13th Congress of the Polish Association of Thermology

and

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

Zakopane, March 27 – 29, 2009

Scientific Committee:

Prof. Jung Anna MD,PhD
Zuber Janusz MD,PhD
Prof. Ring Francis Dsc
Prof. Wiêcek Boguslaw
Murawski Piotr MSc,Bsc.
Prof. Klosowicz Stanislaw
Prof. Ammer Kurt MD,PhD

Organizing Committee:

Prof. Jung Anna MD,PhD
Zuber Janusz MD,PhD
Kalicki Boleslaw MD,PhD

Conference venue: Hotel "HYRNY"
Zakopane, Pilsudskiego str 20

Organizers: Paediatric,Nephrology and Alergology Clinic
Military Institute of Health Service
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Chairman of the Organizing and Scientific Committee Prof. Anna Jung MD,PhD

Scientific and Social Programme

Friday, 27th March 2009,

19:45 Welcome

Saturday, 28th 2009

9:00-10:30 **Session I**
Chairmen: Prof. K. Ammer, Dr med. J. Zuber.

. **Opening lecture:** *Prof. Ring E.F.J., Vardasca R.*
The first International Symposium of Medical Thermography New York December 1963: Lessons from the past.

Prof. Ammer K.
Same Magnitude of Temperature Gradients When Raynaud´s Phenomenon Is Present In Individual Or In All Fingers.

Dr med. Mikulska D., Prof. Maleszka R.
Usefullness of thermal imaging in evaluation and monitoring the treatment of morphea lesions.

10:30-11:00 **Coffee break**

11:00 – 13:30 **Session II**
Chairman: Prof. EFJ. Ring, Dr med. J. Zuber

Vardasca R, Prof. Ring EFJ.
Symmetry of temperature distribution in the upper and the lower extremities.

Prof. Wiêcek B.
Attenuation of infrared radiation by humid atmosphere.

Prof. Nica A, Mologhianu G, Murgu A, Ojoga F, Sirghii B, Miron L
Thermography Study of Patients with Stroke in the Post-acute and Chronic Stage Treated in a Rehabilitation Department.

Prof. Hisashi Usuki
A history thermological study about carcinoma and
the problems of Medical Association of Thermology in Japan.

Murawski P, Prof. Jung A, Dr med. Zuber J, Dr med. Kalicki B.
Method of the anatomical point selection on the face in the thermographic data.

13:30-15:00 **Lunch**

15:00- 17:00 **Training course**
Chairman: Prof. B. Wiêcek, Prof. S. Klosowicz

Prof. Wiêcek B.
Heat transfer basis useful for infrared thermography

Rutkowski P,
New developements in thermographic equipment

Prof. Klosowicz S.
Problems of Physics In Thermographic Studies.

19.00-22.00 **Dinner**

Abstracts

THE FIRST INTERNATIONAL SYMPOSIUM OF MEDICAL THERMOGRAPHY NEW YORK DECEMBER 1963: LESSONS FROM THE PAST.

E.F.J.Ring, R Vardasca.
Medical Imaging Research Unit, University of Glamorgan, CF37 1DL UK.

Infrared imaging before the late 1950's was a military classified technology.

The New York Academy of Sciences announced a conference in 1963, to bring together the pioneers in the first medical studies. This meeting's published proceedings provide a detailed record of that historical symposium, with its surprising range of clinical applications, considering the early camera technology of the time.

The introduction was written by J.Gershon Cohen and R.Bowling Barnes, the latter being the engineer who had built an infrared scanner for medical applications.

This was followed by a short history of Medical Thermometry (Gershon Cohen), a paper on elevation of body temperature in disease, and a paper by the well known pioneer Ray Lawson on early applications of thermography. The next section is on technology covering the early American and English cameras, a paper on densitometric analysis, the first attempts at quantifying thermograms and more from Ray Lawson on temperature measurements of localized pathological processes.

The third section is the largest of over 200 pages on clinical applications. There are 13 papers on medical applications and a further section of 4 papers on breast diseases. The British surgeon K.Lloyd Williams wrote on the value of infrared thermometry as a tool in medical research. Two American authors Rosenberg and Stephanides described the use of thermography in the management of varicosed veins and venous insufficiency. Another group described thermography in peripheral vascular disease. Other subjects included are Orthopaedics, Trauma, Neurology, thoracic and abdominal conditions, obstetrics and rheumatology. Veterinary medicine was presented by Wendall Smith.

In the breast diseases section were papers on the need for early diagnosis to improve the results of breast surgery, Temperature in breast disease (Lloyd Williams) Mass screening for breast cancer (P. Strax) and advances in mammography and thermography by Gershon Cohen.

Considering the passage of time and the remarkable changes in imaging technology, enhanced by computer processing, this historic meeting must have beeen ahead of its time.

Few of our modern applications for thermography had not been tried or envisaged, even with the primitive technology of the time. Some of the papers showed how carefully the authors had considered their data, and studied the relevant pathology to explain the changes in skin temperature. However, the extraction of temperature data from the early thermograms was difficult and certainly unreliable. In most cases thermal printing from slow scans (5 minutes or more) could only be analysed by densitometry, and the thermal print-outs were unstable after just a few days of storage. Today's high speed and higher resolution images, stored and analysed directly by computer has revolutionized the technique. Now some 45 – 50 years later, we know much more about the reliability of thermography and how that can be optimized. Do we understand any more than the pioneers of thermal physiology and the effects of pathology on neighbouring skin temperature? I believe that this symposium which was followed a few years later by others in Europe, particularly in Strasbourg France and Leiden The Netherlands have provided a good foundation for medical thermography despite the technical limitations. While not all the expectations described have been borne out, the majority have been repeated over time with improving camera technology.

Reference

Thermography and its Clinical Applications. Annals of The New York Academy of Sciences Ed. H.E.Whipple, Vol 121. ART 1 Pages 1-304 New York October 9th.1964.

SAME MAGNITUDE OF TEMPERATURE GRADIENTS WHEN RAYNAUD´S PHENOMENON IS PRESENT IN INDIVIDUAL OR IN ALL FINGERS.

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Medical Imaging Research Group, Faculty of Advanced Technology, University of Glamorgan, Pontypridd, UK

Background: Secondary Raynaud´s phenomenon may affect individual fingers only and it was proposed that the temperature difference between finger tips and dorsum of the hand is larger than in patients suffering from primary Raynaud´s phenomenon which affects by definition all fingers.

Aim of the study: Comparison of temperature gradients from the dorsum of the hand to the fingertip in patients presenting with thermographic signs of Raynaud´s phenomenon in all or in individual fingers.

Study design: Retrospective analysis of thermal images of consecutive 135 patients with suspected Raynaud´s phenomenon

Method: After acclimatization for 15 minutes to a room temperature of 24 degrees, the hands were positioned on a table, and images in the dorsal view for both hands were recorded. Then the hands, covered with plastic gloves, were fully immersed for 1 minute in water of 20°C. Immediately after taking off the gloves, and at in interval of 10 minutes 3 other thermal images were captured. Spot temperatures were measured on the tip and over the mid of metacarpal bone of each finger. Gradients were calculated by subtracting the metacarpal temperature from the temperature of the finger. Raynaud´s phenomenon was diagnosed when negative temperature gradients > 1° were detected 20 minutes after the cold challenge. Patients were allocated with respect to the distribution of Raynaud`s phenomenon. The magnitude of temperature gradients in patients with Raynaud´s phenomenon present in all or in individual fingers was compared statistically.

102 females (age range: 14 to 81 years) and 33 males (age range: 17 to 83 years) were investigated. In total, 69 patients (8 males,61 females) showed Raynaud´s phenomenon in all fingers, and 28 subjects (10 males, 18 females) had involvement of individual fingers. The remaining 37 subjects (14 male, 23 females) presented with normal temperature recovery after the cold challenge.

No significant difference in the magnitude of temperature gradient was obtained in patients with Raynaud´s phenomenon present in all or in individual fingers. A higher proportion of females (78%) than males (66%) presented with thermographic signs of Raynaud´s phenomenon. Involvement of all fingers, was a common finding in our sample,which was not restricted to young age, as slow recovery of temperature after cold challenge was detected in all fingers in 20 of 29 patients aged 65 years or older.

Conclusion: There is no relationship between the magnitude of temperature gradients and the distribution of thermographically identified Raynaud`s phenomenon in all or in individual fingers

USEFULNESS OF THERMAL IMAGING IN EVALUATION AND MONITORING TREATMENT OF MORPHEA LESIONS

Danuta Mikulska, Romuald Maleszka
Department of Dermatology and Venereology, Pomerania Medical Academy, Szczecin

Objective: The aim o the study was to define the usefulness of thermal imaging in detection and monitoring the response to treatment of morphea skin lesions.

Materials and methods: The studies included 14 patients suffering from morphea (9 female, 5 male), aged from 16 to 65 years. The diagnosis of morphea was based on typical clinical picture, there were no evidence of systemic involvement and no history of Raynaud's phenomenon. Laboratory tests: scleroderma antibodies (ACA, SCL70) in all patients were negative. ThermaCAM SC500 thermographic camera was used in the study. All cases were confirmed by histopathology. The patients were separated in to different disease subsets: localized scleroderma, generalized morphea and linear scleroderma. Thermal images of 104 morphea plaques were evaluated and compared with 104 thermograms of symmetrical skin regions. The average and maximal temperatures were estimated. All patient's skin morphea lesions were monitored during 1.0 to 1.5 year of the treatment.

Results: 1/ All skin morphea lesions were hyperthermic. 2/ The higher mean of median temperature was recorded in the central regions of morphea plaques, with the increased fibrosis revealed in the histopathological examination. 3/ Thermal images of 104 morphea lesions had higher mean of median temperature value than 104 healthy summetrical skin regions of the same group of patients (>1.7°C, $p<0.001$). 4/ Thermal images of 104 morphea plaques had higher mean of maximal temperature value than 104 healthy symmetrical skin regions of the same group of patients (> 1.9°C, $p<0.001$). 5/ The clinical improvement of morphea lesions correlated with decrease of local hyperthermia of morphea plaques.

Conclusions: Thermal imaging is helpful in evaluate and monitoring the response to treatment of morphea skin lesions.

SYMMETRY OF TEMPERATURE DISTRIBUTION IN THE UPPER AND THE LOWER EXTREMITIES

Ricardo Vardasca, Prof. Francis Ring
Medical Imaging Research Unit, Faculty of Advanced Technology University of Glamorgan, Pontypridd, RCT, CF37 1DL, United Kingdom

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

In this study skin temperature measurements have been carried out using thermograms of 39 healthy subjects. Measurements were obtained from an infrared camera using the CTHERM application developed at the authors' research unit. CTHERM is capable of calculating statistical data such as temperature averages and standard deviation values in corresponding areas of interest on both sides of the body. Results show that in healthy subjects the overall temperature symmetry difference was at most 0.37°C ± 0.25°C in total body views and 0.36°C ± 0.11°C in regional views. Total body views and regional views produced comparable results although better results were achieved in regional views. Using a high-resolution camera the study achieved better results on thermal symmetry in normal subjects than previously reported. Symmetry assumptions can therefore now be used with higher confidence when assessing abnormalities in specific pathologic states.

ATTENUATION OF INFRARED RADIATION BY HUMID ATMOSPHERE

Boguslaw Wiecek
Technical University of Lodz, Institute of Electronics, Poland

IR radiation transmission of the atmosphere is an important factor during the thermovision remote sensing and measurement. Transmission coefficient of the atmosphere depends on its content and it is attenuated mainly due to the vapor concentration. Every calibrated thermal camera should be equipped with the digital system which implements the transmission model of the atmosphere. The model presented in this work is based on Beer and Bouguer laws (Fig.1, eqn. 1).

In order to calibrate the model, a single measurement or data from the literature has to be used. The model allows evaluating the transmission coefficient versus distance, relative humidity,

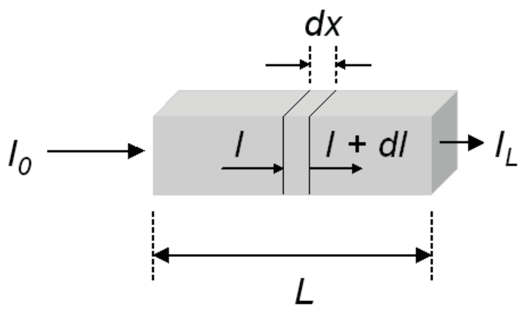

Figure 1
Attenuation of radiation intensity passing through the gas

gases contents and wavelength. The model for the water vapor is based on the fundamental relation (1)

$$\tau(RH, T_a L) = e^{-\alpha(\lambda)\frac{p_s RH}{k_B T_a} L}$$

where: L –distance, p –saturation pressure, T –temperature of the atmosphere, and α(λ) – the expermentally tuned factor stronly dependent on the wavelenght

The exemplary results of the model are presented in Fig. 2

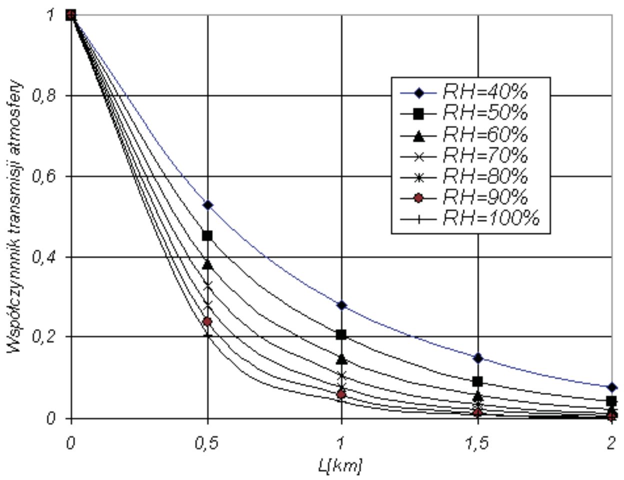

Figure 2
Transmission coefficient of the atmosphere for
T_a=295,15K, λ = 5μm

The proposed simplified model of transmission atmosphere is suitable for implementation in the thermal cameras. A simple digital controller of the camera can calculate the transmission coefficient and correct the temperature measurement. The model takes in account both scattering and absorption due the quantum effects when the photons are interacting with the molecules.

THERMOGRAPHY STUDY OF THE PACIENTS WITH STROKE IN THE POST-ACUTE AND CHRONIC STAGE TREATED IN A REHABILITATION DEPARTMENT

Adriana Sarah Nica, Gilda Mologhianu, Andreia Murgu, Florina Ojoga, Brindusa Sirghii, Lili Miron
University of Medicine and Pharmacy, Bucharest, Romania

Introduction:The pacient with stroke develops, after the central neurological injury, secundary problems related to the central and especially peripheral thermal adaptation system in the affected area of the body. In the same time, some of them have multiple pathologies, particularly degenerative jpont dsisorders and disturbed peripheral perfusion due to vascular disease.

The consequences are clinical, symptomathical and objective and they can be studied in the vasomotor and thermic context.

Infrared thermography of the patient with stroke is a new area of interest in Romania and we explored the upper and lower limb temperature by thermography to observe different types of peripheral thermoregulation in connection with that pathology. The systemic and local context of the pacient with stroke were also analysed in the complex thermological analysis.

Material: We have studied 57 in-patients with recent stroke, using an FLIR ThermaCam medical thermograph in standard evaluation conditions.

Method: We have applied a standard program of physical therapy using electrostimulation, ultrasounds, massage and kinesotherapy.

We recorded thermographies in the beginning and in the end of the treatment for each patient. We studied temperature gradients for single areas, we have compared the temperature gradients between the left and the right part of the body, and finally we have observed the therapy effect in time.

Results: The results were biostatistical transformed and interpreted and they underline different degrees of circulatory problems and the different types of answer and reaction in connection to the intensity of the neurological injuries.

HEAT TRANSFER BASIS USEFUL FOR INFRARED THERMOGRAPHY

Boguslaw Wiecek,
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Heat can be transferred by conduction, convection and radiation. Convective heat transfer is described by Newton law:

$$q_k = \alpha_k (T - T_a) \qquad (1)$$

where: q – heat flux [W/m], a – heat transfer coefficient [W/mK], T – ambient temperature [K], T – heat transferred surface temperature [K].

Thermodynamics describes convection by dimensionless Nusselt number. For natural convection it takes a form:

$$N_U = 0.135 (G_R \cdot P_R)^{\frac{1}{3}} \qquad (2)$$

where: Nu – Nusselt number. GrPr – product of Grasshoff and Prandtl numbers. From above equations, heat transfer coefficient can be express as:

$$\alpha_k = 1.66 (T - T_a)^{\frac{1}{3}} \qquad (3)$$

For forced convection, when the air moving along the surface Nusselt number depends on gas velocity and Reynolds number:

$$N_U = 0.032 R_e^{0.8} \qquad (4)$$

where: Re – Reynolds criterion number.

Radiation heat transfer is based on emission and absorption. The bodies can be heated or cooled even in the vacuum. The basic Planck's law describes the monochromatic hemispherical emissive power of the black body.

$$e_{\lambda c}(T) = \frac{2\pi h c^2}{\lambda^5 \left(e^{\frac{hc}{\lambda k T}} - 1 \right)} \qquad (5)$$

where: *h=6,6260755×10J×s* – Planck's constant, *c* – light velisity in vacum, *k =1,3806×10J/K* – Boltzmann constant, *T[K]* – black body temperature.

The energy transferred between two bodies in temperature T i T, having surface S can be presented using Stefan-Boltmann law.

$$Q = \sigma S (T_1^4 - T_2^4) \approx 4\sigma S T_0^3 (T_1 - T_2) = \alpha_r (T_1 - T_2)$$

where: T_0 is the mean value of the temperature of these two bodies (T_1 i T_2), and a_r denotes the radiation heat transfer coefficient, very similar to the convective one α_k.

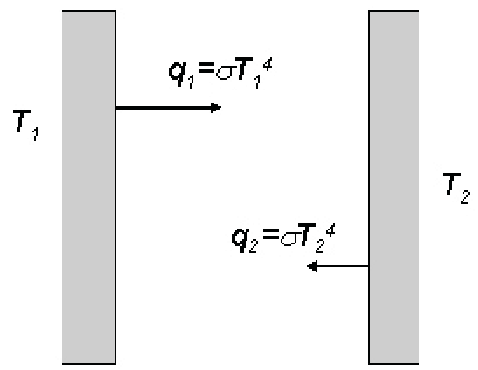

Figure.1.
Radiation heat transfer between 2 surfaces

PROBLEMS OF PHYSICS IN THERMOGRAPHIC STUDIES

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The general physical problems interesting for an interpretation of thermographic studies will be presented. The special attention will be paid to thermal properties of patient's body and the techniques of thermal image processing in respective thermal devices. As a conclusion the advantages and limitations of thermography will be described from medical doctor point of view.