15.Thermologischen Symposium am 27. April 2002

veranstaltet von der
Ludig Boltzmann Forschungsstelle für Physikalische Diagnostik und Österreichischen Gesellschaft für Thermologie

Wir danken der Fa. Schlumberger
für die freundliche Unterstützung der Veranstaltung

Programm

Standards in Thermal Imaging

Chair. Prof Dr. O.Rathkolb *(Wien),* Prof. Dr. F. Ring *(Pontypridd)*

9.00 Francis Ring *(Pontypridd)*
Protocol and sources of errorr in thermal imaging
9.20 Diskussion

9.25 Kurt Ammer *(Wien/Pontypridd),*
Reproducibility of standard positions used for image capturing within the standard protocol for thermal imaging
9.45 Diskussion

9.50 Piotr Murawski, Anna Jung, Francis E.J. Ring, Peter Plassmann, Janusz Zuber, Boleslaw Kalicki *(Warsaw/Pontypridd)*
"Image ThermaBase" - A Software Tool to Capture and Analyse Thermal Images
10.10 Diskussion

10.15 Kurt Ammer *(Wien/Pontypridd)*
Reliability of temperature readings from seleceted standard views for thermal imaging
10.30 Diskussion

10.35 -11.05 Kaffeepause

Recent Advances in Thermal Imaging

Chair: Prof DDr.K.Ammer *(Wien),* Prof. Dr.B.Wiecek *(Lodz)*

11.05 Boguslaw Wiecek, Slawomir Zwolenik *(Lodz)*
The Thermal Wave Method – Fundamentals and otential Applications in Medicine

11.25 Diskussion

11.30 T.Maca *(Wien)*
Infra red thermal imaging of arterial steal phenopmenon
11.50 Diskussion

11.55 Krzysztof Siniewicz, Boguslaw Wiecek, Jan Baszczynski, Slawomir Zwolenik *(Lodz)*
Thermal imaging before and after physical exercises in children with orthostatic disorders
12.15 Diskussion

12.20 Anna Jung, Boleslaw Kalicki, Janusz Zuber, Lech Gawron, Radoslaw Rówycki, Andrzej Stankiewicz *(Warsaw)*
Thermographic monitoring of ophthalmic surgery –extraction of cataract
12.40 Diskussion

13.00 Ende der Veranstaltung

Kurzfassungen der Vorträge

PROTOCOL AND SOURCES OF ERROR IN THERMAL IMAGING

EFJ Ring,

Thermal Physiology Lab, School of Computing,
University of Glamorgan, UK

Infra red thermal imaging is a powerful tool for the study of human body temperature. Modern thermal imaging systems are highly developed, and produce a digital two-dimensional image of skin temperature. In clinical practice there are a number of essential steps to apply the technique to the examination of the human body. There are now a number of factors recommended for clinical practice, which are needed for reliable and reproducible thermal imaging. Ignoring any one of these steps leaves the investigation open to error, and thus reducing the clinical acceptance and understanding of thermal imaging for medical applications. A knowledge of normal thermal patterns and temperatures is required, and awareness of clinical causes for those patterns to be changed, with increased or decreased temperatures.

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

The equipment must be of proven stability and accuracy, with the IR camera mounted on a parallax free stand. The examination room must be at a controlled temperature, usually from 20°C (used for inflammatory studies) to 24°C (used for vasomotor studies). Standard views of each required area of the body are essential, and the angle between camera and patient should be around 90° whenever possible. Standard distances are also advisable, since resolution (thermal and spatial) are usually decreased as scanning distance increases.

Image analysis must also be standardized. Regions of interest are frequently chosen on subjective parameters, which have been shown to be irreproducible even by the same investigator on the same image with repeated analysis. A protocol for defined regions of interest based on anatomical limits is the only sure way to minimize inter operator variation.

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

Examples will be given of false results in thermal imaging from failure of the investigator to understand the essential factors for the patient examination. Inadequate camera settings, or unproven stability after starting the camera have been found to significantly alter the final image. Errors resulting from subjective sizing and placement of regions of interest also show significant variations, all of which can be avoided. The importance of standardized reporting is evident when comparisons over time are required. In medical-legal issues, each image must be clearly identified, and shown to be taken under comparable conditions. No less a standard is required for normal clinical work with this technique. Knowledge of the normal patterns, and causes of hyperthermia or hypothermia are also important to both the technician and the physician using this technique.

Under correct conditions good reproducible images are obtained from which reliable thermal data can be extracted. Poor technique results in avoidable errors and artifacts, which confuse and even invalidate the clinical findings. A good knowledge of thermal physiology is important, but is not enough, if protocols for image capture and analysis are not carefully followed. Modern hardware and software have transformed this technique in recent years, the limitations are more subjective than objective. User-friendly software can provide prompts to help the inexperienced user of thermal imaging.

REPRODUCIBILITY OF STANDARD POSITIONS USED FOR IMAGE CAPTURING WITHIN THE STANDARD PROTOCOL FOR THERMAL IMAGING

Kurt Ammer

Ludwig Boltzmann Forschungsstelle für Physikalische Diagnostik, Wien & School of Computing, University of Glamorgan, Pontypridd, UK

We have established a protocol for capturing a series of images that covers the whole body of a healthy subject. The protocol defines a healthy subject as someone who has had no problems with mobility, no difficulty in caring for himself, no restrictions in performing normal activities, experienced no pain or discomfort and was not suffering from anxiety or depression. A total of 24 views of the body were specified and within these views, a total of 87 regions of interest (ROI) were defined. The consistency of the standard views "Face", "Anterior Left Arm" and "Dorsal Hands" have been evaluated. The distance, measured in pixels, from the upper or the lower edge of the image to anatomical landmarks was used for evaluation. The cross section tool of Ctherm was used for the determination of distances.

Positioning for the face varied in very narrow way. However, any tilting of the head which may be an important source in defining reference values , was not assessed in this procedure, but can easily performed by flipping the region of interest (half of the face) of one side to the contralateral.

Hand views varied in a wider range as the positioning of the face. This might be caused by a higher varibility of hands between subjects. A different degree in spreading fingers may also contribute to this variation, as one definitions of positioning "middle fingers are parallel, thumbs do not touch" was not always followed

Related to the difficulty of positioning the arm, where 3 landmarks must be placed within the image, repeatability of this view was slightly better than the positioning of hands. Bending of the elbow at 90 degrees was not always performed and this may contribute to the variation of temperature readings.

The repeatability of standard views varies by the body regions investigated. However, standards views can be reproduced within a narrow range by different investigations. Reference values for the surface temperature of body regions based on images captured according to our protocol will mainly reflect the individual temperature variation.

"IMAGE THERMABASE" – A SOFTWARE TOOL TO CAPTURE AND ANALYSE THERMAL IMAGES

Piotr Murawski[1], Anna Jung[1], Francis E. J. Ring[2], Peter Plassmann[2], Janusz Zuber[1], Boleslaw Kalicki[1]

1 Thermology Laboratory, Paediatrics and Nephrology Clinic Military Medical School of Medicine in Warsaw, Poland

2 Thermal Physiology Laboratory, School of Computing, University of Glamorgan, UK

„*Image ThermaBase*" is a software package that was designed and implemented at the Thermology Laboratory of the Paediatrics and Nephrology Clinic, Military Medical School of Medicine in Warsaw, Poland. Its underlying concept is to enable the acquisition, processing and collection of examination results of medical thermal imaging. For that purpose, the package produces and stores thermal images together with medical data to allow the correct interpretation of images. The design of the system is aided by the Power Designer 7.5 CASE software tool and implementation is achieved in the Borland Delphi 5 Client / Server RAD environment. Sybase SQL Anywhere 6 was used as a database engine. First experiences suggest that "Image Therma Base" is as useful in every day medical practice as originally intended.

In this paper we show also a portion of the data requirement analysis. This analysis was made during the design period of the application. Its main goal was to include patient related data that are not usually considered to be part of a thermological examination. However, this additional information may be useful for clinicians involved in the evaluation and assessment of thermal images. Functionality and coefficients, which are computed by "*Image ThermaBase" software,* are also included.

In the last part of this paper an outline of ongoing and future work in collaboration with the Thermal Physiology Laboratory, School of Computing, University of Glamorgan, UK, is presented.

RELIABILITY OF TEMPERATURE READINGS FROM SELECETED STANDARD VIEWS FOR THERMAL IMAGING

Kurt Ammer

Ludwig Boltzmann Forschungsstelle für Physikalische Diagnostik, Wien & School of Computing, University of Glamorgan, Pontypridd, UK

Definition of regions of interest for temperature measurements must meet two challenges. Firstly, the region must capture as much information from the body area of interest, and secondly, positioning of the region must show a high degree of reproducibility. Together with the use of standard views reproducible temperature readings from regions of interest will reduce the variability of temperature to individual features of the subjects investigated.

Inter operator reliability of temperature measurements of 3 regions of interest on the view “Anterior Arm” was evaluated for 5 newly trained investigators-. In this experiment one thermal image of the anterior arm was given to these five people, who evaluated the thermal image twice following the protocol on standard views and definition of regions of interest. This evaluation resulted in deviations from the mean temperature of the region of interest between 0.001 and 0.10 °K at the elbow, between 0.06 and 0.27 at the upper arm and between 0.02 and 0.1 at the upper arm. Mean difference between 1st and 2nd measurement of individual investigators was 0.024.

In another experiemt, a circle, a square and an hourglass shaped area were applied to the same image in the standard view “Anterior Knee” by three newly trained investigators. Using the hourglass shape revealed a better precision of temperature readings than the other shapes. The reason for that might be that the alignment of the region of interest is easiest to perform with the hourglass shape.

Interrater reliability coefficient alpha and ICC of the ROI “Lower Arm”, and the hourglass shaped ROI at the anterior knee confirmed excellent repeatability of ROI placement. The investigated regions of interest show high reliability and therefore reference values created in such way are highly credible.

THE THERMAL WAVE METHOD – FUNDAMENTALS AND POTENTIAL APPLICATIONS IN MEDICINE

Boguslaw Wiecek, Slawomir Zwolenik

Technical University of Lodz , Institute of Electronics , Computer Thermography Group , Poland

This paper shows the basis and preliminary applications of lock-in and pulse thermography for Non Destructive Testing (NDT). 3D thermal modelling is presented to confirm the usefulness of the simple analytical solutions, and to setup the experiments. For example, the thickness of thin film coatings is briefly described.

The proposed method is based measuring the thermal response as a result of delivering power to the investigated body. Human skin or the internal layer of tissues can be investigated by this method. According to the theoretical background, with this method we can penetrate inside of the body, not very deeply, but deep enough for many applications. We emphasize that the thermal process is dynamic, and in many cases very fast. Authors are aware that thermoregulation existing in the living body can reduce the thermal effect of irradiation, but as soon as modelling is added into the investigations, it seems that we can detect inhomogeneous parts of the human body on the skin or just below.

INFRA RED THERMAL IMAGING OF ARTERIAL STEAL PHENOMENON

T.H. Maca.

Departmentof Medical Angiology, University and General Hospital of Vienna, Austria.

Introduction: Peripheral arterial steal syndromes may be coexistent with cerebrovascular insufficiency in case of a subclavian artery stenosis. Post occlusive steal syndromes are of importance in the microcirculation. Further clinically relevant steal phenomena are seen in patients with haemodialysis shunts (HDS) or arterio-venous-fistulas (AVF), respectively.

Aim of the Study: To evaluate the clinical impact of infrared tele-thermography in various peripheral arterial steal phenomena.

Patients and Methods: We prospectively screened 30 persons: 10 patients with known subclavian artery stenosis/occlusion, 10 patients with HDS and compared them to 10 control subjects. The peripheral arterial perfusion of the upper extremity was measured by following techniques: Blood pressure and oscillometry, colour coded duplex scan (Acuson XP 128) and infrared imaging (Thermo Tracer TH1100, NEC, San-ei).

Results: Patients with subclavian artery stenosis or occlusion present usually with low mean arm temperature differences < 1.0 °C less compared to the contra-lateral extremity and show stable temperature gradients after stress tests (candle stick manoeuvre). A moderate temperature difference of 1.0-2.0 °C or a severe distal hypo-perfusion (difference > 2.0 °C) is more often diagnosed in HDS patients. The finger temperature distal to the AVF may increase or remain stable after stress tests (compensated) or show a further decline (de-compensated).

Conclusion: Infra red imaging of the upper extremity may be helpful in detecting patients at risk for critical peripheral arterial hypo-perfusion or ischaemia caused by arterial steal phenomenon

THERMAL IMAGING BEFORE AND AFTER PHYSICAL EXERCISES IN CHILDREN WITH ORTHOSTATIC DISORDERS OF THE CARDIOVASCULAR SYSTEM

Krzysztof Siniewicz[1] , Boguslaw Wiecek[2], Jan Baszczynski [1], Slawomir Zwolenik [2]

[1]Department of Pediatrics Military medical University of Lodz , Poland (Director : Professor Jan Baszczynski , M.D., Ph.D., F.I.C.A.)

[2]Technical University of Lodz , Institute of Electronics , Computer Thermography Group , Poland, (Director ; Boguslaw Wiecek , M. Sc., Ph.D., D. Sc.)

Orthostatic disorders of the cardiovascular system in children are frequently caused by transient disturbances of resistive and venous blood vessels . The purpose of this work was to estimate the usefulness of thermography in children with orthostatic disorders of the cardiovascular system . The analysis was carried out of 30 children with orthostatic disorders. The control group consisted of healthy children.

The new generation Inframetrics 760 thermographic camera was used in this study. Every child with orthostatic disorders was subected to physical training for a period of 1 year to improve cardiovascular reactions. Thermal imaging was repeated after the period with exercises.

These studies showed confirmed differences in temperature distribution in children with orthostatic cardiovascular disorders compared to healthy children used as controls. Both the clinical symptoms of the orthostatic disorders and the temperature changes disappeared after physical exercises. Thermal imaging is a new, non-invasive method for examination of the cardiovascular system, which is very useful for the diagnosis of orthostatic disorders in children.

THERMOGRAPHIC MONITORING OF OPHTHALMIC SURGERY – EXTRACTION OF CATARACT

Anna Jung[1], B. Kalicki[1], J. Zuber[1], L. Gawron[2], R. Rówycki[2], A. Stankiewicz[2]

1 Thermology Laboratory of Central Hospital Military School of Medicine, Pediatric and Nephrology Clinic.
2 Central Hospital Military School of Medicine, Clinical Ophtalmology

Aim: To follow the decay of the surface temperature of the eye during the stages of cataract surgery.

Method: The cataract operation was performed using phaco emulsification. Several phases of the surgical procedure were defined: topical anaesthesia, the pulsed emulsification of the nucleus lens, the irrigation and the aspiration of the cortical masses, the implantation PC – IOL and the first hour after the operation.

Research thermography was performed with the Inframetrics S. C. 1000 camera throughout all phases of surgery maintaining the standard conditions for thermal imaging.

Results were analysed by our own programme Image ThermaBase.

Results: After the topical anaesthesia and humidification of the cornea, the temperature on the eye surface decreased in the range of mean, minimal and maximal temperatures by 4,2 C. During the thermo-coagulation a localised increase of the temperature up to 64 C , lasting a few seconds was observed. In the next phase of the operation. the phaco-emulsification probe reached 34,8 C resulting in a very slight increase of the local temperature of 0,6 C. The measurement of the phaco- emulsification probe temperature in a test had produced a temperature increase of 3,3 C.

The changes of the temperature after the implantation (attachment) PC – IOL were insignificant and did not exceed 0,2 C. 15 minutes after the end of the operation, the surface of the eye warmed up by 1,2 C, and returned to baseline values one hour later.

Conclusion: 1.An increase of temperature during the cataract operation was only observed during diathermy. The change was local and persisted for few seconds.

2.The temperature of the probe increased by 0,6 C during the phaco-emulsification and was at a similar temperature level as the surrounding tissue.