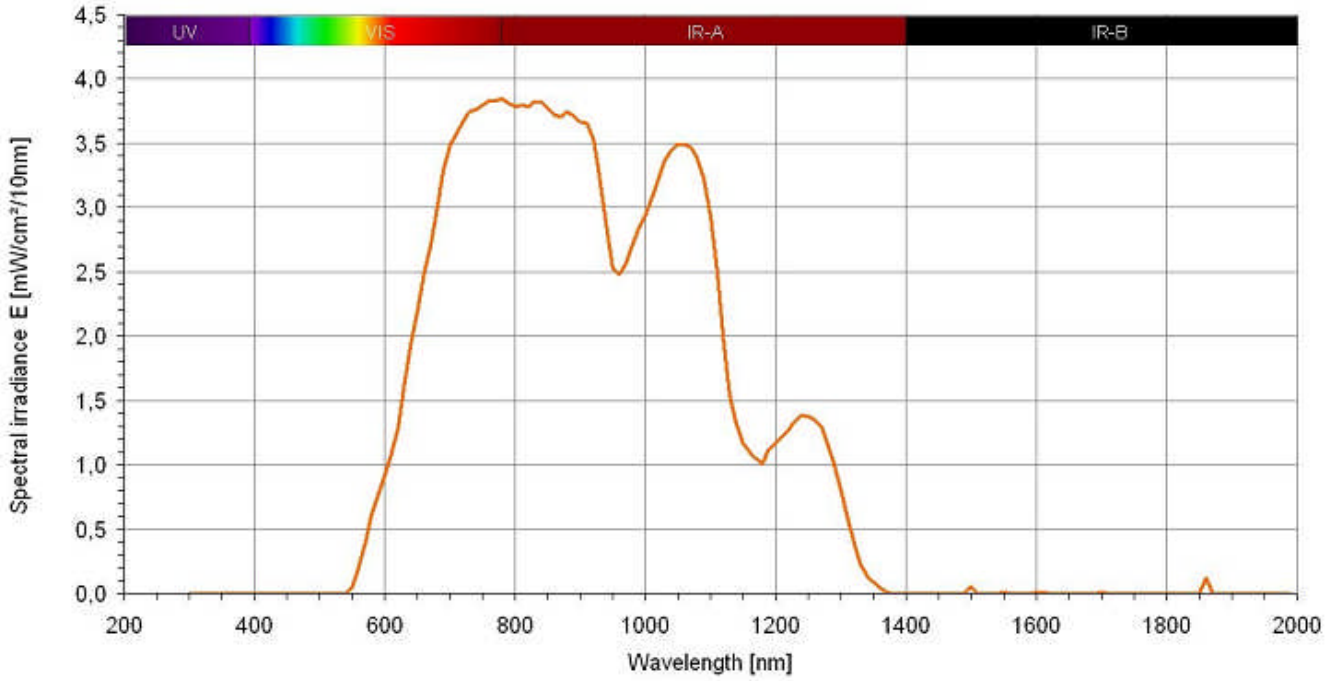

Figure 3:
Spectrum with spectral irradiation intensity E (mW/cm²/10nm) of a water filtered infrared-A radiator (Hydrosun® 501) Calculated for Hydrosun® 501 with 10 mm water cuvette and standard orange filter at approximately 185 mW/cm² (= 1.85 x 10³ W/m²) total irradiation intensity (at a distance of 25 cm) with approximately 140 mW/cm² wIRA and 45 mW/cm² (Mercer et al. 2009)

Electric auto focus is another important item, because the measurement accuracy depends on sharp and crispy images.

The medical infrared thermography measurement unit is connected to a computer through a real time data transfer interface (50 Hz).

The wIRA equipment – HeatControl unit

HeatControl is a medically certified thermal administration unit (complying with the European MDD). A dedicated microcomputer with the highly specialized software application HeatControl registers the detailed heat pattern of the irradiated skin area of the patient, sent by the thermography measurement unit (Fig. 5). Heat control is operated by the physician who adjusts the upper and lower threshold individually for every patient. The program directly controls the wIRA irradiation unit by a switch (on off), depending on the real time heat pattern of the irradiated area.

The systems aims to shift as much heat as possible into the cancerous infiltrated tissue, but (most important) ensuring to avoid any thermal overload of the irradiated skin that

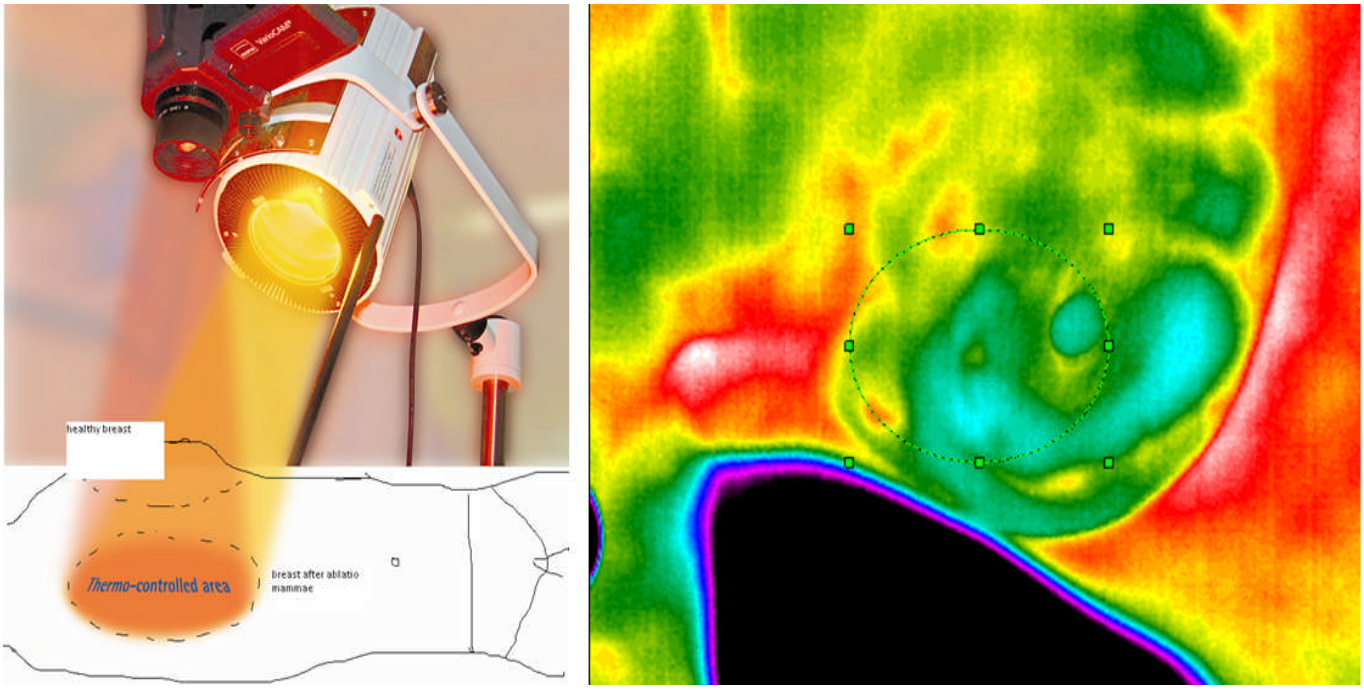

Figure 5:
Position of the wIRA heat source and the infrared thermography measurement unit, covering the same thermo controlled area; infrared image of the affected breast before wIRA irradiation

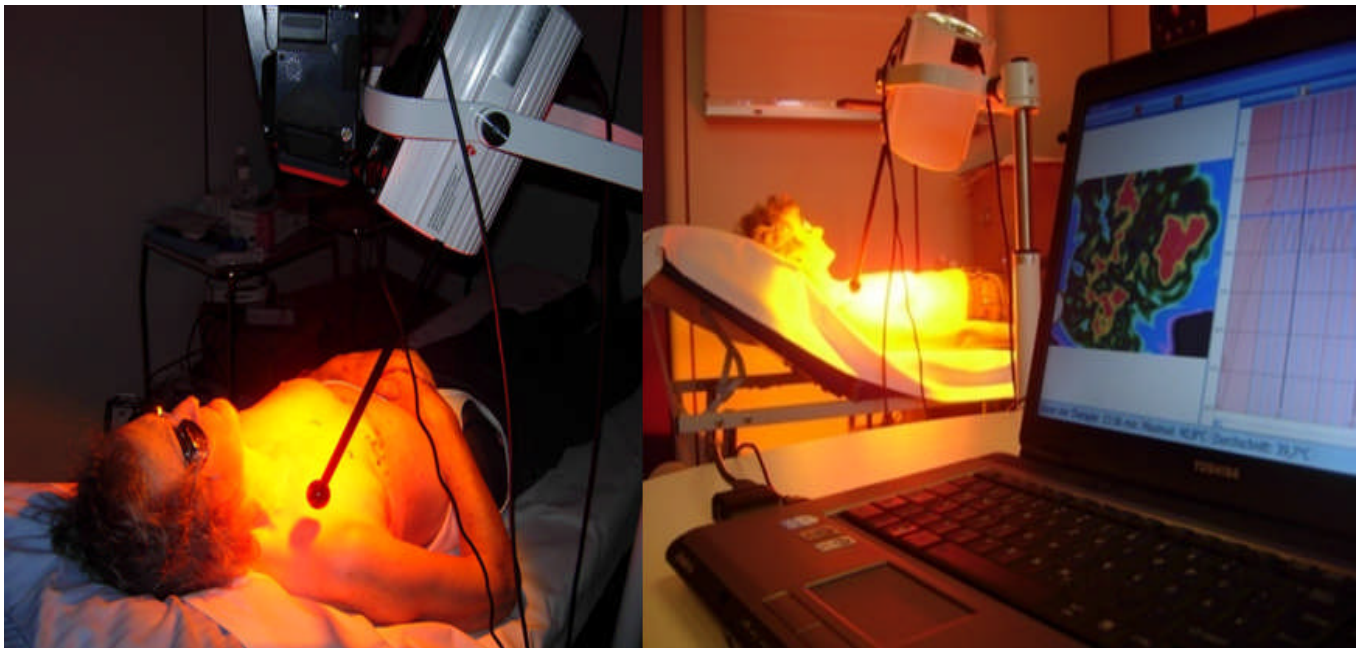

Figure 6:
Breast cancer patient undergoing wIRA irradiation controlled by HeatControl: The infrared thermography measurement unit is mounted close to the wIRA source (left image), and the software program HeatControl automatically controls the dose of heat applied (right image).

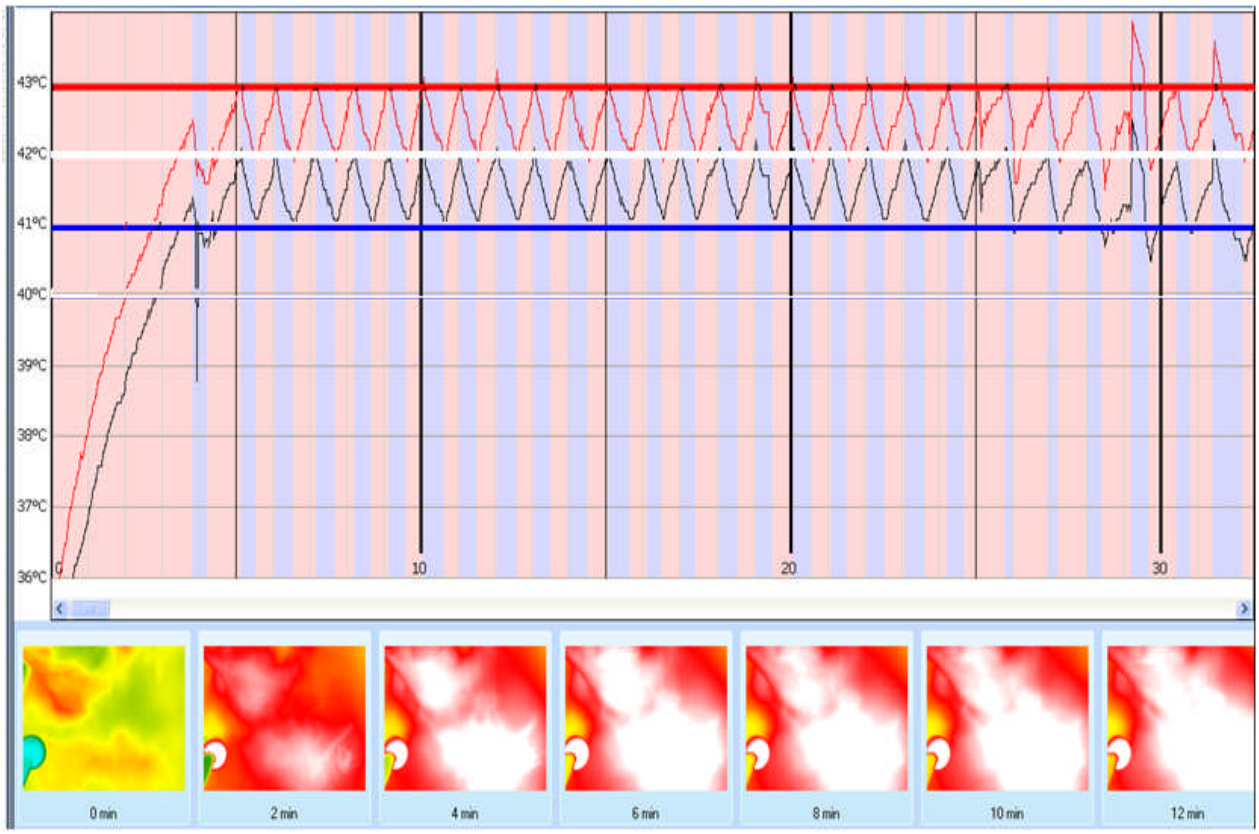

Figure 7:
Software protocol of HeatControl with upper (red) and lower (blue) threshold, >30 minutes of wIRA irradiation are automatically applied to the patient; when the maximum temperature in the area of interest reaches the upper threshold (in this case 43 °C), the wIRA source is switched off; when the average temperature reaches the lower threshold (in this case 41 °C), the wIRA source is switched on. The infrared images below show the heat pattern and pinpoint to hot spots.

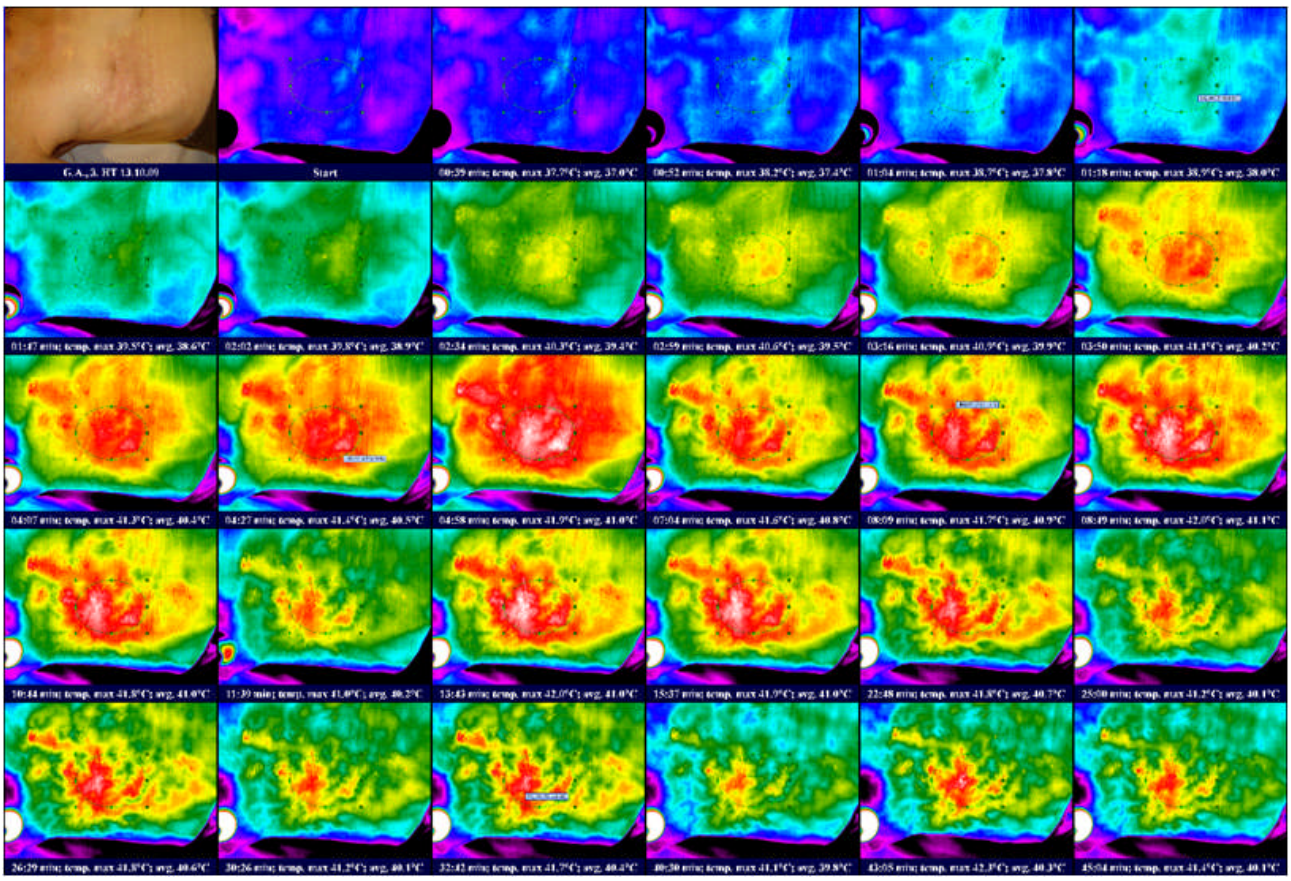

Figure 8:
HeatControl administered wIRA hyperthermia therapy of 30 minutes, recording one image per

could lead to severe burns. Especially scarves after breast surgery have a very poor blood supply and perfusion. Heat irradiated to scarves cannot sufficiently be removed by blood convection; therefore scarves are very susceptible to heat: They heat up very quickly and bear a tendency to skin burns.

The operator adjusts the wIRA beamer to the area that is to be irradiated. The infrared thermography measurement unit which is mounted close to the optical axis of the wIRA beamer is focused to the same area, but has a much wider field of view (FOV), which is necessary to monitor more than just the irradiated parts of the skin. Then the operator marks the irradiated area with a circle or ellipse. Within this marked area the program HeatControl does the mathematical evaluation for controlling the wIRA heat source. Important statistical values are maximum and average. Maxim um should not exceed the upper threshold to avoid skin burns. The average should not fall below the lower threshold to ensure the best therapeutic efficacy (Figure 6 and 7).

First results

Since installing the wIRA combined with the HeatControl unit in the "Service cantonale de radiothérapie" in the Cantonal Hospital of Neuchatel/La Chaux de Fonds, Switzerland, eight patients have been treated with the equipment. They sufferd from recurrent breast cancer with previous radiotherapyand progression under chemotherapy / hormonal treatment. 12 treatment volumes onsisted of re-irradiation: 8 x 2.5 Gy 2x/week or 5 x 4 Gy 1x/week and wIRA - hyperthermia: T_{max} 43°C, T_{min} 41°C

Table 1
Clinical results in patients with recurrent breast cancer (9/2009-2/2111)

patient	localisation	RT dose	result	Time to PDloc	comment
R.Y	chest wall	8 x 2.5 Gy 2x/w	CR	CR 12 mts	PD lung
G.E	sub-axillar	5 x 4 Gy 1x/w	CR	CR 15 mts	NED
G.A	chest wall	5 x 4 Gy 1x/w	CR	CR 9 mts	PD lung/ outside
S.T	R chest wall lat subclavicular L breast R chest wall med	8 x 2.5 Gy 2x/w 8 x 2.5 Gy 2x/w 5 x 5 Gy 1x/w 5 x 4 Gy 1x/w	CR CR NC PR	7 mts 4 mts 3 mts 3 mts	rec border rec inside PD loc stable
C.M	chest wall	2 x 4 Gy 1x/w	NC	0 mts	Stop, PD lung
B.J	subclavicular	5 x 4 Gy 1x/w	CR	CR 6 mts	PD bone
V.A	Left chest wall	5 x 4 Gy 1x/w	CR	CR 3 mts	PD outside
S.H	R chest wall sup R chest wall inf	5 x 4 Gy 1x/w 2 x 4 Gy 1x/w	PR PR	0 mts 0.mts	Stop. PD brain

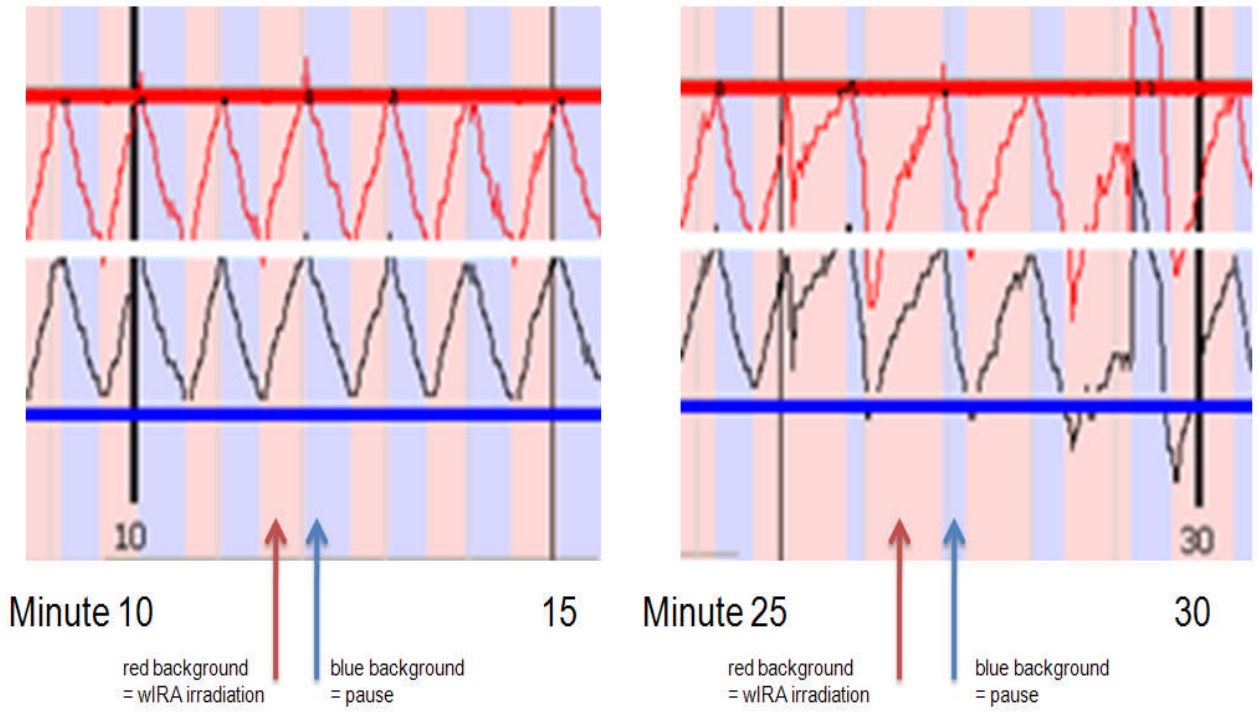

Figure 9:
HeatControl administered wIRA hyperthermia therapy of 30 minute: Initially the time slots of irradiation and pause are nearly equivocal; after 25 minutes the irradiation time slots are much longer, and the pause time slots are very short. This can be weighted as a sign of increased heat capacity of the tissue (better therapy effect) without the risk of skin burns

Re-irradiation and hyperthermia were well tolerated. Compared to the wIRA therapy without HeatControl, more heat could be applied to the cancerous infiltrated tissue. This leads to a higher susceptibility of the cancer cells when exposed to electron radiotherapy (linear accelerator).

The patients underwent multiple sessions of 30 minutes wIRA hyperthermia therapy prior to radiotherapy with ionizing irradiation. Due to the real time thermal monitoring of the heat pattern of the wIRA irradiated area, no skin burning symptoms have occurred. The wIRA application was perceived as comfortable by the patients without pain or other symptoms. Also there were no delayed symptoms after the hyperthermia therapy.

Figure 8 demonstrates a wIRA-HeatControl hyperthermia therapy of 30 minutes, recording one image per minute. It takes several minutes to initially heat up the irradiated region. After 14 minutes the peak of the skin heat pattern is visible, and after 21 minutes the heat transport capacity of the skin seems to increase, while the hot area is shrinking to a small hot spot caused by a scarf (that leads to periodically switch-off of the wIRA heat source avoiding skin burns). This phenomenon can also be seen in the HeatControl protocol (Fig. 9). After 25 minutes much more heat can be applied without burning the skin. This demonstrates that thermography guided wIRA irradiation is much more effective compared to usual hyperthermia therapy.

Conclusion

Traditional hyperthermia treatment of women with inoperable recurrent breast cancer has shown good results as a complementary method applied before radiotherapy. The more heat is applied to the cancerous infiltrated tissue, the more the cancer cells are susceptible to radiotherapy. But the amount of heat deposed was limited by the hazard of skin burns. Without infrared thermography measurement of the irradiated area, the heat could only be applied "blindly", not being able to see signs of beginning heat overload and the hazard of severe skin burns in real time during the infrared irradiation process.

Thermography guided wIRA irradiation using Heat Control is a milestone for an optimized hyperthermia therapy of women with inoperable recurrent breast cancer. Applied before radiotherapy, the susceptibility of the cancer cells is much better, and the chance for therapy in these desperate cases rises.

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15th Congress of the Polish Association of Thermology

and

Certifying course: ”Practical application of thermography in medical diagnostics”

Zakopane, March 18 – 20, 2011

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Military Institute of Health Service

Scientific Programme

Saturday, March 19, 2011

09:00 – 11:00 Session I
Chairman: Prof. Francis Ring, Prof. James Mercer

1. Kalicki B, Jung A, Ring F, Saracyn M, Niemczyk S.	Thermographic Monitoring of the Hands in Renal Dialysis Patients. Comparison of High and Low resolution Cameras.
2. Ammer K.	Infrared Thermography as a diagnostic tool and outcome measure in patients suffering from Raynaud's Phenomenon.
3. Mercer JB, de Weerd L.	Abdominal skin perfusion following breast reconstruction with a free abdominal flap anastomosed to the internal mammary vessels evaluated with Dynamic Infrared Thermography (DIRT).
4. Murawski P.	Tele Med Net programme.
5. Vardasca R., Ring F.	HAVS objective procedure assisted by medical thermography.

11:30 – 13:30 Session II
Chairman: Prof. Kurt Ammer, Prof. Boguslaw Wiêcek

1.Cholewka A, Stanek A, Kwiatek S, Sieroñ A, Drzazga Z.	Thermovision applications in physical medicine.
2.Domaniecki J, Wysoczañski B.	Thermal study of changes in pain intensity after surgery in cryochamber.
3.Pawlak J, Zalewski P, Klawe JJ, Tafil-Klawe M, Lewandowski A.	Thermovision analysis of skin surface temperature in subjectsexposed to a whole-body cryotherapy.
4. Strakowska M., Strzelecki M., Wiêcek B.	Automatic measurement of human body temperature in eye canthus using thermovision camera.
5. Strakowski R., Wiêcek B., Strakowska M	Microbolometer thermovision camera for medical applications.

15:00 – 16:00 Session III – Training course
Chairman: Prof. Ricardo Vardasca, Prof. Anna Jung

1. Więcek B — Importance of Radiation Heat Transfer In IR-Thermography
2. Rutkowski P. — FLIR

16:00 – 17:00 EAT board meeting

Abstracts

ABDOMINAL SKIN PERFUSION FOLLOWING BREAST RECONSTRUCTION WITH A FREE ABDOMINAL FLAP ANASTOMOSED TO THE INTERNAL MAMMARY VESSELS EVALUATED WITH DYNAMIC INFRARED THERMOGRAPHY (DIRT).

James B. Mercer[1,2] and Louis de Weerd [3]

[1]Cardiovascular Research Group, Department of Medical Biology, Faculty of Health Sciences, University of Tromsø, Tromsø, Norway. [2] Department of Radiology and [3]Department of Plastic Surgery and Hand Surgery, University Hospital of North Norway, Tromsø, Norway

Introduction: Breast reconstruction with a free flap from the lower abdomen has become increasingly popular. After transfer of the free abdominal flap to the thoracic wall, the vessels of the flap are preferably anastomosed to the internal mammary vessels in order to reestablish the flap's blood circulation. As the name suggest, the internal mammary vessels perfuse the mammary glands. However, these vessels continue caudally as the superior epigastric artery and vein, an important source of blood for the abdominal wall. Little is known if the removal of this blood source following the anastomotic process has an impact on the skin circulation of the abdomen.

Methods: Dynamic infrared thermography (DIRT) was used to monitor indirectly skin perfusion of the lower abdominal area in patients that have undergone autologous breast reconstruction with a free abdominal flap anastomosed to the internal mammary vessels. DIRT was performed at the end of surgery by examining the thermal recovery patterns following washing of the skin with saline at room temperature. On day 1, day 3 and day 6, DIRT was performed following a mild thermal challenge (short period of fan cooling). All IR-images were taken using a FLIR ThermaCAM S65 HS, FLIR Systems infrared camera. For processing the electronically stored IR digital images we used image analysis software ThermaCAM Researcher Pro 2.8 SR-1 (FLIR Systems AB, Boston, MA, USA).

Results: Immediately at the end of the operation skin temperature patterns of the lower abdominal area showed a clear asymmetry that was caused by a decrease in skin perfusion on the same side of the used internal mammary vessels. This asymmetry became less visible during the following days. In most patients a clear improvement in skin blood circulation was evident on the 3 day. On the 6 post surgical day, the majority of patients showed thermal distribution patterns of the lower abdominal area that were more symmetrical

Conclusion: The use of the internal mammary vessels in autologous breast reconstruction with free abdominal flap results in a temporary reduced skin perfusion of the lower abdomen on the operated side of the body.

THERMOGRAPHIC MONITORING OF THE HANDS IN RENAL DIALYSIS PATIENTS. COMPARISON OF HIGH AND LOW RESOLUTION CAMERAS

Kalicki.B, Jung A, [1]Ring F, Saracyn M. Niemczyk S.

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Introduction: Renal is a medical process that becomes necessary when the normal functions of the kidneys become compromised by failure. The process involves filtering the blood of excess fluid, , and waste when the kidneys can no longer perform this function efficiently. An arteriovenous shunt is surgically implanted to enable the regular haemodalysis to take place, As this is carried out on a regular basis on patients with chronic renal failure, problems can occur with the peripheral vascular system. When this becomes evident, it is necessary to relocate the shunt. This study has been set up to investigate the possibility of using infrared thermal imaging during dialysis to detect changes in peripheral temperatures of hands or feet to provide an objective and non-invasive indicator of the status of peripheral circulation. After repeated use the fistula can cause a blockage in blood flow.

Methods: Two low cost infrared cameras were used FLIR i5 and FLIR i7. To fully evaluate the temperature distribution a FLIR P640 high resolution camera with a combined visible light recording was used. The main differences between the two low-cost cameras were that i5 has an 80x80 pixel resolution image, i7 has 120x120 pixels. The P640 gives a better image with 640 x480 pixel image. However the higher resolution camera is almost 2kg in weight whereas the small cameras are 0.35kg each.

Performing thermal imaging of the extremities in the dialysis unit is not always simple. The patients are immobile, and the tubes conveying blood to and from the patient to the dialysis unit are often overlaying the patient. The camera needs to be mobile, and recoding images should be performed in minimal time. Wherever possible the sites to be imaged, hands or feet should be well clear of the tubes that are at blood heat. Internal storage of the images in the camera digital memory is an advantage, enabling later image analysis after computer download.

Regions of interest were drawn over the coldest finger tips of the hands and a larger region of interest selected over the dorsal and palmar area. The maximal temperature difference was calculated from the central (palmar or dorsal) region to the coldest finer tip. The i7 data was better than from the lowest resolution i5. These were compared with the identical measurements obtaiued from the P640 camera. The visible images from the latter were helpful in interpretation of the thermograms

Results: 9 patients were studied, with a total of 60 readings compared, using both the dialysed limb and the contralateral region.

The maximal differences were obtained from the palmar surfaces of the hands. The mean palmar temperatures were 33.0C from the P640, the same data from the i7 gave a mean temperature of 32.6C, a mean difference of 0.4 CWith more pixels in the image, this is an expected finding. Tthe close comparability of data was reassuring that the low cost i7 camera can be considered suitable for monitoring temperature changes in dialysis patients.

INFRARED THERMOGRAPHY AS A DIAGNOSTIC TOOL AND OUTCOME MEASURE IN PATIENTS SUFFERING FROM RAYNAUD´S PHENOMENON

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Diagnosis of vasospastic finger disease, described for the first time by Maurice Raynaud in 1862, is based on clinical signs such as colour changes of fingers when exposed to cold and/ or psychic stress. A primary form of Raynaud´s phenomenon is differentiated from vasospastic attacks secondary to an underlying disease. Slightly different diagnostic criteria exist for the primary and the secondary vasospastic disease. The British criteria used for the epidemiology of Raynaud´s phenomenon include neurological symptoms such as numbness or pins and needles while the screening criteria from US are restricted to colour changes.

Criteria for the thermographic diagnosis of Raynaud´s phenomenon are not yet established. Different procedures for temperature measurement have been published and provocative tests to elicit a vasospastic attack vary in temperature and duration of exposure. However, a combined temperature gradient (CTG) combining the differences of the temperature at the finger tip minus the temperature of the dorsum of the hand, prior and post a mild cold challenge seems to be a sensitive and reproducible measure for diagnosing Raynaud´s phenomenon by infrared thermal imaging. The CTG can clearly differentiate patients with Raynaud´s phenomenon from healthy subjects, but can not separate primary from secondary vasospastic disease.

Only two studies investigated the correlation between clinical and thermographic signs of Raynaud´s. Both investigations applied the British criteria and related them with baseline temperatures of the finger tips and reported a diagnostic sensitivity of 70% of thermal imaging for clinical signs of Raynaud´s phenomenon.

Thermal imaging was used as outcome measure in some trials for Raynaud´s phenomenon including drug treatments with prostaglandin E, prostacylin, tri-iodothyronine, fluoxitine or, nitroglycerine tape and non pharmacological therapy with low level laser or impregnated gloves. While change of fingertip temperature appeared to be an outcome of good responsiveness, the combined temperature gradient showed only a moderate sensitivity to change.

HAVS OBJECTIVE PROCEDURE ASSISTED BY MEDICAL THERMOGRAPHY

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Background: Hand-Arm Vibration Syndrome is an occupational condition that needs an accurate quantitative and objective diagnostic test to aid clinicians in the judgment of the degree of injury and correspondent treatment.

Aim: An objective assessing method is needed to provide a permanent evidence record of the degree of injury.

Methods: Medical thermography was used with a developed objective mechanic provocation test involving vertical vibration exposure of hands, for 2 minutes at 31.5Hz of vibration frequency and 36 mm/s of vibration magnitude, which was followed by a vascular provocation challenge of the hand for a period of 1 minute at 20°C. In order to assess the peripheral temperature changes of the hand a computational model was developed and the images standardised and analised.

Results: It was possible to discriminate between degrees of injury groups ($p<0.05$) but not individuals.

Conclusion: The proposed method is objective and repeatable, can provide information of the evolutionary stage of the condition. Medical thermal imaging can be used as diagnostic tool to provide evidence of occupational condition affecting upper limbs in support to medical history in medico-legal liabilities

THERMOVISION APPLICATIONS IN PHYSICAL MEDICINE

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In chosen physical medicine therapeutic applications: whole body cryotherapy, hyperbaric oxygen therapy (HBO) and Fotodynamic therapy (PDT) thermovision was used as a non-invasi ve diagnostic technique.

All studies were performed by thermovision camera Flir A40.

Volunteers were divided into three groups: 6 patients suffered from *spondyloarthrosis* treated at the Provincial Centre of Rheumatology and Rehabilitation in Gocza³kowice Zdrój (WORR) where whole body cryotherapy was applicated, 19 patients suffered from trophic ulceration of tibias treated by HBO in Burn Treatment Center in Siemianowice Œl¹skie, and 7 patients suffered from *basal cell carcinoma* (BCC) treated by PDT in Chair and Clinic of Internal Diseases, Angiology and Physical Medicine in Bytom.

Results of the studies showed that diagnostic value of thermal imaging increases due to different physical factors. This effect was especially seen after body cooling where temperature contrasts enhance was obtained and more details were visible in thermograms performed after cold impact than before one. Moreover it was confirmed that increased of oxygen pressure used in hyperbaric oxygen therapy also caused the differentiation of skin temperature gradient. In this case healing process induced by hyperbaric oxygenation improves the neoangiogenesis especially in the periphery of the wound changing metabolism and the thermal skin map. Some skin temperature changes were also observed for patients suffering from BCC due to PDT and metabolism changes caused by cancer development.

Obtained results confirmed that thermovision can be useful as a diagnostic technique in chosen physical medicine applications. It seems that thermal imaging may give also some information about therapeutic effects.

THERMAL STUDY OF CHANGES IN PAIN INTENSITY AFTER TREATMENT IN A CRYO-CHAMBER

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The etiology of pain is multisystemic. This phenomenon is difficult to assess objectively. Despite this, the definition of change in the level of pain is one of the determinants of the physical therapy progress.

The purpose of this study was to determine the relationship between changes in body temperature at the spot of pain, and the subjective feeling of pain in patients.
Study subjects were 18 persons of both sexes, aged from 32 to 64, reporting pain in the area of the lumbar and thoracic spine. Before the treatments, they were examined by a doctor and a physiotherapist.
Patients underwent a series of treatments, using the cryo-c hamber. The temperature in the main chamber was set at -130°C. Treatments were taking place once a day for 10 days. After each cooling, the patients were subjected to warming exercises.
Before the treatments, and after the series, a value of subjective pain using Visibility Analog Scale (VAS) was set. Additionally, pictures were taken, using thermal imaging camera Flir A325 and ThermaCam Researcher Professional version 2.9 software system. The biggest pain points were marked on the thermograms.

Results: 15 patients reported reduced pain after surgery (difference in VAS after surgery was 1.2 or 3 points). In twelve cases thermography indicated a reduce of the temperature of the most painful areas, and in two other, the temperature rose by 0.2 and 0.7 degree, and one patient's temperature did not change at all.
Two respondents reported an increase in pain after surgery (1 point on the VAS. In both cases the temperature of the painful areas increased).
One patient did not observe any changes in pain intensity, and the thermograms did not show changes in surface temperature of his body.

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THERMOVISION ANALYSIS OF SKIN SURFACE TEMPERATURE IN SUBJECTS EXPOSED TO A WHOLE-BODY CRYOTHERAPY

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Introduction: Whole body cryotherapy is a stimulating use of extremely low temperatures ranged from -100 C to -160 C, within 2-3 minutes. The effects of systemic cryotherapy can be registered by thermo-visual methods. The aim of the present work was to evaluate the dynamics of body surface temperatures changes in healthy people, within 6 hours after whole body cryotherapy.

Material and Methods:25 healthy men aged 22 to 49 years (31,5 +/-) were included in examinations. The patients were subjected to single whole body cryotherapy procedure. The research group stayed in a chamber during 3 minutes in temperatures ranged from -100 ^{0}C to -120 ^{0}C. The distribution of temperatures was registered before procedure (01), within a first minute after (02), following 45 minutes (03), within 3 hours after (04) as well as 6 hours from whole body cryotherapy (05). Body surface subjected to analysis was divided into 28 areas (thermograms – marked from R01 to R28), whereas 16 thermograms were subjected to statistical analysis.

The registration of surface temperature variations was performed by means of Flir System Inc. thermovisual camera *ThermaCAM P640*.

Results: As a result of intense cooling of the whole surface of the body, the statistically significant differences between mean temperature before procedure (01) T and after (02) T were noticed, for each analyzed area. The considerable lower temperature was still captured between mean temperature before the procedure (01) T and mean temperature registered 45-55 min after cryotherapy (03) T, for some of considered areas ($p<0,05$). Within 3 hours after whole body cryotherapy (04), the increase of body surface temperature was noticed with relation to values achieved before the procedure, in every considered area. Nevertheless, the statistically significant difference of temperature registered in 3 hours after the procedure (04) T with respect to temperature before entering into examination (01) T was registered only in case of two considered areas ($p<0,05$). After 6 hours from termination of whole body cryotherapy (05), the further increase of temperature was affirmed. Within some areas subjected to analysis, the statistically significant differences between temperature registered before the procedure (01) T and temperature captured within 6 hours after cryotherapy (05) T ,were still noticed. At the same time, despite the further increase of temperature within the majority of considered areas, the statistically significant differences between mean temperature of examined areas after 3 hours (04) and temperature noticed within 6 hours after the procedure (05) ($p>0,05$), were not revealed.

Conclusions: The statistical analysis of registered thermograms of skin surface revealed the intensive cooling after whole body cryotherapy. The compensation of thermal energy loses within determined areas proceeded gradually, with distinctive differences of the process dynamics. The increase of temperature after 3 hours from the procedure, revealed in case of each examined area, as well as further increase of temperature within the consecutive 6 hours, noticed for most areas, with respect to values measured before cryotherapy, is very significant. This increase of temperature, proved in a course of each stage of thermovisual measurements, was observed in case of trunk region and the proximal parts of limbs. In case of distal parts of limbs, the phenomenon maintained during consecutive 3 hours after cryotherapy procedure, and then stabilized, despite the temperature of skin surface of these areas stayed increased with respect to the value before the procedure.

AUTOMATIC MEASUREMENT OF HUMAN BODY TEMPERATURE IN EYE CANTHIS USING THERMOVISION CAMERA

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Last researches show that human body core temperature can be measured in eye canthis using thermovision camera [1]. Automatic detection of eye canthis on thermograms can be useful

tool to separate healthy people and people with fever. It is extremely important in crowded places such as airports or railway stations. The proposed system could protect from spreading dangerous illnesses.

An algorithm which automatically measures the human body temperature using thermovision camera was elaborated. The program written in Matlab selects people whose temperature is higher than normal. Implemented algorithm of finding eye canthis on thermograms mainly uses morphological operations. At first, the face is detected. Then, an ellipse is created which surrounds the face. The next step uses the morphological operations to find the local maximums and extract smaller regions of interest. Using the ellipse shape, the next selection of ROIs is performed. The region below the smaller ellipse axis is deleted, and the eye canthis are recognized by finding 2 areas that are the closest ones to the center of mass of the ellipse.

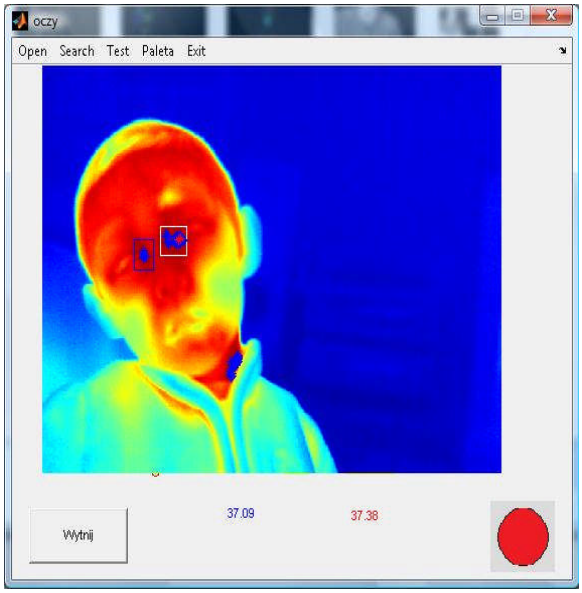

Figure 1
The example using the method of detecting eye canthis and the measuring temperature of human body

Efficiency of the algorithm	84%
Efficiency of the algorithm after deleting 2 thermograms containing 2 persons	92%
Efficiency of working the algorithm after zooming the human face in thermograms	100%

The efficiency of the algorithm is estimated by the number of cases of good detecting eye canthis in comparison to all ones. It the first test, the efficiency was equal to 84%. After deleting two pictures on which there were 2 people (child and parent), the efficiency was increased to 92%. Finally, after zooming the pictures in order to get only the human face in the thermo- grams, all eye canthis were detected. The efficiency was 100%. The improvement of working the algorithm can be done by taking pictures from the closer distance.

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MICROBOLOMETER THERMOVISION CAMERA FOR MEDICAL APPLICATIONS

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The significant growth of applications using thermography for medical diagnosis could be observe in the last years. Though, on the market there is lack of specialized and certified thermovision cameras for that type of use. In Electronic Circuits and Thermography Division at Technical University of Lodz, the uncooled thermovision camera for medical applications was constructed. Designed camera works with uncooled microbolometer detector made from vanadium oxide (VO), which works in long range of infrared radiation (8-14μm). The focal plane array of 288x384 microbolometer detectors with thermal resolution of NETD@ 300K<50mK, allows acquiring 25 frames per second. Detector's parameters together with appropriate temperature span for calibration and non-uniformity correction were selected to achieve the best measure parameters for medical applications. For the purpose of obtained thermographs analysis the dedicated software ThermalScope has been created. This environment give users access to wide range of thermal image pro- cessing tools e.g.: calculating basic and complex statistical parameters, wavelet transform, analysis using artificial neural networks and calculating Fourier transform of thermal image sequence. The software allows using camera for passive or active thermography. Actually the camera is under the certification process, which is required for medical devices.

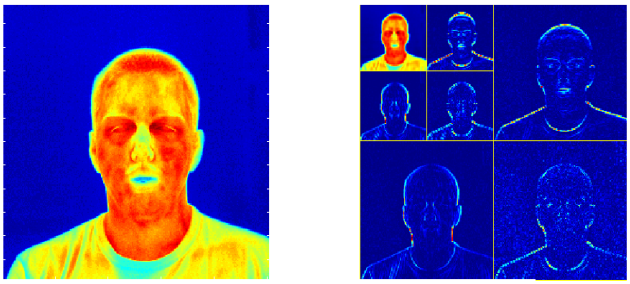

Figure1
The use of ThermalScope software for thermograph analysis – wavelets transform

IMPORTANCE OF RADIATION HEAT TRANSFER IN IR THERMOGRAPHY

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What does IR camera measure?

Relative heat transfer plays the key role in thermal imaging in every thermovision camera. The first problem mentioned in this communication is the radiative temperature measurement of the objects located at different positions versus the camera axis – fig.1. Typically the radiation intensity varies with the angle according the Lambert cosine law. The larger the angle *?* between the camera axis and the object's normal direction, the smaller the intensity *I*.

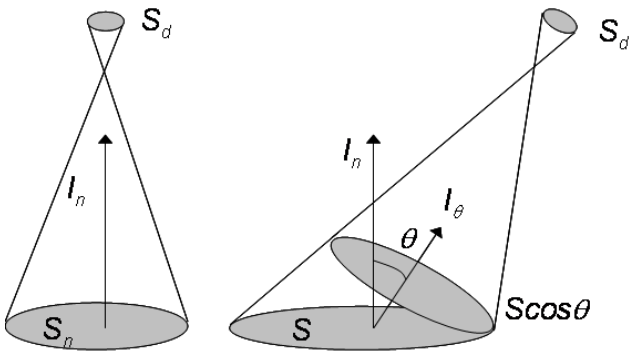


Fig.ure 1
Camera measurement with different observation angles

For larger angles, the smaller radiation intensity in compensated by increased emission area. It proves the thermovision temperature measurement regardless of the observation angle. It's valid both for the photon-cooled and bolometer-uncooled cameras. When the angle is greater than 50?, the directional (angular) emissivity changes the emissive power, and the camera calibration is no valid anymore [1].

Object's emission and reflection

Typically, the emissivity of the object is smaller than 1. It denotes that the real bodies are not the black ones, and they emit less energy one can evaluate using Max Planck law. The lower emissivity results in the object's reflection. Because the surrounding objects have typically the ambient temperature, they can be reflected from the measured surface like in a mirror – fig. 2. The reflection coefficient is estimated as *1-?*. In consequence, the radiation failing on the IR detector consists of two components: emitted and reflected from the body.

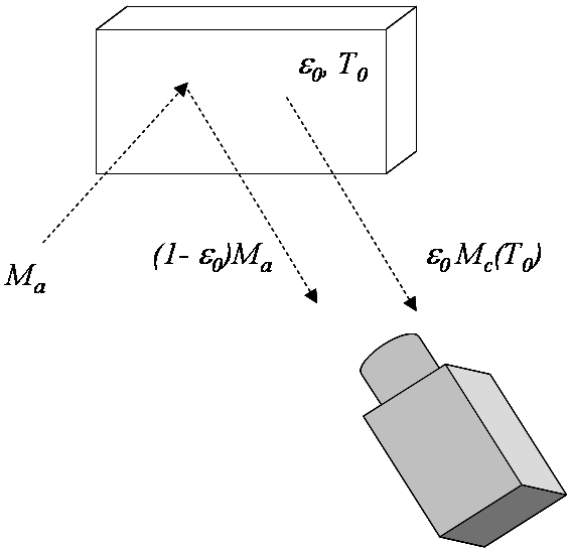


Figure. 2.
Emissivity influence on the radiation partition measured by IR camera

In addition, the radiation is attenuated by the atmosphere having the transmission coefficient τ. Every camera has to recalculate the object's radiation as it is presented by eqn. (1).

$$M_c(T_o) = \frac{M}{\varepsilon_o \tau} - \frac{(1-\varepsilon_o)M_a}{\varepsilon_o} \qquad (1)$$
$$M = \varepsilon_o \tau M_c(T_o) + (1-\varepsilon_o)\tau M_a$$

where: *M* - radiation exitance, *T0* – object's temperature, *?* – transmission of optics and atmosphere, *?0* – object's emissivity.

How to make a black body

In many practical cases, such as camera calibration and non- uniformity correction, the black body with very high emissivity has to be used. In order to design the black body, one needs to apply the theory of radiation configuration (geometry) factors. Let's assume the conical cavity as shown in fig. 3 [1]. The incident radiation is almost fully absorbed by the cone due to the multiple reflection and partial absorption. In effect, the emissivity of the structure significantly grows. This is a principle of construction of black bodies.

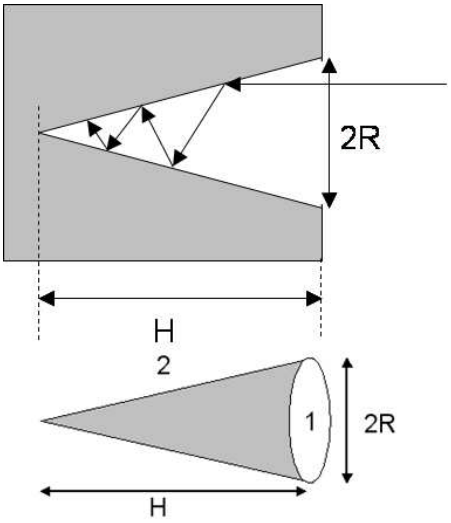


Figure 3
Conical black body

The apparent emissivity for conical geometry can be calculated using egn. (2).

$$\varepsilon_z = \frac{\varepsilon}{1-(1-\varepsilon)F} \qquad (2)$$
$$F = 1 - \frac{R}{\sqrt{R^2 + H^2}}$$

where: ε_z =apparent emissivity, ε=real body emissivity *and* *F* =geometry factor

For real material emissivity ε = 0.9 and *H = 10R*, geometry factor equals to *F* = 0,9004, and apparent emissivity ε_z = 0,989.

Bolometer detector

The last but not least is the problem of theoretical limits in the operation of microbolometr detectors. The bolometer detector absorbs the radiation energy and coverts it into heat – figure 4. In effect, the heat augments the temperature of the detector, and it changes the electrical resistivity, dielectric polarization or Seebeck voltage in resistive, pyroelectric and thermoelectric devices, respectively.

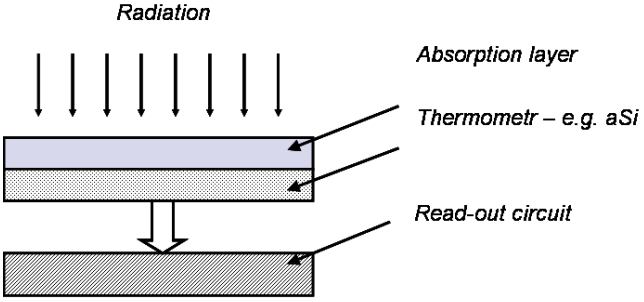


Figure 4.
A structure of microbolometr

The basic equation that governs the heating (cooling) of the bolometer describes the energy balance. The incident radiative power P is divided into the accumulation of heat in the detector and leakage of energy to the ambient – eqn. (3).

$$C_{th}\frac{dT}{dt}=\eta P-G_{th}(T-T_a) \tag{3}$$

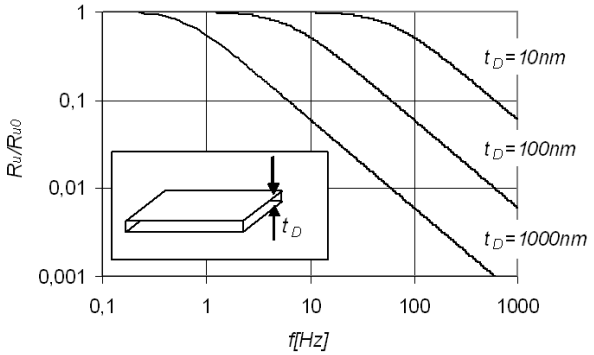
where C_{th} – thermal capacitance, G_{th} – thermal conductance between the detector and ambient, ? – absorption of IR radiation, T – detector temperature, T_a – ambient detector.

In consequence, the detector responsivity R is be essentially decreased when the heat leakage and the thermal inertia (capacity) are too high – eqn. (4).

$$R_v=\frac{\eta I_b\frac{dR}{dT}}{\sqrt{G^2{}_{th}+\omega C^2{}_{th}}} \tag{4}$$

where I – the bias current, R – electrical resistance of a bolometer, T – temperature.

As a conclusion, one can say, that the bolometer generates a signal dependent upon the radiation flux frequency [2]. With higher rate of radiation variation, the detector responsivity dramatically decreases – fig. 5. The high responsivity can only be achieved for thin (~100 nm) detectors, low thermal process variation rate (~10 Hz) and the detector encapsulated in a vacuum package.



Even if all conditions mentioned above are fulfilled, for typical microbolometer detector 25x25 μm, assuming the radiative thermal leakage only (perfect vacuum) and very small thickness (~100 nm), the thermal time constant is equal to 26 ms – eqns (5).

$$\begin{aligned}&S=25\mu m\ x\ 25\mu m\\&d=100nm\\&R_{th}=\frac{1}{\alpha_r S}=0{,}26\cdot10^{9}\,\frac{K}{W}\\&C_{th}=c_v Sd=0{,}1\cdot10^{-9}\,\frac{J}{K}\\&\tau_{th}=R_{th}C_{th}=26ms\end{aligned} \tag{5}$$

The direct consequence of long thermal time constant is the low frame rate of bolometer cameras. If someone wants to investigate high speed thermal processes, he has to buy the photon cooled camera which can easily generate more than 500 frames per second. In addition, the thermal camera has to be equipped with the opaque shutter to compensate a thermal drift. It stops the image stream, what can be inconvenient in various applications. The shutter has to be very uniform, because it generates a radiation flux which compensate the drift for every single detector in the matrix. If the thermal camera is moved from/to warm/cold ambient, the user has to wait a sufficient time in order to stabilize the temperature inside the camera.

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CRPS, RSD & Medical Thermography

CME Accredited Scientific Session
Hyatt Regency Hotel, Greenville, South Carolina April 30th,2011
South Carolina Society of Physical Medicine & Rehabilitation Scientific Session
South Carolina Medical Association Annual Meetings

Speakers

Marcos Leal Brioschi, MD, PhD

General Surgery, Forensic Sciences

Dr. Brioschi is the president of the Brazilian Thermology Society. He is also the Editor in Chief of The Journal of Pan American Medical Thermology.

Dr. Brioschi is a graduate in Surgery from Universidade Federal do Paraná in 1996 and received his master's in Medicine from Faculdade Evangélica do Paraná in 2000. He earned his PhD in Surgery from the Universidade Federal do Paranáin 2003. Dr. Brioschi is a Post-doctoral Faculty of Medicine at the Hospital and Clinics of the Universidade of Sao Paulo within the Department of Neurology. He has experience in Surgery, Forensic Medicine and Clinical Thermology (infrared imaging, thermography). He has special interest in the following subjects: pain management, breast cancer, angiology and surgery.

Kamayni Agarwal-Kozlowski, MD

Anesthesiology

Dr Agarwal-Kozlowski is Medical Director at the Center for Palliative Care and Pain Management, Hanseatic Care, in Hamburg, Germany. She has sub specialization in Pain Medicine, Emergency Medicine, Palliative Medicine, Traditional Chinese Medicine, Ayurveda, Neural Therapy and Psychosomatic Care. Dr. Agarwal-Kozlowski is a member of the German Association for Anesthesiology and intensive Care, the German Association for Palliative Medicine, the German chapter of the International Association for the Study of Pain (IASP) and the German Association for Acupuncture. She has utilized Medical Thermology for the past 16 years and has special interest in interventional pain management of neuropathic, sympathetically maintained and malignancy associated pain.

Robert G. Schwartz, MD

Physical Medicine & Rehabilitation

Dr. Schwartz owns and operates Piedmont Physical Medicine & Rehabilitation, PA, in Greenville, SC. Within his practice he specializes in pain diagnosis and treatment, physical medicine & rehabilitation, and peripheral vascular medicine.

Dr. Schwartz completed his undergraduate studies at the University of Michigan in Ann Arbor, Michigan, attended medical school at Wayne State University in Detroit, Michigan and completed his residency in Physical Medicine & Rehabilitation at the University of Texas Health Science Center in San Antonio, Texas. He is Board Certified Physical Medicine & Rehabilitation, Pain Management, Electro diagnostic Medicine, Orthopedic Medicine and Thermology. Dr. Schwartz is also a Fellow of the Society for Vascular Medicine and Biology. Dr. Schwartz is the President of the American Academy of Thermology, theExecutive Director for the South Carolina Society for Physical Medicine & Rehabilitation, and the Medical Director for Physical Medicine & Rehabilitation at Bon Secours St. Francis Hospital in Greenville, South Carolina.

Hisashi Usuki, MD, PhD.

Surgical Oncology

Dr. Usuki is the Director and Chief of the Japanese Association of Thermology. Dr. Usuki is a Clinical professor and the Director of the Surgical Center at Kagawa University Hospital in Kagawa, Japan. Dr. Usuki is a member of the International Society of Surgery, the Society of Medical Innovation and Technology, and on the Editorial Board for the journal Thermology International. His published areas of research include Thermographic examination of breast disease, surgical therapy for digestive cancer and postoperative quality of life, efficiency improvement of surgical care centers and thermal management of patients in operative rooms.

Ho-Yeol Zhang, MD, PhD

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Abstracts

GUIDELINES FOR NEURO MUSCULOSKELETAL THERMOGRAPHY
(SYMPATHETIC SKIN RESPONSE STUDIES)

General Statement:

This guideline was prepared by members of the American Academy Of Thermology (AAT) as a guide to aid the neuro-muscular thermologist and other interested parties. It implies a consensus of those substantially concerned with its scope and provisions. The AAT guideline may be revised or withdrawn at any time. The procedures of the AAT require that action be taken to reaffirm, revise or withdraw this guideline no later than three years from the date of publication. Suggestions for improvement of this guideline are welcome and should be sent to the executive director of the American Academy of Thermology. No part of this guideline may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

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Updated 2009

Extremity and Spine Infrared Sympathetic Skin Response (SSR) Evaluation

Purpose:

Infrared SSR studies of the extremities and spine are performed to provide an overview of the location, extent and severity of sympathetic skin response abnormalities. When abnormalities due to vasomotor/sudomotor dysfunction occur there are associated changes in skin galvanic impedance and skin temperature. Skin galvanic impedance changes map closely with skin temperature. In physics this is explained by the fractal nature of infrared waves and their relationship to resistance and conductivity. The SSR evaluation can be performed from the cranium to the base of the spine (inclusive of all segments) and torso to the extremities, extended to the fingers and toes.

Common Indications:

Some of the common indications for performance of extremity and spine infrared SSR imaging include (1-11):

- Evaluation or follow-up of patients with known or suspected vasomotor instability.
- Assessment of patients with known Reflex Sympathetic Dystrophy (RSD), Chronic Regional Pain Syndrome (CRPS) types I and II, Thoracic Outlet Syndrome, Vaso-motor Headache and Barre'-Leiou Syndrome.
- Pre-procedure assessment for planning of intervention.
- Follow-up to determine technical adequacy of surgical intervention, i.e., sympathetic block, sympathectomy and/or spinal cord stimulator placement.
- Follow-up to detect improvement, progression or spread of disease, which may reflect change in condition.
- Evaluation of vasospastic disorders, rheumatic inflammation and unexpected post operative or post fracture pain.
- Evaluation of trauma, shoulder hand syndrome or other disorders associated with autonomic dysfunction.
- Mapping of the extent of vasomotor instability to guide sympathetic response generator identification.
- Mapping of the location of vasomotor instability for impairment rating purposes.
- Confirmation of diagnostic inclusion criteria for clinical diagnostic purposes.
- Confirmation of diagnostic inclusion criteria for research purposes.

Contraindications and Limitations:

Contraindications for extremity and spinal infrared SSR imaging include the following:

- Presence of casts, bandages or other technical factors that preclude the ability to expose skin to a temperature equilibration environment.
- An uncooperative patient.

Guideline 1: Patient Communication and Preparation:

1.1 The examining physician explains why the extremity and spinal Infrared SSR examination is being performed to the patient, taking care to ensure that the patient understands the necessity for each aspect of he evaluation.

1.2 Responds to questions and concerns about any aspect of the examination.

1.3 Advises the patient about risk factors and symptoms of vasomotor instability or C Fiber (sympathetic) pain, and the benefits of movement in the presence of sympathetic pain or vasomotor instability.

1.4 Refers specific diagnostic, treatment or prognosis questions to the patient's physician.

1.5 Patient should not have contact with any object if that body part is being imaged. Cotton garments may be worn to cover breast or genital areas when they are not under study.

1.6 Shower or bathe the morning of the test to ensure that the skin is as clean as possible; however, avoid hot water exposure to the skin for at least two hours prior to the test.

1.7 Avoid placing any material of any kind on the skin, such as any skin lotions, deodorants, preparations, moisturizers, liniments, topical analgesics, etc. Avoid make-up if the face is to be examined

1.8 Wear loose clothing to the test; avoid anything binding against the skin; avoid support undergarments or pantyhose. Do not wear jewelry, including rings if the hands are to be examined.

1.9 Avoid skeletal manipulation, acupuncture, physical therapy, the use of TNS units, or electrodiagnostic testing for 12 hours prior to the test. Exceptions should be noted in the record.

1.10 Whenever possible steroids, sympathetic blockers, vasoactive medications, opiates and transdermal patches should be avoided for 24 hours prior to testing (8-16 hours minimum). Exceptions should always be recorded in the record.

1.11 When Stress examinations are being performed, medications that are not medically necessary and that alter sympathetic function should be avoided for at least 24 hours prior to testing.

1.12 In the absence of extenuating circumstances, for original diagnostic studies sympathetic and neurolytic blocks should be avoided for 3 days prior to testing (5,12,13,14).

Guideline 2: Patient Assessment

Patient assessment should be performed before infrared SSR imaging. This includes assessment of the patient's ability to tolerate the procedure and an evaluation of any contra-indications to the procedure (4,15).

2.1 Obtain a complete, pertinent history by interview and/or review of the patient's medical record. A pertinent history includes:

a. Current medical status, especially regarding pain and vasomotor instability.

b. Presence of any signs or symptoms of allodynia or hyperalgesia in association with sudomotor, vasomotor or other autonomic dysfunction.

c. Relevant risk factors for vasomotor instability: prior history of RSD or CRPS, trauma, fracture, repetitive use, vibration syndrome, peripheral neuropathy, spinal pathology, radiculopathy, vasomotor headache, rheumatic illness, cardiovascular disease, hypertension, diabetes, peripheral vascular disease, coagulopathy, birth control pill use, hypothyroidism or infection.

d. Pathology/Laboratory investigation values.

e. Current medication or therapies

f. Results of other SSR, thermographic or vascular studies

g. Results of prior autonomic, sympathetic or vascular interventions

2.2 Complete a limited, focused, detailed or extensive physical examination, which includes assessment of all structures under study. Trophic changes, vasomotor or sudomotor changes and possible pain generators should be documented.

Guideline 3: Examination Guidelines

3.1 Infrared thermography both measures and maps the degree and distribution of skin temperature changes. Skin temperature is largely under the control of the autonomic nervous system and bilateral symmetry is expected through out the body. Asymmetric patterns of 1 degree centigrade or greater (that are not due to local traumatic, inflammatory or vascular disease) occur when sympathetic pathology exists.

Thermography is not a test of structure, but rather physiology and therefore when structural injury is suspected other radiographic imaging or diagnostic studies should be performed. This is important as treating other previously undiagnosed conditions can often result in resolution of symptoms.

Due to the complex nature and etiology of painful conditions associated with skin temperature asymmetry patterns, only those doctors trained in the proper techniques required to perform and interpret SSR should do so. When present, the pattern of asymmetry discovered by infrared SSR examination should guide the treating physician in determining the source or generator of the abnormality. Both response to treatment and additional testing may still be required to complete this task (16-21).

3.2 All studies should utilize infrared technology with sensitivity of at least 0.1 degree centigrade (100 units nominal expansion thermal drift; NETD) and a minimum of 100 micro- radians spatial resolution.

3.3 All studies should be performed in a laboratory where ambient temperature is controlled, free from drafts and where there is no exposure to ultraviolet rays that may result in heating. The imaging room should be comfortably cool to allow for pull-off of superficial heat from the skin (20-25 degrees centigrade is commonly used). Unless a stress exam is intentionally being done no extraneous thermal stresses should exist.

3.4 Ventilation systems should be designed to avoid direct airflow onto the patient. Carpeted flooring is preferred. Exposing the patient's feet may assist with equilibration, even with upper extremity examinations. Standard fluorescent lights are appropriate.

3.5 While a single set of images can be adequate in cases where obvious thermal asymmetry exists, repetition at specified time intervals (usually fifteen minutes, but not to exceed twenty minutes) allows for assessment of reproducibility and progressive change with increased exposure to the ambient temperature. No equilibration period is required for post block or stress test examinations.

3.6 A standard exam protocol for each segment evaluated should be used. This will frequently require multiple infrared SSR windows with different points of focus (arm, forearm, wrist, hand, thigh, leg, foot, cervical, thoracic and lumbosacral spine). Each point of focus should include anterior, posterior, medial, lateral or oblique views. Contralateral and AP views should be equidistant and fill the image screen.

3.7 The patient's physical and mental status is assessed and monitored during the examination, with modifications made to the procedure plan according to changes in the patient's clinical status during the procedure. Also, findings are analyzed through-

out the course of the examination to assure that sufficient data is provided to the physician to direct patient management and render a final diagnosis.

3.8 Appropriate infrared SSR instrumentation, which includes real time display, electronic static image capture, storage, post capture annotation or hard copy documentation capabilities.

3.9 Evaluate the patient's physical and mental status prior to discharge (22-27).

Guideline 4:
Review of The Infrared Thermography Examination

4.1 The data acquired during the extremity and spinal infrared SSR examination should be reviewed to ensure that a complete and comprehensive evaluation has been performed and documented. Any exceptions to the routine examination protocol (i.e., study omissions or revisions) should be noted and reasons given.

4.2 Record all technical findings required to complete the final interpretation so that the measurements can be classified according to the laboratory diagnostic criteria (these criteria may be based on either published or internally generated data, but must be internally validated regardless of the source). (see Appendix)

4.3 Complete required laboratory documentation of the study.

4.4 Alert medical director or other responsible physician when immediate medical attention is indicated, based on the infrared SSR examination findings.

Guideline 5: Presentation of Exam Findings

5.1 Provide preliminary results as provided for by internal policy based on examination findings.

5.2 Present the record of diagnostic images and when applicable, explanations for sub-optimal examination findings to the interpreting physician for use in diagnosis and archival purposes.

5.3 Alert laboratory medical director or appropriate health care provider when immediate medical attention is indicated.

Guideline 6: Exam Time Recommendations

High quality and accurate results are fundamental elements of the infrared SSR examination. A combination of direct and indirect exam components is the foundation for maximizing exam quality and accuracy.

6.1 Indirect exam components include pre-exam procedures:

a)obtaining previous exam data, completing pre-exam paperwork,

b)exam room and equipment preparation and

c)patient assessment, history, and positioning (Guideline 1 & 2).

6.2 Post exam procedures include:

a)clean up consisting of compiling, processing, and reviewing data for preliminary and/or formal interpretation (Guidelines 3 and 4),

B) patient communication (Guideline 2),

c)examination charge and billing activities where appropriate.

Recommended time: 30-40 minutes.

6.3 Direct exam components include equipment optimization, patient positioning throughout the exam, and the actual hands-on examination process. (Guideline 3)
Recommended time: 60 minutes.

Guideline 7: Continuing Professional Education

Certification is considered the standard of practice for infrared SSR technology. It indicates an individual's competence to perform medical technology at the entry level. After achieving certification, all Registered Infrared SSR Technologists are expected to keep current with:

7.1 Advances in diagnosis and treatment of sympathetic pain syndromes with and without vasomotor instability.

7.2 Changes in infrared SSR examination protocols or published laboratory diagnostic criteria.

7.3 Advances in SSR technology used for the extremity and spine examinations.

7.4 Advances in other technology used for extremity and spinal SSR examination.

Needs Assessment

Pre-existing vasomotor tone and vasomotor capacitance plays a significant role in thermoregulation, clinical symptomatology and manifestations of systemic illness.

Thermography is the only non-invasive technology available to image and map microcirculatory arterial-venous shunting (vasomotor instability) associated with these disorders. It can play an important role in clinical diagnosis and in distinguishing between central and peripheral etiologies of thermal change. Medical Thermography can also be used to document drug induced symptoms and paradoxical responses to blocks (8,16,23,27,28).

Other technologies like PET scan, MRI, Spectroscopy, Electrodiagnostics or EEG do not provide the same information offered by Medical Thermal imaging (18). The clinical application of Thermography can help physicians both understand the patho-physiology associated with these changes and improve patient outcomes (6,26,29,30).

The mission and bylaws of the American Academy of Thermology support the incorporation of thermal imaging into clinical medicine. The AAT recognizes a current and ongoing need to promulgate CME in the science and methods of thermal imaging and the clinical application of heat asymmetry patterns obtained from thermal imaging among both physicians and thermal technologists.

Appendix

It is recommended that published or internally generated diagnostic criteria should be validated for each thermography system used. When validating infrared SSR diagnostic criteria, it is important to realize that equipment, operator and interpretation variability is inherent to this process.

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INFRARED THERMOGRAPHY VASOMOTOR MAPPING FOR CRPS/RSD SYNDROMES

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When performed with proper technique and under controlled conditions, medical Infrared Thermography is the test of choice for mapping of heat emission asymmetry patterns. The thermographically generated vasomotor map helps both with diagnosis of the underlying condition and provides invaluable information for therapeutic decision-making. The American Academy of Thermology 2009 Guidelines for Neuromusculoskeletal Thermography (Sympathetic Skin Response Studies) are attached to this abstract and will be reviewed.

From a thermographic perspective what is important is whether the resultant vasomotor response is great enough to create a change in skin temperature of greater then 1 degree centigrade compared to the contralateral side or with respect to the surrounding dermatome, sclerotome or vasotome. While dermatomes represent the distribution of sensory nerve fibers upon skin, a sclerotome reflects the distribution of skin galvanic impedance influenced by a visceral or non-visceral soft tissue structure. Numerous sclerotomal patterns exist.

Diffuse vasomotor instability involving an entire limb, or limb segment, not confined to a particular dermatome or sclerotome is the hallmark of true RSD. Dural, neuro-immuno-infectious interactions and multiple generators should be aggressively investigated. Sympathetic variants such as the Angry Back firing C syndrome where backfiring of the C fiber produces a localized increase heat asymmetry pattern (Ca+ dependant K+ channel mediated) and the Triple C Syndrome which produces a localized cold asymmetry pattern (fast K+ voltage gate driven) exist.

A combination of expertise in the basic physiology and anatomy of those structures that can exert influence in the distribution of the vasomotor abnormality found, the ability to objectify where heat emission asymmetry is actually occurring, and an understanding of what kind of variant exists allows for a more rational approach to intervention that is otherwise not possible.

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DIAGNOSIS AND MONITORING OF COMPLEX REGIONAL PAIN SYNDROMES (CRPS) WITH INFRARED THERMOGRAPHY. OVERVIEW OF CRPS/RSD DIAGNOSIS AND TREATMENT: THE AMERICAN ACADEMY OF THERMOLOGY GUIDELINES FOR NMSK THERMOLOGY

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Complex Regional Pain Syndrome (CRPS) is a painful syndrome usually affecting distal extremities manifesting with a wide variety of symptoms. The most outstanding feature is unbearable pain including spontaneous pain, allodynia, hyperpathia, and hyperalgesia. Usually, the affected extremity displays changes in color and/or temperature (vasomotor disturbances), edema, alterations in transpiration, hair and nail growth (sudomotor disturbances), and muscular atrophy and/or dysfunction (mototrophic disturbances). Temperature variations are commonly considered as a major diagnostic criterion, hence infrared thermography can be utilized as a diagnostic tool with extraordinary sensitivity and repeatability. As with all physiologic studies this method does not provide exact specificity so it is still up to the physician to provide clinical correlation.

Pain in CRPS may not be initiated nor maintained by the somatic nervous system alone, which is normally involved in conveying information on damage to the organism, the autonomous nervous system is also involved. Skin temperature is a superior predictor of sympathetic activity as a good correlation is found between skin temperature and skin sympathetic nerve activity.

Surface temperature of an extremity reflects the result of a complex combination of central and local regulatory systems. Unfortunately, infrared thermography is rarely applied as a diagnostic tool although it may depict physiologic changes that cannot be demonstrated by ultrasound, CT or MR imaging. It is a non-invasive imaging technique that allows visualization of minor cutaneous temperature alterations. It is inevitable to establish standardized room conditions in order to produce repeatable as well as comparable thermograms, as inter- and intraindividual temperature may vary extremely.

SYMPATHOLYTIC TREATMENT IN ANESTHESIOLOGY FOR COMPLEX REGIONAL PAIN SYNDROMES (CRPS): PATIENT AND TRAINEE EDUCATION. Anesthesia Approaches And The Importance Of Outcome Measurement In CRPS/RSD And Other Sympathetic Pain Syndromes

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Determining pain intensity is a key intention in pain management. Unfortunately, no tool has been developed to date, that sufficiently fulfils this task, hence, it is extremely complex to conclude, if treatment offered to a patient is helpful or not. In neuropathic and sympathetically maintained pain, blocks to the sympathetic nervous system are performed in order to diminish pain intensity. They often result in dramatic relief, though, there is no way of proving, if improvement results from blocking other structures than the sympathetic nervous system, e.g. spinal nerves. As sympathetic fibers influence blood flow by varying size of vessels, a rise in the skin temperature is expected when performing sympathetic blocks, because variation of skin perfusion correlates with surface temperature. The configuration of changes in skin temperature provides us with precious information on the success of the intervention besides the patient's subjective impression.

Multiple methods have been described in treating patients with complex regional pain syndromes. The traditional therapeutic approach is a conservative one. Local anesthetic blockade of the stellate ganglion or the lumbar sympathetic chain are a widely accepted practice in the management of a variety of pain conditions. Due to anatomic hazards blocks of the thoracic sympathetic trunk are performed rarely. Effects of sympathicolysis in the management of CRPS are often distrusted as the role of the autonomous nervous system in producing and sustaining this syndrome are not clear yet.

To achieve a pain reduction of 50%, continuous block via a percutaneous catheter to the thoracic sympathetic chain had to be performed in average for 68.8 ± 80.2 hours (median 216 hours, range one to 400 hours) and for 104.0 ± 111.4 hours (median 246, range two to 599) to attain a score that would be appraised as "sufficient pain reduction" from the patients' point of view. Patients and physicians may become impatient and distrust the procedure, if clinical effects do not appear immediately. As a result, therapy is often discontinued. Here, infrared thermograms are essential to distinguish between ineffective sympathicolysis and improper technique. Latter is very important in training of medical students and residents. Also, posture and motor function may be monitored with this valuable tool.

THE ROLE OF INFRARED THERMOGRAPHIC IMAGING IN IDENTIFYING CRPS/RSD GENERATORS, RSD LOOK ALIKES, AND FORMULATING A RATIONAL TREATMENT APPROACH

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Infrared thermographic vasomotor mapping defines the distribution of heat asymmetry and addresses the question of which body parts are involved in sympathetic pain syndromes. Diagnostic examples include RSD & its variants, Thoracic Outlet Syndrome (TOS), Cervical-Brachial Syndrome, Vasomotor headache, atypical facial pain, Barre-Leiou and Failed Back Syndrome.

While a sympathetic component should be considered in each of the aforementioned conditions, TOS deserves special attention. Patients who suffer from this malady often undergo extensive work ups only to find the results to be negative. X-ray examination for a cervical rib is only found in a minority of cases and when present an even smaller number of cases show positive arteriograms. Infrared imaging is uniquely suited to objectify the diagnosis of TOS.

There are several chronic regional pain syndromes that look like RSD but behave quite differently then true RSD. RSD Look Alikes and RSD variants will be reviewed. Points of differentiation will be discussed. A through knowledge of peripheral vascular and neuro-musculoskeltal disorders and how they can overlap in comorbid disease is fundamental to identifying RSD Look Alikes.

It is important to understand that treating any structure capable of generating a sympathetic response may actually correct the abnormality. Blocking above the vasomotor asymmetry followed by treatment below can be very effective. This may mean a local injection of medicine into a torn ligament that stops inflammation or repairs the underlying injury, or injection of a neurolytic agent that alleviates a persistent non-physiologic contraction of muscle. Naturally other examples exist, such as hyaluronidase injection into a knee, and oral or topical medications that restore blood flow and modulate sympathetic tone.

Through identification of the vasomotor map and variant presentation of the underlying condition, medical infrared imaging provides a unique diagnostic tool that is immensely instrumental in both diagnosis and treatment of associated painful conditions.

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HUMAN BEING SYMPATHETIC-STRESS LEVEL MONITORED BY IR REMOTE SENSING.

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This paper described the use of non invasive remote passive IR imaging for measurement of human vital signs to detect altered autonomic physiological status, defined as physiological stress. By means of statistical signal processing, an automated system can detect levels of physiological stress, analyzing different human being sympathetic and parasympathetic functional variables such as breathing, supra-orbital artery pulse, cold nose, ears and hands, dry mouth, flushing and moving of the face. Breathing causes noticeable changes in temperature at the nasal area, which appear as periodic changes in the face IR image. The supra-orbital arteries of the face produce time-varying heat patterns which yield information about the cardiac cycle, called pulse. Ears, nose, hands vasoconstrictions and dry mouth diminish the IR radiation proportionally to the elevation of the stress level, contrary the hyper-radiation occasioned by the vasodilatation of the face. Results on human normal subjects and exposed during a

television reality show were provided and validated against standard approaches for physiological parameters measuring. The proposed method has medical, traffic accident and public security applications as non-contact vital signs monitoring, driver's stress detection and intent identification at a distance. So it is ready to be used at airports, and health screening for monitor sympathetic-stress treatments, police departments, elder care, workplace preventive care, and vehicles dashboards.

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AUTOMATED COMPUTER MEDICAL THERMOGRAPHIC DIAGNOSIS.

Brioschi ML, Matias JEF, Colman D, Adratt E, Vargas JV, Yeng LT, Teixeira MJ.

Sao Paolo University Hospital - Neurology Department. Parana University Hospital Post-Graduation Department of Surgery. Brazilian Thermology Society. www.infraredmed.org

In order to improve infrared (IR) imaging diagnosis, application of computer software to the quantitative analysis of IR images has been studied by some investigators for years. The utilization of merely temperature alarms is not satisfactory for accurate diagnosis, it's is necessary to work with thermal patterns tools, as example algorithms and fractals, to identify physiological abnormalities like fever and some diseases, adjusted with ambient and inner eye reference temperatures. The authors have developed an on-line IR image processing system with specialized algorithms to identify different diseases. Using a system of IR pattern recognition, digital geometry and signal processing was possible to create a diagnostic tool to increase the accuracy of risk analysis of breast cancer, diabetic foot ulcer, sympathetic mediated pain syndromes, fibromyalgia thermoregulatory disturbance, knee osteoarthritis, hand/wrist rheumatoid arthritis, sleep disturbance, fever, and physiologic stress parameters. All the results were achieved from a data bank of FLIR images from the authors along 10 years of practice. From the results obtained, the quantitative diagnosis method by a computer was found to be a significant method. The overall accuracy of a computer diagnosis may vary more or less by different diseases assignments. The present processing system is being improved by the data bank.

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INFRARED 4IMAGING MONITORING (IRIM) OF NEUROVASCULAR REACTIVITY TO ASSESS THE CARDIOVASCULAR RISK.

Brioschi ML, Colman D, Adratt E, Matias JEF, Vargas JV, Yeng LT, Teixeira MJ.

Sao Paulo University Hospital. Brazilian Thermology Society. www.infraredmed.org

An impressive amount of evidence has suggested that vascular endothelium plays an important role in the control of vascular

function and structure by the production of nitric oxide. Skin vascular response is believed to be primarily due to micro-vascular reactivity; however, it is also mediated by sympathetic neurovascular interactions. This autonomic neurovascular response is involved with endothelial- and sympathetic neuronal-nitric oxide synthase (eNOS and nNOS) activity. A dysfunctional endothelium is an early marker of the development of atherosclerotic changes and can also contribute to cardiovascular events. Infrared Imaging Monitoring (IRIM) of vascular reactivity is a non-invasive, operator-independent test based on changes in fingertip temperature during and after arm cuff occlusion. IRIM has been shown to correlate with the burden of subclinical coronary atherosclerosis in asymptomatic patients, measured by coronary artery calcium (CAC) and nuclear perfusion imaging. Tarján et al. (2005) which reported that in patients with chest pain, low fingertip temperature rebound was strongly associated with myocardial infarction. Vascular reactivity is a vital component of vascular function that enables the circulatory system to respond to physiologic and pharmacologic stimuli that require adjustments of blood flow and alterations of vessel tone and diameter. Vascular reactivity can be exhibited at both the macro-vascular and micro-vascular levels. "Macro-vascular" pertains to large, conduit arteries, and "micro-vascular" refers to small, resistance vessels. Micro-vascular reactivity causes reactive hyperemia, whereas macro-vascular reactivity (flow-mediated dilatation or FMD) results from reactive hyperemia. Both macro- and micro-vascular reactivity are governed by multiple physiologic (endothelium-dependent and -independent) regulatory mechanisms and are mediated by a number of biochemical agents, such as nitric oxide (NO), endothelium-derived hyperpolarizing factor (EDHF), prostaglandins, adenosine, bradykinin, histamine, and other vasoactive substances. It is believed that macro-vascular reactivity is predominantly mediated by endothelium-derived NO, whereas micro-vascular reactivity is only partially mediated by NO. Previous studies have demonstrated the relationship between impaired micro- and macro-vascular reactivity and atherosclerotic cardiovascular disease. Similarly, several studies have demonstrated strong correlations between endothelial-dependent and independent vascular dysfunction and cardiovascular risk factors. In this regard, vascular dysfunction may be seen as an important "integrative factor" of the inherent atherosclerotic risk of an individual, taking into account the cumulative effect of various risk and protective factors. In addition to risk assessment for prediction of outcomes, another important aspect of using vascular function is to evaluate response to therapies. Jzerman et al. (2003) have found that individuals at high risk of CAD exhibit impaired micro-vascular function in skin. Moreover, recent studies have shown that skin vascular reactivity was significantly improved after statin therapy. Neurovascular dysfunction measured by IRIM is associated with the extent of myocardial perfusion imaging (MPI) and strongly correlates with Framingham risk score and CAC independent of age, sex, and traditional cardiac risk factors and is superior to Framingham risk score for the prediction of significant CAC.

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STATISTICAL RELIABILITY AND VASOMOTOR CONSIDERATIONS IN DEGENERATIVE SPINAL DISEASES

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Diseases of spinal neurosurgery are degenerative spinal diseases, spinal cord tumors, spinal injuries. I am discussing about the statistical reliability and vasomotor considerations in various spinal diseases.

Firstly, in the degenerative spinal diseases, thermography can be used to detect the radiculopathy. Meticulous division with 110 sectors was done at the neck, upper trunk and arm. Normal reference values in each sector were collected from 50 healthy controls. In the basis of this normal reference data, normal distribution curves of each thermal difference between the each opposite site sectors. After this, abnormal thermal difference between both opposite sector was calculated by the 99% confidence interval (i.e., $p<0.01$). Comparison with this thermal difference distribution curve and the temperature data of 110 sectors from each HCD (herniated cervical disc) patient's collection with unilateral protrusion was done. Cervical thermatomes of C4, C5, C6, C7 and C8 were calculated by these serial statistical analyses. Same procedure on the back and lower extremities were done and made the results of minimal abnormal thermal differences in each opposite sectors in the lower extremities and L4, L5 and S1 thermatome were made.

In the herniated lumbar disc (HLD) disease, the thermal asymmetry of the lower extremities means the amount of pain or the severity of disc protrusion and the inverse proportion of the symptom duration. And also thermography can be used to the operative indicator of chemonucleolysis of HLD.

Secondly, in the spinal cord tumors, the roles of thermography are the detections of many neurologically specific finding. Ipsilateral hypothermia in the motor weakness side can be found in the Brown-Sequard syndrome. Leveling of lesion in paraparetic or quadriparetic patient is possible in many cases. Thermatomal hypothermia in the nerve root tumor (schwannoma) can be found. Differential diagnosis between the cauda equina tumor and conus medullaris tumor can be done by thermography.

Thirdly, in the whiplash injuries, thermography can be used to the immediate diagnosis, recovery evaluation and differential diagnosis between whiplash injury and HCD.

In conclusion, these results which was based on the meticulous statistical analysis of the thermographic data with checking the

temperature in the region of interest (ROI), can use in the clinics for the diagnosis, therapeutic effect and the decision of prognosis.

THE FIBROMYALGIA SYNDROME: THERMOGRAPHIC SCORE.

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Sao Paulo University Hospital. Brazilian Thermology Society.
www.infraredmed.org

Fibromyalgia syndrome (FMS) diagnosis, characterized by chronic widespread musculoskeletal pain, disturbed sleep, fatigue, depressive mood, anxiety, is eminently clinical and depends cautious evaluation. Two hundred and twenty and six patients with FMS and a group of 34 normal volunteers proceeding from the Clinic of Pain of the Division of Neurological Clinic of the Clinics Hospital of the College of Medicine of Sao Paolo University (HC-FMUSP) and of the particular doctor's offices examiners, had been selected according to American College of Rheumatology (ACR) criteria and evaluated later by infrared (IR) thermography. It was possible to create by the thermal distribution an agreement classification on the basis of cutaneous characteristics with visual inspection of the thermograms of 7 different regions: postero-inferior (G), antero-superior (A), lumbar (L), antero-inferior (P), face (F), postero-superior (C) and palmar (M). The test of multiple linear regression demonstrated that all the regions had correlated in the evaluation of the thermal alterations. Each region of interest (ROI) presented 2-4 typical characteristics, as the disposal and extension of the thermal alterations, that had been structuralized in the form of one prop up by means of multiple regression to predict the FMS presence (R2=0,94). The hyper-radiating image in complete or not "mantle form" and paravertebral associated with hypo-radiation of extremities resulted in a FMS thermographic impression. It had significant difference of the standard of cutaneous thermal distribution between all patients with FM and normal controls. Being that it was possible to classify them by means of IR imaging and to establish quantification criteria of the presence or not of the illness. Being overcome for base the clinical criteria of the ACR for fibromyalgia syndrome the clinical correlation with infrared imaging was possible and demonstration of one prop up thermographic diagnosis.

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THE ROLE OF THERMAL IMAGING IN BREAST ONCOLOGY AND OTHER SURGICAL PATIENTS.

Hisashi Usuki, Norikatsu Maeda, Hironobu Sutou, Minoru Ohshima, Hirotaka Kashiwagi, Naoki Yamamoto, Shintarou Akamoto, Masao Fujiwara, Keitarou Kakinoki, Takehiro Takama, Masanobu Hagiike, Keiichi Okano, Yasuyuki Suzuki

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(A) Introduction. Thermography is a functional examination method. It has many different characteristics from other morphological examination methods. Researchers of thermal imaging were interested in such characteristics, which other examina tion methods did not have. In the results many important facts were detected for thermographic science. But, the all important discoveries for the thermological studies were not necessarily essential for the studies of each disease. They might not be useful for diagnosing or treatment of diseases. A diagnostic result, which was recognized by thermography, might be detected more accurately by other examination methods. Moreover, the medical science is developing continuously, and the requests for the treatment of each disease are changing all the time. In this presentation I will enumerate the characteristics of thermographic examination and discuss about which characteristics are important for the treatment of breast diseases and for the patients undergoing surgical treatment.

(B) Surgical Patients:In my previous study it was reported that the body temperature of the patients undergoing laparoscopic surgery had the hypothermia in comparison with the open surgery. The temperature of the patients with laparoscopic colectomy at the middle point of surgical period was 35.8±0.5 degree centigrade. This tended to be lower than the patients with open surgery (36.4±0.5).

The temperature of abdominal wall was also decreased from the beginning of pneumoperitoneum. In the typical case the lowest point of the abdominal wall temperature was ten minutes later than the tube temperature. In the next ten minutes, the body temperature became lowest.

It was reported that the risk of surgical site infection was related to the peri-surgical hypothermia. The body temperature can be measured without using thermographic instrument. But, the temperature of abdominal wall in a surgical period can be measured only by thermographic instrument which is non-touched measuring instrument. Then, it is necessary for demonstrating the usefulness of thermographic examination to certificate the relationship between the intra-operative hypothermia of abdominal wall and the post-operative infection of abdominal wall.

(C) Breast oncology. There are many unique characteristics of thermography in the diagnosis and the treatment of breast diseases. Thermography can detect non-palpable breast cancers. It can detect the breast carcinomas, which is not detectable by other morphological examination methods. It is able to forecast the carcinogenesis. Then, it may be useful for the mass screening of breast.

The thermographic findings relate to the prognosis of breast cancer patients. They have close relationship with its progress stage. They are also related to the proliferating ability of breast cancers. Then, it may be useful for foreseeing the prognosis of the patients.

Thermal abnormality of tumor covering skin is related to the dilatation of the subcutaneous vessels. It seems to be influenced by the producing ability of chemical mediator in the tumors. The findings of nipple hyperthermia are related to the distance from tumor to nipple. Then, it may be useful for determination of surgical method for each breast cancer patient.

However, the diagnostic accuracy of thermography can not surpass that of ultrasonography for breast diseases. There are many non-palpable breast cancers with micro-calcifications which were detected only by mammography. There are many reports "magnetic resonance imaging (MR)" are used for determination of the resecting line in breast preserving surgery. Then, the researchers should decide which way of thermographic usage could do what other examination methods could not do, and they should concentrate their effort to such study fields.

A RANDOMIZED SINGLE-BLINDED PLACEBO-CONTROLLED CLINICAL TRIALFOR ASSESSING EFFECTS OF ACUPUNCTURE AT HEGU (LI4) BY CONTACT FREE INFRARED THERMOGRAPHY

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Department of Anesthesiology, University Medical Hospital
Hamburg- Eppendorf; Germany

Even though evidence of its effects is tentative, acupuncture has long been used in the treatment of multiple maladies. So far, it has not been possible to discriminate the effects of the venue

from specific results of needling itself, thus physicians merely depend on patients' statements. We investigated the efficacy of infrared thermography in distinguishing response to "true" acupuncture as compared to non-acupoint cutaneous and muscular needling ("sham" or "minimal" acupuncture) as well as without manipulation.

Thermographic imaging was performed in 50 healthy volunteers randomly assigned to four groups: acupuncture of hegu (LI 4), needling of a cutaneous and a muscular point where no acupuncture point has been described yet, and without manipulation. In a cross-over-protocol each proband completed all four arms of the protocol in a random order. Infrared thermograms were gathered at defined points in each group. The study protocol was approved by the ethics review board.

A significant increase in surface temperature occurred within 2 minutes after needling the acupuncture point hegu (from 30.1 ± 2.7°C to 31.2 ± 3.0°C and to 31.9 ± 2.5°C after 10 minutes, $p < 0.001$), whereas needling of the cutaneous, muscular as well as without any manipulation resulted in a decrease of temperature in the monitored area. Contact free infrared thermographic imaging is a reliable and easy to handle tool to distinguish between needling at hegu and needling of a non-acupoint ("sham" acupuncture).

OCULAR MANIFESTATIONS OF REFLEX SYMPATHETIC DYSTROPHY

Heitman, KF
Greenville, SC

Reflex sympathetic dystrophy (RSD), otherwise known as complex regional pain syndrome, is characterized by a history of trauma or disease, presence of persistent pain described by burning, throbbing or aching, presence of a vasomotor/ pseudo- motor disturbance, trophic changes of skin, muscle or bone, sensitivity to cold and/or edema, and relief with regional sympathetic blockade. Since the eye and its adnexa are richly innervated by the sympathetic nervous system, it is reasonable to expect RSD symptoms in these areas. Horner's syndrome and Barre Lieou syndrome, both of which consist of sympathetic dysfunction that involves the eye and ocular adnexa can help us understand and anticipate eye findings with RSD. Asha (1999) describes a patient with the optic-spinal phenotype of multiple sclerosis who developed syringomyelia with resultant RSD. This patient developed sympathetic dysfunction including Horner's syndrome and RSD of the hand. Kapoor (2002) describes a patient with RSD and associated visual sensorimotor findings. Morimoto (1997) describes a patient with chronic ocular pain after retina surgery that was diagnosed as RSD. Schwartz (2006) describes sympathetic dysfunction found in Barre Lieou syndrome, one subset of which involves ocular symptoms. There is plenty of evidence to suggest that RSD can be accompanied by ocular findings which will be described in this paper.

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News in Thermology

Call for Papers:
Clinical Temperature Measurement,
14th June 2011,
National Physical Laboratory, Teddington, London

Temperature as an indicator of fever and disease is as old as medicine itself. Today patient temperature remains a fundamental physiological measurement used not only for observation and diagnosis but also in treatment: surgery (thermal ablation), cancer therapy (high intensitiy focused ultrasound, HIFU) and brain therapy (hypothermia treatment).

A variety of temperature measuring technologies are used clinically and these can be separated into two categories either contact (e.g. oral thermometers, axillary thermometers, temporal strips, thermocouples) or non-contact devices, for example ear thermometers and thermal imagers (thermography), which detect emitted infrared radiation.

Recent developments have realised high-speed and high-resolution systems, but temperature, its measurement and relationship to the human body still hold many new areas of understanding and innovation.

Abstracts are invited describing all clinical applications of temperature measurement. Contributions are also encouraged which address issues of instrument calibration, quality assurance and future developments in medical thermography and thermometry.

Key speakers include:

Helen McEvoy
(Head of Radiation thermometry, National Physical Laboratory)
Prof Francis Ring (University of Glamorgan)

Registration

Please register for the event on-line at

www.regonline.co.uk/clinicaltemperaturemeasurement

Submission details

Deadline: 15th April 2011

Submit to: measuremen_network@npl.co.uk

Please submit a A4 page abstract of no more than 200 words, full papers will not be required

Course on medical infrared thermography in Portugal

The instructional course on medical thermography, which was held eight times at the University of Glamorgan and once at the University of Medicine and Pharmacy "Carol Davila" in Bucharest, will be given in Leiria, Portugal on 26th and 27th July 2011. Board members of the European Association of Thermology and members of the Medical Research Unit at the University of Glamorgan will conduct this course together with Prof. Ricardo Vardasca from the Computer Engineering Department, School of Technology and Managemen at Polytechnic Institute of Leiria.

Leiria, is the designated place of the 12th European Congress of Thermology in 2012, when the main European congress of medical thermology will return to the Iberian peninsula, 32 years after the second European Thermology congress, held in Barcelona in 1978.

This course is a perfect opportunity for the EAT board members to inspect the conference facilities in Leiria, and contact and support the local organising committee. It is also a good chance, to revive the interest in medical thermography in Portugal and Spain. Spain was not only the venue of the second European Congress of Medical Thermology, it used to have many thermographic activities in the seventies and eighties of the 20th century.

12th European Congress of Medical Thermology

The board of the EAT discussed at their business meeting in Zakopane the bid of Prof. Vardasco to organise the 12th European Congress of Thermology in his hometown Leiria in Portugal. Prof Vardasco presented a provisonal budget for the congress, a conference facility at the Polytechnic Institute of Leiria and logistics for hotels and transport of participants from the hotels to the conference venue.

The EAT board members discussed the topics of the congresss and agreed that papers on technical/ engineerig aspects of thermology and on clinical applications in medicine and biology should be recruited.

Technical /engineering topics,

- Camera technology
- Image Processing/Software
- Standards
- Static and Dynamic Thermography/Provocation tests

Clinical Applications in

- Alternative Medicine
- DermatologyDentistry
- Fever Detection
- Forensic Medicine
- Physiotherapy
- Rheumatology
- Sports Medicine
- Surgery
- Thermal Physiology

- Vascular medicine
- Veterinary Medicine

Key note lectures will provide the framework for scientific content of the 12th European Thermology Congress and will include

- History of infrared Thermography
- Which Camera should I use ?
- Infrared Imaging in Wildlife Animals
- Infrared Imaging in Agriculture and Ecology

It is planned to create a webpage that will include all important informations of this conference. The EAT web- page at www.europeanthermology.org will regularly provide further informations on registration and how to submit an abstract.

Meetings

30th April 2011

CRPS/RSD & Thermal Imaging
South Carolina Society of Physical Medicine & Rehabilitation Scientific Session

South Carolina Medical Association Annual Meeting

Programm Director: Dr. Robert Schwartz

Venue: Hyatt Regency Hotel, Greenville, South Carolina

Program

8am: Welcoming remarks

8:15: Introduction of International Guest Professors

8:30-10:30 Session 1: An overview of CRPS/RSD

10:30-10:45 Break

10:45-12:00pm Session 2: Importance of Outcome Measurement in CRPS/RSD and other Sympathetic Pain Syndromes

12:00pm-1:30pm Lunch (on your own, around town)

1:30pm-3:30pm Session 3: Vasomotor Monitoring, Statistical Reliability and Vascular Considerations in Sympathetic Pain Syndromes.

3:30- 3:45 Break

3:45-5:00pm Session 4: Infrared Thermal Imaging in Surgical and Other Applications

5:00-5:30pm Panel Discussion

Information: www.piedmontpmr.com

May 2011

Veterinärmedizinisches Infrarot-Imaging

Schwerpunkt Pferde-Thermographie, (mit Zertifikat Stufe 1)

Veranstalter Deutsche Gesellschaft für Thermographie und Regulationsmedizin e.V. (DGTR, gegr. 1954)
Kurstermine 07. und 08. Mai;
28. und 29. Mai;
18. und 19. Juni 2011 (jeweils Sa. und So.)
Examen 09. Juli 2011 (Sa.)

Ort Rittergut Holdenstedt, Schlossstr. 2,
29525 Holdenstedt bei Uelzen, Lüneburger Heide

Dozenten Prof. Dr. med. Reinhold Berz,
Dr. med. vet. Andreas Feuerherdt,
Armgard von der Wense

Anmeldung und Information

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14th June 2011

Clinical Temperature Measurement
National Physical Laboratory, Teddington, London

Key Note Speakers:
Helen McEvoy (Head of Radiation thermometry, National Physical Laboratory)
Prof Francis Ring (University of Glamorgan)

Registration:
Please register for the event on-line at

www.regonline.co.uk/clinicaltemperaturemeasurement

Submission details

Deadline: 15th April 2011

Submit to: measuremenCnetwork@npl,co.uk

Please submit a A4 page abstract of no more than 200 words, full papers will not be required

17th-19th June, 2011

International Medical Thermography Seminar during the Sao Paolo University's Brazilian Pain Meeting (CINDOR2011) in Sao Paolo, Brazil

Prof Marcos Leal Brioschi – Organizing Committee

Information:
http://www.cmasp.org.br/index-cindor2011.htm

July 2nd -3nd, 2011

Jahrestagung der Deutschen Gesellschaft für Thermographie & Regulationsmedizin

Information

Geschäftsstelle DGTR

D-76337 Waldbronn-Reichenbach, Rheinstr. 7,

Telefon +49 (0) 72 43 – 6 60 22, Fax 0 72 43 – 6 59 49

July 6th-8th, 2011

17th International Conference on Thermal Engineering and Thermogrammetry (THERMO)

at the Budapest University of Technology and Economics (BME), Budapest, XI .Müegyetem rkpt.3., Hungary

THE CONFERENCE ORGANIZER:
Branch of Thermal Engineering and Thermogrammetry (TE and TGM),

Hungarian Society of Thermology (HST) at MATE,
European Association of Thermology (EAT)

ABOUT THE CONFERENCE

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

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

OBJECTIVES

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

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

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

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, multidisciplinary 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 a 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. Muegyetem rkpt.3.,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**:**

INFORMATION

Application Forms and abstracts/papers should be sent to:

Dr. Imre BENKÕ,
MATE Secretariat, House of Technology, III. 318.
H-1372 Budapest, POB. 451., Hungary

Fax: +361-353-1406, Phone: +361-332-9571.,

E-mail: ,mate@mate-net.hu,

2011: www.mate-net.hu/03menu/03index.htm and
for previous 16th THERMO
www.mate.mtesz.hu/eng/Pages/2009/THERMO2009/index.php

EAT :www.europeanthermology.com (upcoming events)

For any further information and personal inquiries please contact the following address

Dr. Imre BENKÖ,

H-1112 Budapest, Cirmos u. 1, 6/38, Hungary

Phone/fax: +361-310-0999.
E-mail: ibenko@freestart.hu

July 11th - 13 th 2011

8th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2011 in Mauritius

Conference website: http://www.hefat.net

Key note lectures

Dr Dongsheng Wen (School of Engineering and Materials Science, Queen Mary University of London, U.K) - Remote controlled nanoparticle heating for targeted medical applications

Prof. John R. Thome (Laboratory of Heat and Mass Transfer (LTCM), Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland) - Microscale Two-Phase Flow and Boiling: Fundamentals and Applications to 2D and 3D Chip Cooling

Professor Gordon Mallinson (Department of Mechanical Engineering, The University of Auckland, New Z ealand) - Visualisation Strategies for Computational Thermo Fluid Dynamics

Prof. Predrag Pega Hrnjak (University of Illinois, USA)- Heat Rejection in Condensers Close to Critical Point: desuperheating, condensation in superheated region and condensation of two phase fluid

Yang J, Wang J, Bu SS, Zeng M, Wang QW. (Key Laboratory of Thermal Science and Engineering of MOE, Xi'an Jiaotong University) Forced Convective Heat Transfer in Novel Structured Beds of Particles

De Paepe M, Huisseune H, De Jaeger P, T'Joen C.(Department of Flow, Heat and Combustion Mechanics, Ghent University- Ugent, Belgium) - The use of open cell metal foams in heat exchangers: possibilities and limitations

Dr Mahbub Alam (Department of Mechanical and Aeronautical Engineering, University of Pretoria, Pretoria 0002, South Africa)- Fluid Dynamics Around Twin Cylinders and Interactons

Further information

Prof Josua P Meyer

Chair: School of Engineering
Head: Department of Mechanical and Aeronautical Engineering, University of Pretoria

Pretoria

Tel: (012) 420 3104
Fax: (012) 362 5124

E-mail: josua.meyer@up.ac.za

July 26th-27th, 2011

1st Practical course in medical infrared thermography in Portugal

Venue: Training Room 2, B Building,
School of Technology and Management,
Campus 2,
Polytechnic Institute of Leiria,
Leiria, PORTUGAL

Course Programme:

1st day – Tuesday, 26/07/2011

9h30-10h – Registration, Opening and Introduction (R. Vardasca)

10h-10h30 – History and developments on medical infrared thermography (F. Ring)

10h30-11h – Physical Principles of heat transfer (F. Ring)

11h-11h15 – Film: "Exposure to hot and cold"

11h15-11h30 – Coffee Break

11h30-12h30 – Thermal Physiology: "Understanding thermal distributions patterns of the skin surface" (J. Mercer)

12h30-14h – Lunch

14h-15h – Detector and camera systems (R. Thomas)

15h-16h – Causes for temperature changes in the human body (K. Ammer)

16h-16h20 – Coffee Break

16h20-16h35 – CTherm Introduction (P. Plassmann)

16h35-17h – Quality control and image processing (P. Plassmann)

17h-17h45 – Provocation Tests (K. Ammer)

17h45-18h30 – Standard Protocols (K. Ammer)

18h30-19h – Production of a medical thermographic report (K. Ammer)

19h – Closing of 1st day (R. Vardasca)

2nd day – Wednesday, 27/07/2011

9h30-10h – Introduction to the practical section (K. Ammer / R. Thomas)

10h-12h30 – Practical sessions

12h30-14h – Lunch

14h-14h30 – Evaluation of the practical sessions (K. Ammer / R. Thomas)

14h30-15h –Future developments for medica
l thermography (F. Ring)

15h-15h30 – Medical education, journals and conferences (K. Ammer)

15h30 - Closing (R. Vardasca)

Course Fee = 200.00€ (does not include lunch)

Accommodation is possible on request.

For registration or information, please contact:
Ricardo Vardasca, PhD

ricardo.vardasca@ipleiria.pt

Course Instructors:

Prof. Francis Ring, DSc – Head of Medical Imaging Research Unit, Faculty of Advanced Technology, University of Glamorgan (UK)

Prof. Kurt Ammer, MD, Ph.D – Institute for Physical Medicine & Rehabilitation, Hanusch Hospital, Viena (Austria) / Editor in chief of Thermology International/ General Secretary of the European Association of Thermology

Prof. James Mercer, Ph.D – Cardiovascular Research Group, Department of Medical Physiology, Institute of Health Sciences, Faculty of medicine, The University of Tromsø (Norway) / Department of Radiology, The University Hospital of Northern Norway, Tromsø (Norway) / President of the European Association of Thermology

Prof. Rod Thomas, Ph.D – Manager Thermography Division, TWI Cambridge / Faculty of Applied Design & Engineering, Swansea Metropolitan University (UK)

Dr. Peter Plassmann, Ph.D – Computing and Mathematical Sciences Department, Faculty of Advanced Technology, University of Glamorgan (UK)

Prof. Ricardo Vardasca, Ph.D – Computing Engineer Department, School of Technology and Management, Polytechnic Institute of Leiria (Portugal)

September 15th-17th, 2011
Thermografie- Forum-Eugendorf 2011
in Verbindung mit dem
Energie- u. Luftdichtheits-Symposium Eugendorf

2010 Tagungsort: Eugendorf /Salzburg Gastagwirt

Vorläufiges Programm

DDI Franz Mair- *Unabhängiges Kontrollsystem für Ausweise über die Gesamtenergieeffizienz*

DI Nutz-Schaltenberg - *Richtiges Wohnen im Passivhaus*

Architekt Prof. Dr.H.C.Leindecker- *LQG Datenbank - Ein Tool zur Qualitätssicherung und Optimierung von Gebäuden*

Daniel Eisenmann- *Heizen mit Eis Solareis - die Zukunft des Heizens*

Dr. Renate Alijah - *Neues aus der Normung*

Ing. Gerhard Traxler- *Thermografische Auswertung in einer laserinduzierten Rissprüfung*

Weitere Redner:

DI Michael Pils,

DI. Benjamin Zauner,

Dr. Christian Möller,

Dr. Beate Oswald- Tranta

Auskunft:
Prof. Ing. Fritz Mendel

Österreichische Gesellschaft für Thermografie
Danubiastrasse 12
A - 3400 Klosterneuburg

Tel. + Fax +43-2243-37744

October 19th-21th, 2011
9th Conference on Thermography and Thermometry in der Praxis in Ustron - TTP 2011 (Krajowa Konferencja Termografia I Termometria W Podczerwieni)

Venue:Dom Wczasowy "Jawor" Sp. z o.o. w Ustroniu
ul. Wczasowa 51, 43-450 Ustroń-Jaszowiec

Language: Polish, English

Information:
Sekretariat Konferencji TTP
Instytut Elektroniki
Politechnika Lódzka
ul. Wólczanska 211/215
90-924 Lódz

12thNovember 2011
24th Thermological Symposium of the Austrian Society of Thermology

Venue: Raddisson Blue Palais Hotel Vienna, Austria

Deadline for Abstracts: October10th, 2011

Speakers:

Prof Francis Ring, UK

Prof James Mercer,Norway

Prof Boguslaw Wiecek, Poland

Prof Ricardo Vardasca, Portugal

Prof Kurt Ammer, Austria

Dr Jozef Gabrhel, Slovakia

Information

Prof K. Ammer, MD, PhD

Austrian Society of Thermology
Hernalser Hauptstr 209/14
Email: KAmmer 1950@aol.com

26th-27thNovember, 2011

2nd International Consensus and Guidelines for Medical Thermography (2011 ICGMT)

2nd. International Working Group for Medical Thermography (IWGMT) Meeting

in Foz do Iguaçu Falls, Parana, Brazil .

Prof Francis Ring – 2011 IWGMT Honor President

Prof Manoel Jacobsen Teixeira – 2011 ICGMT Honor President

Prof Marcos Leal Brioschi – Congress President

Abstract acceptance: until 31th July, 2011

Information: www.termologia.org/icgmt

The Organising Committee has great pleasure to invite you to participate in the International Consensus Guidelines and Medical Thermography in 2011 (ICGMT 2011) taking place in Foz do Iguacu, Parana, on 24 and 25 November 2011. The main themes will be:

- ·PAIN CLINIC
- ·EXPERTISE MEDICAL & LEGAL MEDICINE
- ·ENDOTHELIAL DYSFUNCTION: CLINICAL CARDIAC & VASCULAR
- ·BREAST TUMOR

IWGMT - Be part of the International Group for the Development of Medical Thermography (IWGMT), a non-governmental, non-commercial, founded to spread the complementary diagnostic method for medical thermography, increase communication and collaboration among professionals involved in this area with those argue that health policies and provisioning of social funds. The IWGMT is a large global network, consisting of representatives from various countries and societies thermology doctor.

One goal of IWGMT is developing guidelines for improving the medical applications of thermography with more quality and more cost-effective health care based on ethical and scientific arguments and expert opinion.

The principles outlined in the Consensus will be implemented throughout the world. Will be adjusted according to the laws of each country, taking into account the socio-economic and health access.

The International Consensus is established by a group of experienced doctors in Brazil and abroad who collectively have worked for years with thermography and has published in this area by implementing protocols and information technology, increasing their scientific value, performing diagnostics, monitoring techniques and establishing predictions with success in the neuro-musculoskeletal, breast, vascular diseases, among others. The agreement will involve various medical specialties and subspecialties:

Pain Forensic Medicine Forensic & / Medical Examination Cardio logy Neurology Orthopaedics Rheumatology Rehabilitation Sports Medicine Oncology Endocrinology Dermalogica Angiology Mastology Pediatrics Emergency Medicine Anesthesiology Neurosurgery General Surgery Vascular and Cardiac Surgery Plastic Surgery Thoracic Surgery Acupuncture

Based on the overwhelming success of in Fortaleza (Brazil), our meetings on the subject and the return of participants of medical societies in Brazil, the next symposium (ICGMT-2011) will be in Foz do Iguacu, Brazil in November 2011. It will be an event intended for scientific discussions by professors, lecturers and participants in a national and international forum for debate and finally the signing of a new record date for the official participants and members of IWGMT.

Do not miss this great opportunity!

Prof Dr Mark Leal Brioschi

Organizing Committee

2012

XII CONGRESS OF EUROPEAN ASSOCIATION OF THERMOLOGY

LEIRIA - 2012

FIRST ANNOUNCEMENT

19th-21st July , 2012

11th European Congress of Thermology in Leiria
combined with the 25th Thermological Symposium of the Austrian Society of Thermology

Applications in

Alternative Medicine
DermatologyDentistry
Fever Detection
Forensic Medicine
Physiotherapy
Rheumatology
Sports Medicine
Surgery
Thermal Physiology
Vascular medicine
Veterinary Medicine

Topics:

Camera technology
Image Processing
Standards
Static and Dynamic Thermography/Provocation tests

Key note lectures

History of infrared Thermography

Which Camera should I use ?

Infrared Imaging in Wildlife Animals

Infrared Imaging in Agriculture and Ecology

Thermology international

Dr. Kurt Ammer
• Österreichische Gesellschaft für Thermologie
•
• Hernalser Hauptstr.209/14
• A-1170 Wien
• Österreich

• This journal is a combined publication of the Austrian Society of Thermology and the European Association of Thermology (EAT)
• It serves as the official publication organ of the the American Academy of Thermology, the Brazilian Society of Thermology tthe UK Thermography Association (Thermology Group) and the Austrian Society of Thermology.
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Thermology international

Dr. Kurt Ammer
• Österreichische Gesellschaft für Thermologie
•
• Hernalser Hauptstr.209/14
• A-1170 Wien
• Österreich

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