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Thermography in Spinal Disorders- a Narrative Review

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SUMMARY

Infrared-thermography and other techniques of mapping temperature distribution on surface of the body has been applied in spinal disorders for more than 40 years. However, the validity of thermal imaging for diagnosing back disorders is in ongoing debate.

This review identified five major applications of thermal imaging of the human back. The symmetry of temperature distribution as a fundamental concept for diagnostic evaluation of thermal images. The few studies that investigated thermal asymmetry vary in methodology and with one exception do not provide absolute temperature values. Both ankylosing spondylitis and scoliosis were early applications of diagnostic thermography, but recent thermographic research in these disorders is not available. Disk herniation and related radiculopathies was also a topic of thermographic research in the past, but recent papers related to these disorders are also rare. Most thermographic research activities are currently conducted in functional disorders of the spine such as restricted joint play and its influence on skin temperature of the back. This research is performed by experts in manual physical examination and manual therapy. Many of the researchers have their background in chiropractice.

In general, the thermographic body of knowledge in spinal disorders is incomplete and more high quality studies are needed before thermal imaging can be recommended as diagnostic method or as outcome measure for back pain.

KEY WORDS: Thermography, ankylosing spondylitis, back pain, vertebral blockage, radiculopathy

THERMOGRAPHIE BEI WIRBELSÄULENERKRANKUNGEN

Infrarot-Thermographie und andere Methoden zur Darstellung der Temperaturverteilung an der Körperoberfläche werden seit mehr als 40 Jahren bei Wirbelsäulenerkrankungen eingesetzt. Der Wert von Wärmebildern für die Diagnose von Rückenerkrankungen wird noch immer diskutiert.

Dieser Literaturüberblick hat fünf Hautanwendungen der Rückenthermographie gefunden. Die Symmetrie der Temperaturverteilung gilt als ein grundlegendes Konzept für die diagnostische Auswertung von Wärmebilder. Die wenigen Studien zur Untersuchung zur thermischen Symmetrie des Rückens in Methodik und berichten mit einer Ausnahme keine absolute Temperaturwert. Sowohl der Morbus Bechterew als auch die Skoliose waren frühe Anwendungen der diagnostischen Thermographie, aber neuere thermographische Untersuchungen über diese Erkrankungen sind nicht verfügbar. In der Vergangenheit waren Bandscheibenvorfälle und die damit verbundene Radikulopathien ebenfalls Thema des thermographischc Forschung, aber auch gibt es kaum rezente Publikationen über diese Erkrankungen. Die meiste thermographische Forschungsaktivität ist derzeit in der Beurteilung funktioneller Störungen der Wirbelsäule wie dem eingeschränkt Gelenkspiel und seinem Einfluss auf die Hauttemperatur des Rückens zu finden. Diese Forschung wird von Experten in der manuellen körperliche Untersuchung undder manuellen Therapie getragen und viele Forscher kommen aus der Chiropraxis.

Im Allgemeinen ist das thermographische Wissen über Wirbelsäulenerkrankungen unvollständig und mehr qualitativ hochwertige Studien sind erforderlich, bevor die Thermographie als diagnostische Methode oder als Ergebnisparameter für Rückenschmerzen empfohlen werden kann.

Schlüsselwörter: Thermographie, ankylosierende Spondylitis, Rückenschmerzen, Wirbelblockierung, Radikulopathie

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Introduction

Although the investigation of patients with back pain was one of the early applications of thermography [1, 2], only few recent publications were dedicated to spinal disorders. Academic chiropractors and bioengineers have recently revived this field of diagnostic thermology. The purpose of this paper is to review the literature on thermal imaging in spinal disorders.

Temperature distribution on the back of healthy subjects

The early studies on temperature distribution on the back of healthy subjects did not provide quantitative data, but described the distribution and shape of warm and cold areas. Most descriptions were based on small numbers of non symptomatic control subjects.

In 1977, authors from Germany made an attempt to describe the normal temperature distribution of the hu- man back [3]. For that purpose, the back thermogram was subdivided into 10 regions. 5 were placed over the spine: cervical, the upper third and the two lower thirds of the thoracic, lumbar and over the sacral bone. 5 other regions, situated left and right from the spine, were named neck, shoulder, dorsal, lumbar and gluteal region. The level of temperature of each region was provided. The label "cold" was given for a temperature of 31°C or less. 32°C was equal to "moderate warm", 33- 34°C was labelled as warm

and 35° C or more was named "hot". The normal temperature pattern was based on back thermograms from 58 back thermograms of 58 healthy subjects recorded at a room temperature of 20°C after 20 minutes acclimatisation to the environmental temperature. Hot circular areas up to 2 degrees warmer than the surrounding tissue with sharp or gradual transition to the adjacent skin were de- scribed. Cold and hot areas of rhomboid or oval shape with vertical or horizontal axis were also described.

The skin temperature of the dorsal neck region was warm, mostly symmetrically distributed, and sometimes increasing gradually from medial to lateral or decreasing from cranial to caudal, both occurring in 13% of cases. In 79% of cases, no difference was observed between the skin overlying the dorsal cervical processes and the more lateral region. In the remaining 21%, the spinal area appeared as a longitudinal stripe which was slightly warmer or cooler than the adjacent skin.

Unfortunately, the authors did not entirely use their own terminology for temperature levels throughout the description of the normal pattern in back thermograms. This resulted in relative descriptions such as one area being cooler or warmer than the adjacent region and missed in this way the intended semi-quantified temperature map. Finally, the authors concluded, that a normal pattern of temperature distribution does not exist.

Woodrough described six patterns of temperature distribution on the human back and three of them were related to healthy subjects. [4,5]. The normal thermogra- phic pattern is characterised by a Y-shape, the high temperature over the vertebral column fanning out in the interscapular region (figure 1). A variation of Y pattern is the V pattern (figure 2). In the obese, this pattern is modified to the Ɏ shape(figure 3). The temperature values were only pro- vided as coloured isotherms, measuring areas have not been defined.

Clark continued with the idea of a V or Y shaped warm area over the spine in healthy subjects [6]. He found this typical pattern disturbed in patients with juvenile arthritis or X-linked hypohidrotic ectodermal dysplasia. He described a new quantitative thermal analysis system based on a computer pattern recognition technique, but data from healthy subjects analysed with such an system were never published. .

Feldman and Nickoloff showed by means of liquid crystals thermography that the temperature is symmetrically distributed on the dorsal neck and on the upper extremities [7]. The authors stated that a temperature difference between the left and the right side of the body is a definite abnormal findings. But due to the thermal imaging technique temperature levels were based on isotherms only.

Pochaczevsky et al. applied also liquid crystal foils on the back for the investigation of temperature distribution in 101 back pain patients [8]. A normal pattern of the back nor a reference for the temperature distribution on the back of healthy people is not provided. A retrospective study did not find statistically significant differences between the mean temperatures of the lumbar region in healthy controls or patients with low back pain [9]. However, the range of temperature recorded by liquid crystal thermography was much wider in patients than in control subjects. It was emphasized in this study, that areas of increased temperature or small hot spots appeared regularly as a very tender body surface. Einsiedel-Lechtape et coworkers [3] have also described "hot spots" on back thermograms from healthy subjects, but could not relate these temperature anomalies to other pathological findings.

Silberstein et al published temperature values for the anterior and posterior chest, the anterior abdomen and posterior lumbosacral region based on densitometry of gray shade thermograms from ten healthy males[10]. Although the authors were mainly interested in temperature differences between the right and the left side of the body, they provided also mean temperature values after 20 minutes acclimatisation to a room temperature of 23 ± 1°C.

The standard references for thermal symmetries by Uematsu et al [11] and Goodman et al [12] do not provide

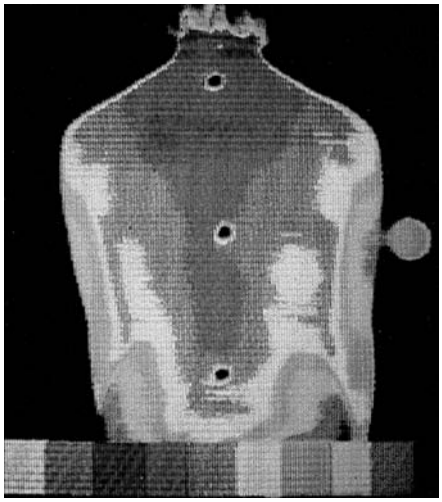


Figure 1
Y-shape

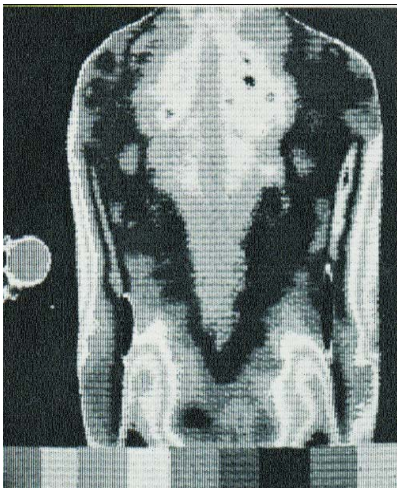


Figure 2
V-shape

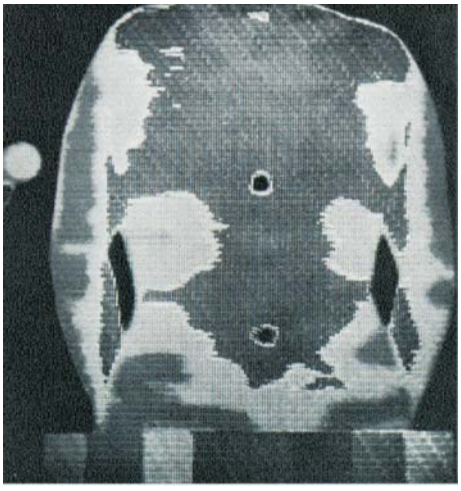
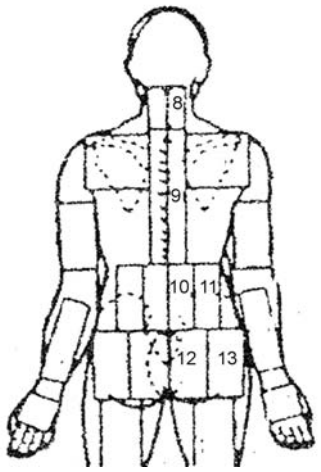


Figure 3
Ɏ-shape

Table 1
Thermal asymmetry of the human back (from 11)

Region of interest	No of Cases	Dermatome	ΔT (mean ±SD)
8- cervical	45	C3 -C5	0.23 ± 0.16
9- thoracic	46	T2-T12	0.20 ± 0.17
10- lumbar(medial)	90	T11, 12, L1,2,3	0.22 ± 0.19
11 - lumbar(lateral)	88	T11, 12, L1,2,3	0.34 ± 00.26
12 -sacral (medial)	90	S1,2,3	0.28 ± 0.19
13 - sacral (lateral)	90	S1,2,3	0.26 ± 0.22

ΔT = temperature difference
SD = standard deviation
C= cervical dermatome
L= lumbar dermatome
T=thoracic dermatome
S= sacral dermatome



absolute temperature values of the human back, but report the side to side differences of body regions. Uematsu investigated 90 healthy subjects, 38 men and 52 women. He defined in total 40 matched rectangular shaped regions of interest in the anterior and posterior view of the body. The lowest temperature difference from one side to the other was obtained for the forehead 0.18 ±0.18 °C and the highest difference was reported for the fifth toe 0.67 ± 0.55°C.

Table 1 summarises the side to side differences of temperature over the human back as reported by Uematsu.

Goodman[12] based his approach on thermal symmetry on the following 9 views:

1. Anterior (volar) forearms and hands.
2. Posterior (dorsal) forearms and hands.
3. Cervicothoracic back.
Vertical extent was hairline to the scapular angle, and the horizontal extent was acromioclavicular joint(ACJ to ACJ.
4. Thoracolumbar back.
The vertical extent was from the levels of the scapular angle to the lower rib cage (lateral indentations, corresponding to upper lumbar vertebral level), and the horizontal extent included the entire silhouette.
5. Lumbosacral back.
The vertical extent was from lower rib cage to midgluteal levels, and the horizontal extent included the entire silhouette.
6. Posterior lower extremities.
7. Anterior lower extremities.
8. Right lateral lower extremity.
9. Left lateral lower extremity.

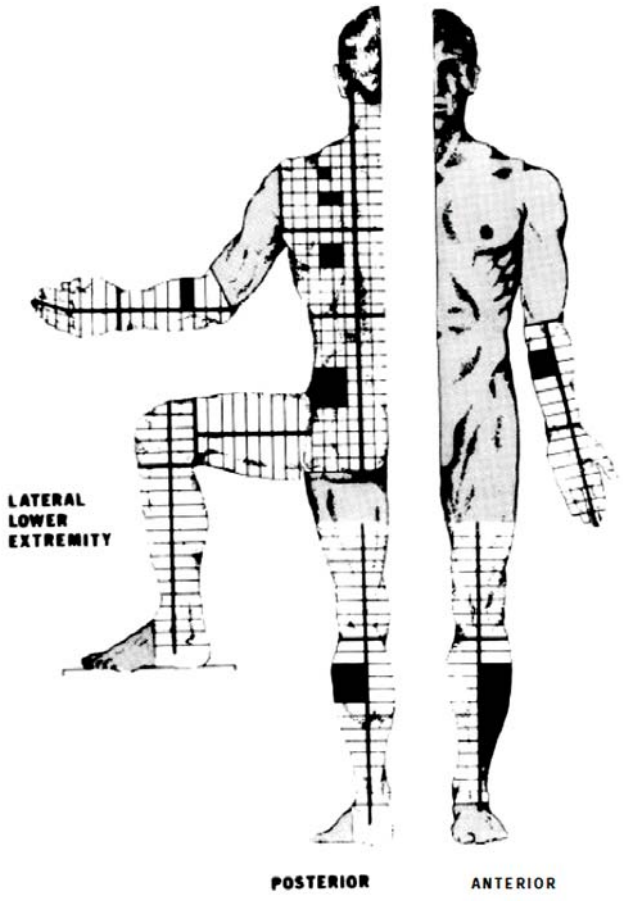


Figure 4
Body views and measurement grid for the evaluation of thermal asymmetry (from 12)

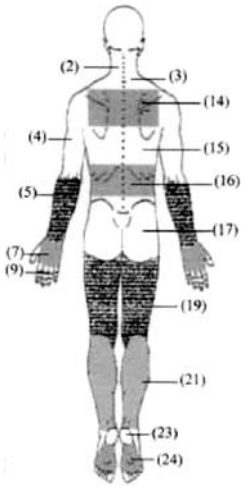
Table 2
Thermal asymmetry of the back based on differently sized measurement areas (from 12]

Region of interest	1 Frame	2 Frames	2 x 2 Frames	3 x 3 Frames
Cervicothoracic, medial	0.21 ± 0.06	0.20 ± 0.05	0.18 ± 0.04	0.18 ± 0.03
Cervicothoracic, lateral	0.28 ± 0.10	0.28 ± 0.09	0.26 ± 0.08	0.22 ± 0.06
Thoracolumbar, medial	0.22 ± 0.06)	0.21 ± 0.06	0.20 ± 0.05	0.18 ± 0.05
Thoracolumbar, lateral	0.27 ± 0.08	0.26 ± 0.08	0.20 ± 0.05	0.21 ± 0.05
Lumbosacral, medial	0.13 ± 0.04	0.12 ± 0.04	0.09 ± 0.04	0.09 ± 0.03
Lumbosacral, lateral	0.17 ± 0.05	0.17 ± 0.04	0.17 ± 0.04	0.16 ± 0.03

Table 3
Thermal asymmetry of the back in a Chinese population(from 13]

Area number	Surface area	Right side	Left side	Δt (mean±SD)
2	neck	31.7±0.6	32.1±0.6	0.4±0.3
14	upper back	31.2±0.7	31.2±0.8	0.2±0.2
15	medium back	30.6±0.8	30.5±0.9	0.3±0.2
16	lower back	30.5±0.7	30.3±0.8	0.3±0.3
17	buttock	29.5±0.8	29.5±0.8	0.4±0.3

SD = Standard deviation



For statistical evaluation rectangular frames of variable height and width were generated and positioned over any region of the infrared image (figure 4). For the back, the average temperature value within an overlying square "frame" enclosing 2.5 x 2.5 cm (6.25 cm²) area of the subject's skin was the fundamental unit for temperature measurement. 1, 2, 4 and 9 frames were compared at a time. As expected, the temperature difference of single frames was bigger than in combined frames (table 2). The magnitude of the mean Δt was in the same range as reported by Uematsu, but standard deviation was much smaller.

The most recent study on thermal asymmetry was published in Taiwan , where 57 healthy volunteers, aged 24 to 80 years, were investigated by infrared thermography [13] Thermal images were recorded after 20 minutes acclimatisation to a room temperature of 21 ± 1° C°. 5 out of 24 regions of interest were defined over the neck and back. The magnitude of side to side temperature difference was in the same range as in previous studies [11,12] (table 3).

Measurement of paraspinal skin temperature has long been used by chiropractors. Although standards for the implementation of infrared thermography in chiropractic practice exit [14], many chiropractors use a pair of infrared radiometers for the assessment of paraspinal skin temperature [15, 16].¶

Hart and Owens investigated temperature profiles recorded with radiometers along the spine at five-minutes intervals during acclimatisation for 31 minutes to room temperature[15]. They observed a continuous decrease of skin temperature in the lower back, whilst the skin temperature of the cervical spine appeared rather stable. In general, the temperature pattern stabilised after 16 minutes. It must be noted that the results rely not on absolute temperature values, but on the similarity of temperature profiles recorded along the spinal column.

Different versions of software for the analysis of temperature profiles recorded with a pair of radiometers showed a high repeatability of results between investigators and different methods of evaluation [16]

However, the authors emphasised, that validity of paraspinal temperature profiles is still unknown and the relationship between findings from manual-medical examination and temperature changes of the skin in the lower back must be further investigated..

Roy and coworkers have published a series of investigations on the validity and reliability of paraspinal temperature measurement [17, 18, 19]. There was good agreement between temperature measurements by contact with thermistors and the results recorded with an infrared camera, but temperature measurements by contact were lower than the temperature recorded by infrared [17].

In a further study Roy et al. investigated the time requirements for stable recordings of core temperature and skin temperature of neck or lumbar spine [18] After 30 minutes recording core temperature, the temperature readings appeared to be stable. For skin temperature measurements, both measuring devices thermistors and infrared camera recorded only slight changes between 8 to 16 and 20 to 24 minutes of measurement. The well known dependence of the skin temperature from the ambient temperature was also confirmed. .

Recently Roy et al. reported the dependence of skin temperature from body position. [19]. There were slightly higher values when skin temperature was measured in standing than in prone position (prone position: 33.92°C ± 1.05°C (left) and 33.81°C ± 1.10°C (right), standing position: 34.17°C ± 0.99°C (left) and 34.44°C ± 1.02°C).

Ankylosing Spondylitis

Ankylosing spondylitis, the spinal manifestation of seronegative spondylarthropathies, is characterised by inflammatory back pain. Inflammatory back pain is located in the lumbar spine or buttocks, appears in typically in the second half of the night, gets worse at rest, is reduced by motion and is related to inflammation of the sacroiliac joint [3]. No recent studies have evaluated ankylosing spondylitis patients with infrared thermal imaging.

Referring to case report by Cosh & Ring [20], Agarwal et al. published already in 1970 a series of 31 patients presenting with radiographic signs of inflamed sacroliac joints [21], Twenty-three of thirty-one patients, who all underwent infrared thermography., showed an increased temper-

ature in the region of the sacroiliac joints. The mean blood sedimentation rate of subjects with elevated skin temperature over the sacroiliac joint was higher than the sedimentation rate of patients with normal temperature in the sacral region.

Sadowska-Wroblewska et al. investigated 22 patients with spondylitis and 100 healthy people using infrared thermography. They reported symmetrical temperature profile over the sacroiliac joint in healthy subject, which was not found in spondylitis patients with the same typical shape [22]. However, when compared to healthy subjects, patients with Bechterew´s disease did not present with significantly different temperatures.

Grennan and Caygill investigated 30 patients with ankylosing spondylitis and compared their thermal images with the thermograms of 27 non symptomatic subjects . 13 patients with non inflammatory back pain [23]. Only 13 of patients with ankylosing spondylitis presented with significant temperature changes, no pathological temperature was observed in the two control groups. There was a weak correlation between the clinical activity of the sacroiliac joint inflammation and positive thermographic findings. The authors concluded that thermography has no value for early diagnosis of the sacroiliac joint inflammation, but recommended thermal imaging studies for follow-up of individual patients.

A study from Sweden to described in 1985 the variability the temperature distribution in the sacral region and compared the findings with those from patients suffering from inflammation of the sacroiliac joints [24]. To improve the thermal contrast 95% ethanol was sprayed on the sacroiliac region. However, the authors failed to describe clearly the temperature distribution in a typical thermogram of the sacroiliac region of a healthy subject.

Dr Tauchmannova from Piestany has repeatedly described the temperature distribution in the sacroiliac region of patients with ankylosing spondylitis [25,26]. These studies had shown that thermography may be helpful for the early diagnosis of sacroiliac joint inflammation. But even patients with radiographic signs of totally ankylosed sacroiliac joints showed a significant temperature increase due to florid inflammatory activity [26]. For the last fifteen years, no thermographic investigations were published for patients with ankylosing spondylitis.

Scoliosis

Infrared thermographic studies were already performed in the seventies of 20th century for patients with scoliosis of the spine. Three out of six patterns of temperature distribution on the human back reported by Woodrough [3,4] were related to spinal scoliosis, were high temperatures may be found on the concave side of the spinal curve.

10 years ago, Polish orthopaedic surgeons [27] and medical information specialists [28] resurrected infrared thermography for scoliosis in adolescents. The authors developed software to extract and merge information from radiographs of the spine with thermal images to define the curvature of the spine. The thermal images were generated on a screen of 140 by 140 pixels, where the temperature from 10 pixels for each horizontal line on either sides of the spinal midline was calculated [27]. In healthy subjects the mean side to side difference was 0.3°C and the maximum difference 0.5°C. There is also temperature gradient along the spine with highest temperature readings between 33 to 35 °C in the upper part of the spine and low temperature between 31.5 to 32.5°C in the lower part. In patients with single curved spinal deformity the mean side to side temperature difference increased to 0.7°C and maximum values of 1.7C. The highest temperature changes were reported for double-curvatures with a mean side to side difference of 1.3°C and maximum values of 2.8 centigrade [28].

Vertebral blockage (restricted vertebral joint play)

Diakow and coworkers compared in 10 volunteers findings from manual- therapeutic examination such as vertebral blockages, tenderness and skinfold changes with the results of liquid crystal thermography recorded from the chest, the lumbar spine and the sacral region [29]. Circumscribed hyper thermic or hypothermic zones (temperature difference to the surrounding tissue at least 1 degrees) were considered as pathological thermographic findings. Agreemended between thermography and vertebral blockage was found in 64.7% of all cases, tenderness and thermal image corresponded in·63.7%, skin fold changes and thermographic findings agreed in·59.9%.

In a case report, a blocked sacroiliac joint appeared similar hyper thermic as reported in the case of inflammatory arthritis [30]. After a series of manual therapies, the symptoms were much reduced and also the temperature over the affected sacroiliac joint decreased .

Engel postulated a reduction of skin temperature in the related dermatome in the case of vertebral blockage, with the intensity of the pain correlate to the extent of hypothermia [31]. A pain induced activation of the sympathetic nerve system is suspected as the cause of the temperature change. Thus, functional deficits of the spinal organ may result in asymmetric distribution of skin temperature, visible in thermal images.

In 1992, Kainz and coworkers recorded the effects of spinal manipulation by infrared thermography in 24 patients of both gender and aged 24 to 56 years [32]. The majority of patients presented with vertebral blockages of the thoracic spine or the costovertebral joints, respectively. The surface temperature of the back was recorded out immediately before and immediately after manipulation treatment. A control group received a sham manipulation, in which the body position was non correct, but the therapeutic movement applied was the same as in real manipulation.

Successfully performed manipulation led to an immediate change in the thermographic image, with a significant decrease in skin temperature (in average by 0,45°K) not only

in the region where the treatment was applied, but also in caudal of the treatment area lying sections of the back, probably due to a reflex mechanism. Unsuccessful manipulation and deliberately poor settings for the manipulation resulted in a small rise in surface temperatures in all cases investigated due to local mechanical irritation.

In 1993 Ammer reported in the journal "Manuelle Medizin" the results of 29 out-door patients with spinal pain syndromes who received infrared thermal imaging of the back prior to the manual physical examination and immediately after manual therapy [33]. The symmetry of the temperature distribution on the back used as the main outcome. The thermal image of the back was divided into four regions (cervical spine, shoulder girdle, thoracic spine and lumbar spine) and minimum, maximum and mean temperature from both sides of these back regions were calculated. All patients presented with at least one vertebral blockage and all showed an asymmetric thermal image of their back. The symmetry of temperature distribution of the back improved in some patients after manual therapy. Although a few patients increased heat radiation after manual therapy, a significant reduction in mean skin temperature occurred immediately after the therapeutic intervention.

Based on the results mentioned above, the question arises whether the manual investigation alone lead to change in skin temperature. Seven symptom free women aged between 26 and 46 years were studied to answer this question [34]. Infrared thermograms of the dorsal neck were recorded after 15 minute adaptation to a room temperature of 24°C. Then the investigator performed side bending of the cervical spine in each subject and examined the joint play of the intervertebral joint on the levels C3 to C7. Joint mobilisation was performed at the end of the examination in case of proven vertebral blockages.. A thermogram was recorded immediately after each motion test, resulting in series of 14 thermal images for each subject. Two measurement areas were defined on the neck according to the standard protocol developed at University of Glamorgan and the side to side difference of temperature was calculated.

The mean temperature difference between right and left measurement area was 0.10 ±0.08 °K prior to the physical examination. All participants presented with a single hypomobile intervertebral joint, 5 subjects on the right hand side (2 on level C4, 2 on level C6, 1 on level C7) and two people on the left hand side (level C5 and C7). The mean temperature of the measurement area at the right hand side decreased significantly compared to baseline readings in all 6 phases of the physical examination and also after therapeutic mobilisation. A significant reduction of the mean temperature of the measurement at the left hand side was only recorded after examination at the level C7 and following mobilisation. However, the side to side difference of temperature was not affected by any interventions performed.

Non symptomatic blockages and manual physical examination does not affect the temperature difference between left and right side of the dorsal neck. Nevertheless, manual examination of the cervical spine performed unilaterally may be followed by significant temperature changes, and the unilateral mobilisation of a blocked vertebral joint may result in bilateral temperature changes.

A study from Canada investigated the changes in paraspinal temperature after manual therapy at the level L5 [35]. 20 patients with signs of acute lumbar pain syndromes were randomly assigned to a real manipulation with impulse to level L5 or sham manipulation. Main outcome in the study was the paraspinal skin temperature obtained with a pair of radiometers at the spinal level L5 . Patients acclimatised for 8 minutes to the room temperature and the paraspinal temperature was recorded immediately before and 1, 3, 5 and 10 minutes after manual therapy.

Immediately after the manipulation the skin temperature of the treated side increased by 0.2° F, while no significant temperature change was observed at any body side after sham treatment. 3 minutes after the manual therapy the skin temperature increased treated at the treated side on average 0.6°F, while slight cooling was observed at the side not treated. This resulted in significant side to side differences of skin temperature.

In a previous study the same authors investigated the influence of local pressure on skin temperature during manual therapy applied with an activator device. High pressure and normal local pressure followed by a manipulation impulse led to the local decrease of skin temperature, which in the case of manipulation recovered within three minutes to baseline readings [36].

Different causes of back pain may lead to different patterns of temperature distribution on the back. Gabrhel and coworkers reported predominately hypothermic patterns in back pain patients with concomitant urogenital disease, whereas the majority of patients with structural findings of the spine presented with hyper thermic patterns [37].

Coccygodynia

A recent study from Taiwan correlated the pain intensity of patients with coccygodynia with a hyper thermic zone in the region over the sacrum and evaluated the success of a manual therapy intervention by the change of skin temperature in the sacral region [38]. Based on the available data it remains unclear, whether the change of the temperature in the sacral region can be regarded as a responsive outcome measure for patients with coccygodynia.

Non specific back pain

Sherman et al reported a correlation between pain intensity and the symmetry of the distribution of surface temperatures in patients with chronic pain syndromes [39]. Based on thermal images distinction between symptomatic and non symptomatic people was possible in 98% of patients with knee pain, but in back pain patients thermographic differentiation between healthy was successful in 56% only.

Zaproudina et al. observed little correlation between pain intensity and the difference of plantar temperatures be-

tween the symptomatic and non symptomatic side in chronic back pain patients [40]. However, no different temperatures were found in the lumbar region of healthy or back pain subjects.

Uematsu [41] recorded thermal images from patients with partial and total injuries of peripheral nerves and claimed, that the extent of damage can be distinguished by means of temperature mapping. In partial nerve lesions the innervated skin appears cold due to activation of sympathetic nerve fibres. Fully dissected nerves have lost the sympathetic innervation of vessels which leads to increased temperature of the innervated skin area.

A study from Germany, compared thermographic findings with the results of the Minor sweat test in patients with focal, strictly unilateral lesions of peripheral nerves [42]. All patients with disturbed sweat production presented with a clear thermal asymmetry, where the affected skin area appeared initially hyper thermic, but changed to hypothermia. after four to six months.

Ash et al. investigated 87 patients with radiculopathies and 30 healthy subjects with an Infrared radiometer and with contact thermometers and could not find any correlation between skin temperature distribution and somatic sensory dermatomes [44]. The authors emphasised that thermographic imaging of the sensory dermatome is not plausible and that predictable sympathetic dermatomes do not exist.

Radiculopathy

The protruded nucleus of an intervertebral disc may affect the adjacent spinal nerve, particularly the sensory and motor fibres of the dorsal root of the spinal nerve. This may, but must not provoke symptoms of compression neuropathy in the innervation field of the respective nerve fibres.

Wexler developed a special recording technique for infrared thermal images of the back and claimed that his technique can identify disorders of the intervertebral disc [94]. However, a clear description of a normal back thermogram is missing and a formal evaluation of Wexler`s criteria for abnormal thermograms was never performed. The thermographic proof of disc disorders was already a controversial issue in the nineteen-seventies and eighties of the 20th century.

Clear deviations from the normal temperature pattern were detected in 22 patients with herniated discs in the cervical or lumbar spine [3]. The lesions of 19 patients with intraspinal tumours, 6 patients with syringomyelia, 4 patients with spinal metastasis and 4 patients after spinal injury could not be identified by thermography.

Duensig and coworkers evaluated infrared thermal images of the legs of patients with radiculopathy in a semi-quantitative way and found in the majority of cases a reduced infrared emittance from the affected dermatome [45]. The authors discussed three possible mechanisms of reduced skin temperature, but clearly favoured reduced perfusion of muscles.

Gillström [46] reported coincidence between clinical symptoms of sciatica and a temperature difference of the legs of 1°C or more in 51 of 52 patients, but differentiation of a L 4/L 5-syndrome from a S1-syndrome was not possible by thermography. In another study Gillström & Ehrnberg utilised thermal imaging as outcome measure in a study with autotraction as treatment for sciatica [47]. Patients responding well to ther treatment presented more often with a reduced thermal asymmetry than patients with unchanged symptoms.

De Weerdt et al investigated patients with persistent pain after disc surgery and reported significantly lower temperatures on the symptomatic dorsum of the foot than in the not painful leg.

The proceedings of 12th Annual Meeting of the American Academy of Therm ology contains 16 papers related to thermography in spinal disorders [49]. Unfortunately none of these studies performed comparisons between temperature findings and clinical signs of radiculopathy. Correlation to other imaging modalities in patients with herniated discs is not helpful as there is high evidence that a large percentage of patients with proven disc herniations do not present with clinical symptoms.

A systematic review by Hoffman et al. [50] concluded in 1991, that thermography should only be used for research but not for clinical roIn general, the thermographic body of knowledge in spinal disorders is incomplete and more high quality studies are needed before thermal imaging can be recommended as diagnostic method or as outcome measure for back pain.utine investigations. This statement was based on the evaluation of 28 papers, selected from a pool of 81 publications

The study of McCulloch et al. [51] was methodically designed for high level quality, but implemented the intended method incompletely The authors concluded that thermography is not valid method for the evaluation of patients with sciatica. However, the applied method of recording and interpretation of the thermal images may have been insufficient. The room temperature of 20 to 22°C might have been to low for die identification of hypothermic zones. The evaluation of thermograms was based on the observation that at least 25% of a single dermatome has to be cooler by 1 °C than the contralateral side. Such a criterium for evaluation might have been useful for liquid crystal thermography but does not fulfil the requirements of quantitative infrared thermography. The pitfalls of defining dermatomes on infrared images is emphasised particularly when standardised views and body positions for image recording is disregarded.

The paper by Takahashi et al. [52] regarded the thermal deficit identified by infrared thermography as an additional symptom in patients with radiculopathy. The hypothermic zones did not concur with the sensitive dermatomes or muscle weakness in the affected area. The diagnostic sensitivity (22.9 to 36.1%) and positive predictive value (25.2 to 37.0%) of the thermal deficit were low for muscular symptoms such as tenderness or weakness, and also for pain

and sensory loss. In contrast, a high diagnostic specificity (78.8 to 81.7 %) an a high negative predictive value (68.5 to 86,2%) were calculated, the diagnostic accuracy was moderate with 60 percent correct diagnoses.

Only the publications of Kim and Cho [53] and Zhang et al. [54] gave thermography a high priority for the diagnosis of lumbosacral or cervical radiculopathies. However, these studies show several methodological weaknesses. Although a high number of patients were reported in the investigation of lumbosacral radiculopathy, a comparison with healthy control subjects was not mentioned. A description of clinical symptoms is not available and the validity and reliability of the applied thermographic criteria for diagnosis remains questionable.

Korean neurosurgeons described a correlation between pain intensity and the extent of cooling of the symptomatic leg in patients with radiculopathy due to a single level disc herniation [55]. In patients with little pain the leg was 0.26±0.10 degrees cooler than the contralateral side, in moderate pain the reduction of temperature was 0.39±0.19 degrees. In severe pain the affected leg was 0.60±0.26 degrees cooler than the contralateral side and in patients with unbearable pain the temperature difference reached 0.98± 0.41 degrees. The change of temperature was also directly dependent on the degree of disk protrusion, when large herniations led to large temperature changes. Patients with symptoms lasting for 2 months presented with more temperature reduction than subjects suffering of radicular pain for six months or more.

A Chinese study has confirmed that healthy subjects present with symmetrically distributed temperatures at the lumbar spine and the rear of the legs with an upper limit of temperature difference of 0.5° degrees [56]. Hyperthermia at the level of the protruded disk and hypothermia of the affected leg were described as typical signs of disk herniation, but correct identification of the affected spinal level was not possible by thermography. There was a good correlation between pain intensity and extent of temperature difference of legs. However, a high proportion of irregular thermograms was observed in both healthy subjects and patients. Therefore, the authors recommended thermography only as an additional diagnostic method.

Discussion

Absolute temperature values of the human back, recorded at different room temperatures are not yet available. Furthermore, the term thermal asymmetry is misleading as symmetry is a distribution of self similarity of destined attributes. It is not possible to describe symmetry by mean values of the single attribute. A more precise term than thermal symmetry is a statement such as: the mean temperature varies little between regions of the right and left side of the body which is not equal to the expression that the spatial distribution of temperatures is similar on both sides of the body.

The qualitative description of thermal patterns needs further development. There is obviously no consensus on the pattern of the healthy back . It was also never proven, that the pattern of the health back has a normal i.e Gaussian distribution Furthermore, the methodology of studies on thermal asymmetry varied in study design such as sample size. gender and age of participants, room temperature and most important definition and localisation of measurement areas. Pooling of published data and meta-analysis is therefore not possible.

The response of skin temperature to manual therapy remains unclear as increase and decrease of skin temperature was associated with successful interventions. The data related to changes of skin temperature caused by various spinal pathologies are also contradictive. Vertebral blockage was associated with hot spots over the affected region, but also with hypothermia in the area of referred pain.

Pain in radiculopathy was also followed by low temperatures in the painful region. In case of totally dissected peripheral nerves, the innervated area appear to be warmer than the contralateral side. Short lasting nerve compression is associated with more severe temperature changes than long lasting impairments.

Taking all these findings into account, temperature changes on the back and /or the extremities in patients with suspected back disorders or radiculopathy must be interpreted very cautiously as different spinal disorders may generate a similar thermal pattern.

In summary, the thermographic body of knowledge in spinal disorders is incomplete and data of the studies are contradictive. More high quality studies are needed before thermal imaging can be recommended as diagnostic method or as outcome measure for spinal disorders.

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News in Thermology

International Consensus and Guidelines on Medical Thermology Fortaleza, Brazil October 7 -8, 2010

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PProfessor Dr. Marcos Leal Brioschi and Professor Dr. Mario Augusto da Silva Freitas did an exemplary job in their preparation and implementation of the International Consensus and Guidelines on Medical Thermology as recently held in Fortaleza, Brazil on October 7 -8, 2010.

The Speakers included notables from Brazil, Germany, Japan, Romania, South Korea and the United States. In addition to several international keynote speakers several local dignitaries and physicians enrolled in the University of Sao Paolo School of Medicine's Thermographic reading post graduate program presented papers.

A wide range of papers were presented. These included topics on SRPS/RSD, Fibromyalgia, Neurosurgical Monitoring, Anesthesia Techniques, Standards and Guidelines, Forensic Medicine, Plastic and General Surgery Applications, Breast Diseases, Visceral imaging and Acupuncture.

The American Academy of Thermology's Guidelines on Neuromusculoskeletal Thermography as originally passed in 2006 and revised in 2009 were presented as well. While these guidelines have been cited internationally and are rather detailed, they do not specifically address other areas of thermal imaging.

During the meeting in Fortaleza, broad based consensus guidelines for thermal imaging were presented, discussed and passed by the consensus committee. This important work addresses issues surrounding thermographic imaging with very broad strokes. It is not specific to any specialized area of expertise. In this regard it represents an important step in moving the field forward in a uniform fashion.

In addition Dr's. Brioschi, Teixeira, Silva, and Colman introduced their new book: "Medical Thermology Textbook: Principles and Applications". The content in this work is based on the International Consensus and Guidelines for Medical Thermography as noted above. The book includes five different chapters ranging from the fundamentals of thermography to various indications.

The Department of Neurology of Sao Paolo University, Brazilian Society for the Study of Pain, Surgery Post-Graduation Department of Parana Hospital University, Brazilian Academy of Sciences and Brazilian Academy of Legal Medicine graced the audience with the Fortelaza Letter, congratulating the meeting for its works, presentations, and internationally recognized speakers.

Many of the keynote speakers made commitments to participate in the South Carolina Society of Physical Medicine & Rehabilitation's continuing medical education (CME) accredited program "CRPS/RSD & Thermal Imaging" to be held in conjunction with the South Carolina Medical Associations' annual meetings in Greenville, South Carolina on April 30th, 2011. Dr. Robert Schwartz, MD, Current president of the American Academy of Thermology will be the program director. Inquiries can be him though his office web site: **www.piedmontpmr.com**

Finally, the next meeting of the International Consensus and Guidelines will be held in Sao Paolo Brazil, on June 17-19th, 2011 **www.cindorusp.com** during the International Interdisciplinary Pain Congress of USP.

In summary this was an excellent meeting. As Thermology continues to grow the medical community should look forward to such opportunities to learn, share and promulgate this important field.

International Consensus and Guidelines on Medical Thermology Fortaleza, Brazil, October 7 -8, 2010

Abstracts

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 Neuro-musculoskeletal 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.

HOW CAN WE USE THERMOGRAPHY IN SURGICAL CENTER?

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Thermometer is used for many purposes in the surgical center. The temperature of the patients undergoing surgery is monitored constantly, and the temperature of the operation room has to be controlled adequately for the procedure of the surgery. In this presentation some trials of evaluating the pre-surgical stress of the patients, the ischemic change of the gastric tube used for the reconstruction after esophagectomy and the uncomfortable events for the patients in the operation room are demonstrated as pilot studies. And the results of the evaluation of the hypothermia during open and laparoscopic surgery are reported.

(1)Some trials

In the first trial the temperature of the forehead was measured for evaluating the stress of the patients in the surgical center. The temperature of the forehead of the patients was high before anesthesia. This seems to show the patients are very nervous just after the surgery.

In the second trial the thermal change of the gastric tube used for the reconstruction after esophageal resection was evaluated. There were many studies reported about the thermographic evaluation of the organ ischemia. In my experience the ischemic change of the gastric tube can be detected by thermography. But, it could not be determined which temperature of the gastric wall induced the anastomotic leakage by the ischemia. Because the temperature of the gastric tube was influenced by not only the ischemia but also the whole body condition.

In the third trial it was evaluated whether the uncomfortable events in the operation room can be detected by thermography or not. The temperature of the abdominal wall was decreased after washing by warm saline for cleaning the surgical wound. It was also detected the hypothermia of the abdominal skin after the cleaning using alcohol by thermography.

(2)Peri-surgical hypothermia and laparoscopic surgery

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

In the second study the body temperature and the temperature of abdominal wall during laparoscopic cholecystectomy were measured as a pilot study. The body temperature did not change during the surgery. But, the temperature of the abdominal wall decreased from the beginning of the surgery.

In the third study the body temperature and the temperature of abdominal wall during laparoscopic colectomy were measured. The temperature of abdominal wall was decreased from the beginning of pneumoperitoneum and then it rose gradually to the end of the surgery. The temperature of the tube using for pneumoperitoneum 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. The results of the second and third study mean that the hypothermia of the abdominal wall was influenced by pneumoperitoneum and that the body temperature was also influenced by it.

For diminishing surgical site infection and avoiding hypothermia, it is important to observe the body temperature of the patients undergoing surgery, especially in laparoscopic surgery. And the thermography is a useful device for evaluating the hypothermia of the patients during the surgery and detecting the mechanism of the hypothermia.

HOW DOES THERMOGRAPHY HELPS ABDOMINAL PLASTIC SURGERY

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Abdominal plastic surgery has suffered many alterations since its beginning. A revolution started in the eighties with the liposuction introduced by Illouz and his posterior abdominoplasty without undermining. Actually, authors as Avelar and Saldanha have been disseminated the moderns abdominoplasty, as the lipoabdominoplasty.

Infrared Thermography is a method that captures heat alterations of the skin with the infrared spectrum, permitting to study skin vascularization and function.However, there are no references in the literature about the studies of the skin micro circulation to compare surgeries.

In this paper we studied twelve patient preliminaries, without surgery and with different techniques, with the infrared thermography, with comparison of the vascular patterns. After, we studied 25 patients before and after lipoabdominoplasty (LAP), Abdominoplasty without undermining and with preservation of the superficial fascia (APSF) and Classic Abdominoplasty (CAP) with little undermining . The results were evaluated quantitatively (number of perforator vessels) and qualitatively (capacity of maintaining skin thermoregulatory function)

Results: At the preliminary study there were no possibility to establish a circulatory pattern, probably because the groups were heterogeneous. At the prospective study the groups were homogeneous with the control pre operatively ($F = 0,7680$ y $p = 0,5248$) and heterogeneous post operatively ($F = 11,1744$ y $p = 0,0001$).

The LAP patients had the biggest preservation in number of perforated vessels and quality of thermographic images, compared with the control, with low rates of complications.

The APSF had few complications, compared with LAP group, and a reasonable thermoregulatory function, although the number of the perforator had decreased.

The CAP group had the biggest destruction in perforator vessels and the worst thermoregulatory function, with the highest complication rate.

Conclusion: The infrared thermography is a simple and useful method of the evaluation of the abdominal skin vascularization and function. There were decrease in perforator vessel's number and thermoregulatory function, crescent in the groups: LAP, APSF y CAP. The CAP group had the biggest complication rate, wherears the others were comparables and low.

The APSF is an alternative to the patients who cannot have a LAP, with good preservation of the circulation and thermo-regulatory function, with low complication rates.

Other studies are necessary to evaluate the aesthetic or not aesthetic possible changes after functional post operative modifications.

EX VIVO APPLICATION OF DIGITAL INFRARED THERMAL IMAGING IN THE ANALYSIS OF MICROCIRCULATION AND HEPATIC TISSUE VIABILITY WITH ISCHEMIA INJURY IN WISTAR RATS

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Under physiological conditions, homogeneous liver perfusion is to be expected. Heterogeneous perfusion is seen as a bad prognosis for organ and tissue transplantation. The various current techniques used to evaluate organic microcirculation are limited when it comes to: extent of the area, physical contact of lesion potential, reproducibility, use of radiation, lab dependence. Digital infrared thermal imaging is innocuous, precludes physical contact and, for following physical heat transfer principles, it may be an ideal ancillary diagnostic technique in the study of organ and tissue quality.

Objective: Evaluate ex vivo the heat transfer pattern in hepatic and ischemic control tissues and its anatomical correlation (optical macroscopy and microscopy) with digital infrared thermal imaging.

Methodology: Twenty Wistar rats were anesthetized and divided into two groups: Group I (liver control); Group II (ischemic liver), hepatic ischemia by portal triad and hepatics veins clamping for 60 minutes. The livers (ex vivo) were perfused by portal vein with saline at 4oC and imaged with a 25Hz resolution thermal imager. After the perfusion, the livers underwent anatomical pathology examination through standard optical macroscopy and microscopy.

Results: The heat transfer pattern in the control areas (without ischemia) was homogeneous; the ischemic areas perfused heterogeneously versus the control group. There was correlation of the heterogeneous areas with hepatic tissue ischemia under optical macroscopy and microscopy.

Discussion: Microcirculation obstructed by cellular edema, by changes in the hepatocytic microarchitecture, by degeneration of the hepatocellular cords, and by inflammatory infiltrates obstruction impairs the thermal flow of cold fluid in ischemic areas, which explains the pattern in which heterogeneous isotherms are interrupted by hot spots and the improperly perfused hyper radiant areas.

Conclusion: There was anatomical correlation (macroscopy and microscopy) with digital infrared thermal imaging in the detection of hepatic and ischemic control tissue.

MIG3 BIOCERAMIC T-SHIRT FOR TENDINITIS OF THE SHOULDER - A CASE STUDY

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Introduction: Tendinitis of the shoulder is characterized by a reactive calcification that affects the rotator-cuff tendons. Treatments directed toward the calcium deposits, such as surgery and percutaneous needle aspiration, seem to reduce pain and restore shoulder function in some, but not all, patients. In the healthcare field, the effects of luminous radiation on the tissues are well known. Through the action of visible (red) or invisible (infrared)

light, luminous radiation promotes a molecular vibration, leading to an increase in the tissue metabolism, called biostimulation. Radiation acts by increasing the cell membrane permeability, favoring the exchange of metabolites as extracellular medium, and by nurturing the cells. It acts on the mitochondria, favoring the ATP synthesis and, consequently, stimulating the synthesis of proteins such as collagen and elastin. It also enhances cell division. In order to provoke this increase in metabolism, the extracellular medium is required to be healthy. Infrared stimulates chemical mediators and hormones that will act on the control of edema, pH, oxygen free radicals and microcirculation, fostering the required conditions for the increase in the cell metabolism. MIG3 bioceramics, an infrared emitter, incorporated in clothes (gloves, shorts, dressings), allows its use at home, in a simple and non-invasive way, at work, and even during sleep, thereby facilitating a patient's daily life. Recent evidence claims that it can control pain, inflammation, accelerate healing in the post-operative period, and minimize the use of drugs and its side effects, through self-regulation mechanism. Thus, the use of therapeutic far infrared is predominantly empirical, based on reported biophysical effects within tissue and on anecdotal experience in clinical practice. The impregnation of bioceramic MIG3, a far infrared emitter, in fabrics, can increase the area of application and improve the results. Therefore, we assessed the efficacy of MIG3 bioceramic, a far infrared emitter, in T-shirts, as a treatment for idiopathic tendinitis. The objective was evaluating the inflammation in the shoulder before and after the MIG3 bioceramic T-shirt use in a patient with idiopathic tendinitis.

Case study: Woman, age of 19, secretary, with wrist pain for 6 months. She was not using medications. There was made a infrared exam which diagnosed shoulder tendinitis. She wore a t-shirt with MIG3 bioceramics for 20 minutes and, after this period, the infrared exam was repeated. Result: Before using the MIG3 bioceramic fabric, a horizontal line from one shoulder to the other shows a higher temperature (>33oC) at the right shoulder when comparing to the left shoulder (31oC). After 20 minutes use, the temperature of the right shoulder decreased from 33oC to 31,5oC, and after more 20 minutes, both shoulders presented the same temperature.

Conclusion: The use of MIG3 bioceramic fabrics can decrease pain and inflammation of chronic inflammatory diseases such as tendinitis.

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COMPUTERIZED THERMOGRAPHY BY INFRARED IN THE DIAGNOSIS OF DIABETIC NEUROPATHY

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Introduction: The thermography measures the emission of infrared radiation by the human body, which can be converted in temperature; the cutaneous blood flow, measured mainly by the sympathetic nervous system can be evaluated through this methodology. Previous researches have showed that plantar thermic map allows the quantification of asymmetries and patterns indicative of dysfunction of the autonomous nervous system even in asymptomatic diabetics.

Objectives: evaluate the application of computerized infrared thermography in the diagnosis of diabetic neuropathy in individuals with diabetes type 2 (DM) and pre-diabetics.

Methods: 50 individuals of both genders, aging between 19 and 69 were analyzed (26 diabetics type 2, 8 pre diabetics and 16 controls). Individuals with hypothyroidism and/or smokers were excluded. The analysis of the sample was obtained through plantar thermography, with provocative test by cold stimulus, study of variability of heart frequency and electromyography (EMG). The clinic neuropathy was defined by the presence of suggestive symptoms and/or according with the Michigan Inventor with score >3.

Results: The average of age was similar between the subgroups. Among the patients of the control group none showed clinic neuropathy, alterations of EMG or positive cardiovascular tests. Among the pre-diabetics 25% (n=2) presented Cardiac Autonomic Neuropathy (CAN), 25% (2) clinic neuropathy and 12.5% (1), altered EMG. Among the patients with DM the prevalence of clinic neuropathy was of 15.3% (n=04), altered EMG 57.7% (n=15) and cardiovascular tests in 53.8% (n=14). The plantar thermography was altered in 37.5% of the controls, 87.5% of pre-diabetics and 92.3% of patients with DM (p <0.0005). Out of patients who were pre-diabetic or diabetic with symptoms, 100% presented altered plantar thermography. Out of patients who were pre-diabetic or diabetic with altered EMG, 100% presented altered plantar thermography.

Conclusions: The partial results of this study indicate that the plantar thermography can be altered early, even before the confirmed DM diagnose. The clinic neuropathy can appear later in the course of the illness, where plantar autonomic changes can be identified by plantar thermography even before the autonomic cardiac alterations. Prospective studies will define the role of this exam in the evaluation and segment of the patient with DM.

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THE UTILIZATION OF FUNCTIONAL INFRARED IMAGING (FIR) IN EVALUATING PATIENTS WITH PRESUMPTIVE COMPLEX REGIONAL PAIN SYNDROME (CRPS)

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Complex Regional Pain Syndrome (CRPS) is a potentially disabling neuropathic condition characterized by regional pain that is often disproportionate to or occurs in the absence of an indefinable inciting event. Peripheral and central sensitization is a common feature in CRPS. CRPS involves inflammatory, neuropathic and nociceptive mechanisms. CRPS by definition is always associated with abnormal sympathetic nervous system activity that includes a characteristic triad of autonomic (e.g.- sudo and vasomotor changes), sensory (e.g.-pain, hyperalgesia and allodynia), and motor disturbances (e.g.-paresis, tremor, dystonia). CRPS generally occurs following minor or major trauma to soft tissue or peripheral nerves and may also occur following fracture, visceral trauma or central nervous system insult.

To date, a single all encompassing diagnostic algorithm for CRPS remains lacking. Complex Regional Pain Syndrome is characteristically diagnosed using the International Association for the Study of Pain (IASP) criteria. This diagnostic criteria is based upon non-standardized signs and symptoms. Rigorous discriminate function analysis (DFA) applied to these criteria have revealed problems in reliability and validity. Results of validation studies have shown significant potential for over-diagnosis due to low specificity, low inter-observer reliability, and considerable variability in the recognition of relevant clinical signs. The diagnosis is complicated by neuropathic and somatic conditions that often mimic this syndrome. Recent modification of the IASP criteria has increased the diagnostic accuracy. However, recognized disparities in the diagnostic criteria promote inherent difficulties in the clinical management of CRPS which lead to a tendency for either flank under-treatment or excessive utilization of therapeutic interventions that concur significant cost, time and even health burdens for the patient. More reliable diagnostic testing procedures are needed in order to advance both the understanding and treatment of CRPS.

Functional infrared imaging (fIR), if performed according to strict protocols and guidelines and interpreted by a highly trained and qualified doctor, effectively detects the thermal signatures of vasomotor disturbances (ANS dysfunction) that are an important factor in establishing a diagnosis of CRPS. However, ill-conceived use of IR imaging by poorly trained individuals in the past proved to be problematic. Common misuse of IR imaging, when evaluating patients with presumptive CRPS, is the documentation of an asymmetric hypothermic IR signature in the symptomatic limb that becomes a "false hallmark" in diagnosing this often clinically confusing syndrome. Furthermore, numerous somatic and neuropathic conditions present with signs and symptoms that "mimic" CRPS. The mimickers often reveal asymmetrical IR signatures that lead to interpretation errors. Inaccurate interpretation of the IR data may condemn the patient to repetitive sympathetic blocks and unnecessary therapeutic interventions which eventually lead to therapeutic failure.

Appropriate understanding and utilization of fIR imaging guidelines and procedures, in evaluating patients with presumptive CRPS, greatly enhances the sensitivity and specificity of this imaging modality. In order to obtain high sensitivity and specificity outcomes three (3) distinct and objective IR indices must be obtained. The three distinct IR indices include:
(1) quantitative computer generated side-to-side delta T's of the distal involved symptomatic and asymptomatic extremities,
(2) obtaining distal thermal gradient IR signatures (disrupted in patients with neuro- pathic pain syndromes of either sensory or autonomic origin) and
(3) performing cold water autonomic functional stress testing of the symptomatic extremity (helpful in differentiating between sensory and auto- nomic dysfunction). The functional cold water autonomic stress test evaluates the integrity (function) of the autonomic nervous system (ANS). Functional cold water autonomic stress testing is 72% sensitivity and 94% specificity with a kappa index of concordance of 0.69 when comparing patients with the modi- fied IASP criteria for CRPS [Conwell et al., 2010]. Functional cold water autonomic stress testing, in and of itself, may be a valuable screening test for ANS function. The incorporation of these three (3) distinct and objective IR indices (i.e. functional infrared imaging testing procedure) in evaluating patients with presumptive CRPS achieves a 93% sensitivity and 89% specificity [Gulevich et al., 1997].

In conclusion, functional infrared imaging effectively detects specific IR signature indices that objectively reflect vasomotor disturbances that are important in establishing a differential diagnosis of CRPS. The specific objective IR indices cannot be taken in isolation. Therefore, fIR imaging should not be considered or utilized as a stand-alone diagnostic modality. However, it is equally important to recognize that the inherent ambiguities in the presentation and clinical diagnostic algorithm for CRPS fortify the utility of this technology as part of the diagnostic workup. Functional infrared imaging, when administered and evaluated by a competently trained doctor, is both pragmatically valid and ethically imperative.

DIGITAL INFRARED THERMAL IMAGING TO EVALUATE IPSILATERAL TESTICULAR INJURY FOLLOWING SPERMATIC CORD TORSION IN RATS

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Objective: The purpose of this study is to evaluate testicular vascular microcirculation by digital infrared thermal imaging (DITI) in rats undergoing testicular ischemia and reperfusion following different periods of spermatic cord torsion, comparing the results with histopathology.

Material and methods: Sixty adult male rats were subdivided in five groups with 12 animals, each of which underwent 1080-degree torsion of the right spermatic cord for null, 30, 60, 90, and 120 minutes, followed by detorsion and reevaluation after three days or three months. DITI was performed before torsion (T0), after the period of torsion determined for each group (T1), after spermatic cord detorsion (T2), after three days of testicular reperfusion (T3a), and after three months of reperfusion (T3b). All ipsilateral testes were evaluated by histopathology for the presence of testicular necrosis or atrophy.

Results: Compared with T0 (control), there were no differences in mean testicular temperatures evaluated by DITI in T1, T2, T3a, and T3b in the groups undergoing detorsion of the spermatic cord after 30 minutes and 60 minutes of torsion, and the incidence of testicular necrosis or atrophy was similar to the control group in these groups. Animals undergoing torsion of the spermatic cord for 90 minutes and 120 minutes showed significantly lower mean testicular temperatures in T1, and the incidence of testicular necrosis and atrophy was significantly increased in these groups.

Conclusion: Testicular vascular microcirculation evaluated by DITI correlated well with histopathologic findings in the ipsilateral testis of rats undergoing spermatic cord torsion.

BILATERAL MERALGIA PARESTHETICA: IMPORTANCE OF INFRARED THERMOGRAPHY (IRT) IN THE ELUCIDACION AND REHABILITATION OF A CASE.

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Background And Objectives: Meralgia paresthetica (Bernhardt - Roth Syndrome) is caused by compression of the lateral femoral cutaneous nerve by the inguinal ligament as it passes through or under the inguinal ligament. This entrapment neuropathy presents as burning pain, sometimes numbness, and dysesthesias in the lateral thigh. Is almost always unilateral, and affects more men than women. This study aimed at reporting a case of a pacient with intense burning pain (VAS=9) in the lateral of both thighs with associated cutaneous sensitivity, disability, anxiety, and depression, refractory to normal treatment.

Case Report: Male pacient, 37 years old with severo pain, numbness and dysesthesias in the distribution of the lateral femoral cutaneous nerve, bilateral, has been present for two years. All exams, radiographs of the hip, electromyography, magnetic resonance imaging (MRI) scan of the spine did not show any significant findings. Additional testing as complete blood count, uric acid, sedimentation rate and antinuclear antibody testing was normal. Submitted to a infrared termography (IRT) with asymmetry between the regions of the lateral thigh (hyper radiation) in the femoral nerve territory.

Conclusion: The standard found by the infrared termography (IRT) suggesting meralgia paresthetica gave assurance to the pacient of the diagnosis with an overall improvement, proving that, because of the subjectivity of complaint of pain, the IRT can be of great importance like effective diagnosis as early rehabilitation of the pacient.

FOOD ALLERGY AND THERMOGRAPHY IN FIBROMYALGIA

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Current data demonstrate that the entire immune system can be activated by food to produce clinical symptoms. This area of clinical allergy and immunology - the hypersensitivity reactions induced by food - requires further studies. In this report the authors will present one patient diagnosed by thermography signature of fibromyalgia and delayed food allergy, using American Academy of Environmental Medicine Methodology. The signs and symptoms of food allergy are frequently overlooked by both patient and physician. Such signs and symptoms may have multiple possible causes. The least likely of these causes is food allergy. The proper identification of the offending food can be very effective from the standpoint of cost and benefit, allowing the return of the patient to full productivity and quality of life. The authors believe that thermography could be a strong help to doctors who study inflammatory reaction from delayed food allergy.

Male patient (42 years old) complaining of continous pain in the legs was extensively investigated without any diagnosis. After thermography, M.Brioschi found fibromyalgia signature. Following the diagnosis hypothesis De Paula conducted test to food delayed allergy by skin test that revealed food sensitivity to rice and beef. After eliminating them from diet, the patient had complete remission of his legs pain and observed reduction of relative size of his abdomen. The authors strongly recommend further studies connecting the knowledge developed for the study of food delayed allergy and check towards thermography and probable implication in nutritional management of fibromyalgia.

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THERMOGRAPHY IN THE IDENTIFICATION OF MYOFASCIAL TRIGGER POINTS

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Introduction: Computerized thermography is part of the current arsenal of instrumentation in biomechanics. Using this methodology, it is possible to assess the physiology of thermical maintenance through its skin surface representation. The aim of this work is to assess the thermography as the identification method of myofascial trigger points, been chosen the trapezius muscle as study focus since it is one of most affected body regions concerning myofascial syndrome. This syndrome is highly prevalent and historically underdiagnose as it requires expert professional to establish its diagnostic, through physical examination.

Methods: This study had a sample of thirty persons, fifteen men and fifteen women, ages between twenty three and seventy years (32,5 years in average). The algometry by pressure, a highly validated method in previous work, has been used as part of physical examination to confirm thermography events. The equipment used to collect the thermograms was an infrared camera with digital image processing, with thermical sensitivity for spectral ranges from 7-12 micrometers, appropriate for medical diagnostic utilization; the error index for measurement on this equipment is either 2% or 2?C. It has been used a dynamometer, clock type, for the algometry, which makes its possible to assess the applied pressure to the focal point. The trigger point identification was based in a pain diagram filled by the own subject using previously validated parameters. The imaging assessment was done using a descriptive analysis, having been taking in consideration the thermographic event corresponding to the trigger point, the hot spot or a discoid shaped surface, with one or more degrees Celsius hotter if compared to the neighbor reference point. Algometry was used in this work as reference method. Descriptive statistics were applied to assess sensibility and specificity in trapezius Myofascial Syndrome.

Results: A totality of 250 trigger points had been founded: 198 (79.2%) identified by algometry and thermography; 41 points (16.4%) by thermography only; 11(4.4%) identified by algometry only.

Conclusion: It was concluded that thermography is an appropriated method for Myofascial Syndrome diagnostic on trapezius muscle.

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RADIOLOGICAL CONSIDERATIONS ON INFRARED MEDICAL THERMOGRAPHY: FROM TECHNIQUE TO PROFESSIONAL RESPONSIBILITY

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Scientific and technological progress of diagnostic Imaginology provided the arise of new methods, including high resolution Medical Infrared Thermography. Face to current labor market requirements, it is necessary that Infrared Imaging experts ensure their future success through technical training in education programs, acquisition of technical and scientific training, skills development related to medical specialization and awareness of ethical and bioethical issues that compose the "ideal professional profile". Enhancement of these qualities will ensure the Clinical Thermology professional a complete role and resposability as a doctor and as a person.

INTERVENTIONAL PAIN MANAGEMENT IN RAYNAUD'S DISEASE: THE IMPORTANCE OF INFRARED THERMOGRAPHY

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In Raynaud's disease symmetrical vasospasms especially of the extremities occur after provocation by low temperature, vibration and/or stress resulting in massive pain and color changes of the skin lasting for minutes to hours. Other acral parts (nose, tonge) may also be affected. Causes are multiple and include connective tissue disorders, drugs/medication, endocrine, hematologic, neoplastic, neurologic and/or vascular disorders as well as infections or mechanical conditions. The disease may expand to local, extremely painful gangrene. In cases where the stimulus cannot be removed, vasodilating drugs may offer some comfort. If these remedies fail and the disorder progresses surgical debridement may become necessary for ischemic ulcers.

To circumvent major surgical interventions cervical, thoracal and/or local sympathectomy may abolish symptoms. A case of a woman is presented, where more conservative remedies failed to improve local perfusion of the hands. She received blocks at the stellate ganglion and finally a catheter was implanted to the thoracic sympathetic chain. Thermographic imaging was performed to show different stages of the process.

A RANDOMIZED SINGLE-BLINDED PLACEBO-CONTROLLED CLINICAL TRIAL FOR ASSESSING EFFECTS OF ACUPUNCTURE AT HEGU (LI4) BY CONTACTFREE INFRARED THERMOGRAPHY

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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 $\pm$ 2.7°C to 31.2 $\pm$ 3.0°C and to 31.9 $\pm$ 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).

MONITORING EFFECTS OF SYMPATHICOLYSIS WITH INFRARED-THERMOGRAPHY IN PATIENTS WITH COMPLEX REGIONAL PAIN SYNDROMES (CRPS)

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Multiple methods have been described in treating patients with complex regional pain syndromes. Effects of sympatholysis are often distrusted as the role of the autonomous nervous system in producing and sustaining this syndrome are not clear yet. With the aid of infrared-thermometry, it could be shown, that the injection of local anesthetics to the sympathetic ganglia produces different results as compared to the injection of physiologic sodium-chloride-solution or contrast media. Also, posture and motor function may be monitored with this valuable tool as sym- patholysis causes an improved dermal blood flow with an increase in surface temperature.

Here, the case of a young woman is presented who had suffered from complex regional pain syndrome for more than eight years. She was on high dose analgesics and could not use her left arm anymore after she had donated blood. After having undergone different treatments, she received blocks of the sympathetic chain along with intensified physical therapy and psychological guidance. After only 14 days of treatment, changes in physical abilities were overwhelming and could be demonstrated on infrared thermograms as well. Motility and sensory function in patient with complex regional pain syndrome who had suffered for a year could be completely restored after treating her for 22 days. Both courses were followed with infrared thermography.

MONITORING TREATMENT EFFECTS IN OSTEOMYELITIS WITH THE AID OF INFRARED THERMOMETRY

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Treatment of osteomyelitis may be sophisticated and time consuming. The case of a young male is described who suffered from osteomyelitis of his jaw after an accident for more than five years. He had received multiple doses of antibiotics; still healing would not progress as desired. Meanwhile he endured severe pain in his jaw that started spreading over his whole face. As sufficient blood supply is inevitable for delivery of satisfactory amounts of antibiotics to the affected site, the primary aim in treating this patient was, to increase perfusion in the area involved. As he also presented with neuropathic pain in the face, the idea was, that the whole disease might be sustained by the sympathetic nervous system. Hence, he received blocks of the stellate ganglion and the thoracic sympathetic chain. Monitoring sympathetic activity was achieved by infrared thermography: an increased blood flow could be confirmed. Furthermore, the patient depicted less pain as assessed on the numeric rating scale.

IDENTIFICATION OF DIABETIC FOOT VASCULARIZATION BY THERMOGRAPHY

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Abstract: Diabetes Mellitus is a group of metabolic disorders characterized by hyperglycemia, being considered one of the main chronic diseases because of reduction or absence of insulin production related to food habits and absence of physical activity. It represents 5,1% of worldwide adult population aged between 20 and 79 years old. It is a chronic high cost disease to public health and its carriers, because of its long-term complications, consequence of lack of preventive information. Diabetic foot is an expression used to designate cutaneous and deep plans lesions related to neuropathic, vascular, orthopedic, infectious and functional alterations that may occur in an individual's foot and that are responsible for about 20% of hospitalizations of diabetic patients. This study is about the usage of a thermograph as a diagnosis method in the evaluation of diabetic patients' lower limbs. This exam is known as high sensitivity infrared cutaneous thermometry, it is a non-invasive method that doesn't require physical contact with the patient, it doesn't require contrast and it is totally safe to cutaneous microcirculation evaluation. Exam results make possible to determine the functioning of vascular systems, inflammatory processes and dermatological conditions. This exam allows a clinical and safe prognosis that may guide appropriate treatment.

NON-INVASIVE DERMATOLOGICAL MONITORING: HOW EFFECTS OF INTERVENTIONS IN PRESSURE ULCERS CAN BE VISUALIZED WITH THE AID OF INFRARED THERMOGRAPHY

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Pressure ulcers (bedsores, decubiti) occur where tissue is compressed between bony prominences and solid underground resulting in defects ranging from simple erythema to skin loss with extensive soft-tissue necrosis. They especially develop in older patients or people suffering from impaired circulation, immobilization and malnourishment, and bacterial superinfection is a serious risk. Treatment strategies include local care and reduction of pressure. In cases of severe tissue trauma skin grafts and/or myocutaneous flaps might be necessary. As perfusion of affected tissue seems to be of major importance, medical measures may also include procedures to increase blood flow like sympathetic blocks.

Two cases of severe decubiti are presented. The first patient presented at an age of 80 years with an ulcer III° at the os sacrum after having undergone surgery of the hip bone. Local care sufficed to cure the ulcer with thermographic imaging revealing effects of treatment much earlier than clinical improvement could be observed. The second patient aged 74 years suffered from an ulcer at his ankle due to underlying peripheral vascular disease. Multiple strategies had failed thus he was admitted to the hospital for continuous block of the lumbar sympathetic chain. Again, thermographic imaging revealed effects of therapy before clinical revitalization could be revealed.

NON-INVASIVE NEUROMONITORING: HOW EFFECTS OF INTERVENTIONS CAN BE VISUALIZED WITH THE AID OF INFRARED THERMOGRAPHY

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Various methods to monitor effects and function of the nervous system have been described so far. The electroencephalogram (EEG) is the most known procedure in evaluating brain function. More sophisticated techniques have been developed ever since. Unfortunately, in Interventional Pain Management these approaches do not necessarily allocate underlying pathologies or facilitate surveillance of effects during treatment. As the autonomous nervous system is involved in vasomotor action, manipulation at this site may be visualized with the aid of infrared thermography: blocks of the sympathetic ganglia lead to vasodilation and increased acral blood flow resulting in augmented temperature. As these blocks are performed using anatomic landmarks only as opposed to radiographic guidance, patients may portray insufficient pain relieve if the correct structure is missed. Instead of exposing the patient to x-ray, thermography may help illustrate the structures blocked. Moreover, the exact mode of relieve of some procedures has not been determined yet, e.g. acupuncture. Contribution of the autonomous nervous system as well as participation of vasoactive hormones is suspected. Again, infrared thermography depicts changes in acral blood flow in treated patients and helps verify, if a certain therapeutic regime is chosen correctly.

INFRARED THERMOGRAPHY IN THE DIAGNOSIS AND TREATMENT OF "TENNIS ELBOW"-CASE STUDY

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Introduction: The computerized thermography captures the cutaneous infrared emissivity, which can be converted in cutaneous thermal mapping. It serves, therefore, as an auxiliary method of diagnosis of inflammatory pathologies which express by the rise in local temperature and hyper radiation captured by the infrared camara can be monitored before and after treatment. It is a method without contact, non-radioactive and non-ionizing. The mesotherapy, which consists in the application of specific drugs in the intradermal region through punctures with a needle of 0.4mm achieves, initially, the reticular dermis, richly vascularised is one of the mechanisms responsible for the fast therapeutic response of this technique. The anesthetic block with lidocaine is known as an effective technique in the deactivation of myofascial

trigger points which many times accompanies the cases of tendinopathy, aggravating the pain symptoms.

Objective: To evaluate through the thermography by infrared a patient with diagnosis of lateral epicondylitis, symptomatic, before and immediately after treatment with mesotherapy and anesthetic blocking of trigger point.

Material and Methods: Male patient, 20 years old, tennis player, with complaint of pain for 20 days (Visual Analogic Scale 6 at rest and 8 at extension of fist), having interrupted the sport practice because of pain and functional incapacity, with clinic and ultrasonographic diagnosis of right lateral epicondylitis. After thermalization (15 minutes in room with temperature between 23-24ºC) and having followed pre-exam protocol with special attention to restriction towards coffee, nicotine and vasoactive drugs, the infrared images was performed and, afterwards through the physical exam with aid of algometer, it was identified, beyond the classic lateral epicondylitis, pain in extension area of right forearm, with presence of 01 active trigger point with pain referred to the fist. The epicondylitis was treated with a mesotherapic mix constituting of NSAID, vasoactive drug (concentrated rutina), salmon calcitonin and acid Procaine applied in 4 points orthogonal to the epicondyle with a Lebel needle (0.4mm) and blocking of trigger point of common extensor muscle of fingers with lidocaine at 1% without vasoconstrictor. New thermographic images were made 20 minutes after treatment.

Results: The thermography showed qualitative and quantitatively the hyperradiation immediate to the application of the mesotherapy by the lateral epicondyle and the normalization of the temperature in the area of the common extensor muscle of fingers (disappearing of myofascial hot spot). VAS was ZERO at rest and 2 in extensor activity of the fist.

Conclusions: Inflammatory tendinopathies related to repetitive effort can be aggravated by myofascial pain and can be diagnosed and treated in an effective way with aid of Infrared Thermography.

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BLOOD DISTRIBUITION AND ANTIINFLAMATORY PROCESS WITH THE USE OF MIG3 BIOCERAMIC SOCKS

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Introduction: The thermography is a practical help in the clinical evaluation of patients with changes in the legs and is particularly relevant for the assessment of lameness. Thermography is the pictorial of skin temperature. The technique involves the detection of infrared radiation, which can be directly correlated to the blood flow and detects heat before that is noticeable during a routine physical examination and, therefore, it is useful for early detection of stress fractures and tendinitis. It provides a means to evaluate the blood supply to a region and represents one of the only viable means not invasive to evaluate the blood flow to the horse's foot. It is also useful for early identification of stress injuries for orthopedic patients opposite limb.

Case report: S.T.M. P, physiotherapist, 22 years, arrived at the outpatient clinic service with a small and unique lesion on the 5th right toe. The injury had ellipse format (greater axis of 1 cm and minor axis of 0, 2 cm). The patient had beaten the fifth finger against a chair one day before the exam. Felt pain relatively lightweight (grade 3 approximately), which bothered a little, but not limited to anything. She underwent infrared thermography examination for blood microcirculation observation of an acute injury in a small region before and after use of a sock with MIG3 bioceramic. Infrared examination prior to use of sock noted an increase in temperature on the fifth right toe, being observed by the doctor who could see some inflammation. After using the MIG3bioceramic sock, the signs of acute inflammation have reduced and also the level of pain.

Discussion: The first infrared image showed decrease of the 5th right toe hyper radiation after 1 hour of use of sock, which improved foot temperature in degrees; decrease in the 5th finger inflamed temperature of 2, 5oC and increased thermal distribution in the distal region of the foot. The temperature remained after 10 minutes of withdrawal.

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A NEW METHOD FOR AUTOMATIC SEGMENTATION OF THE REGION OF INTEREST OF THERMOGRAPHIC BREAST IMAGES

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Introduction: The use of thermal images has grown in medical applications, the variations of the human body temperature may give a valuable information regarding to physiological disorders [1]. The infrared image of the breast provides physiological information of normal and abnormal functioning [2].

Methodology: For automatic segmentation of the ROI, thermographic frontal images with the arm down (the named T1 acquisition in the developed database) are used. The region of each breast (left and right) is extracted following the schema showed in Figure 1. It has three mains steps: preprocessing, borders detection and ROI definition. A computer developed program removes the background and detect the area between the axilla (armpit) and the inframammary fold. An application of the software includes computer diagnosis based on contra lateral similarities. The efficiency of the extractions are qualitatively verify by a group of radiologists of the Antonio Pedro University Hospital - HUAP [3].

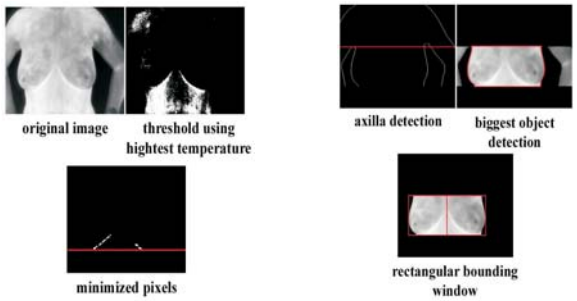

Figure 1 - The main steps of the computer developed system

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ON THE BREAST RECONSTRUCTION BY THERMAL IMAGES

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Introduction: From a database of 2D thermal image, curves are extracted and combined in a developed software to generate a 3D model of the breast (Figure 1). This model has several important applications such as mesh generation for use in nu- merical methods for analysis and visualization Such technique could be used in breast reconstruction or for definition of the best prosthesis for the patient and to aid to the diagnosis, as well [1].

Methodology: Frontal and lateral images are used to detect the body limits points from thermal images. Then specially developed computer software is used for geometric reconstruction of the patient breast [2]. Through this a three-dimensional model is achieved forms very close to the reality of the body of the patient. The obtained results are verified by comparison with Fotographic and 3D laser scan acquired images. Figure 1 shows the IR images used to extract geometric information, a computer model generated by this information and a comparison with a real model of the same volunteer.

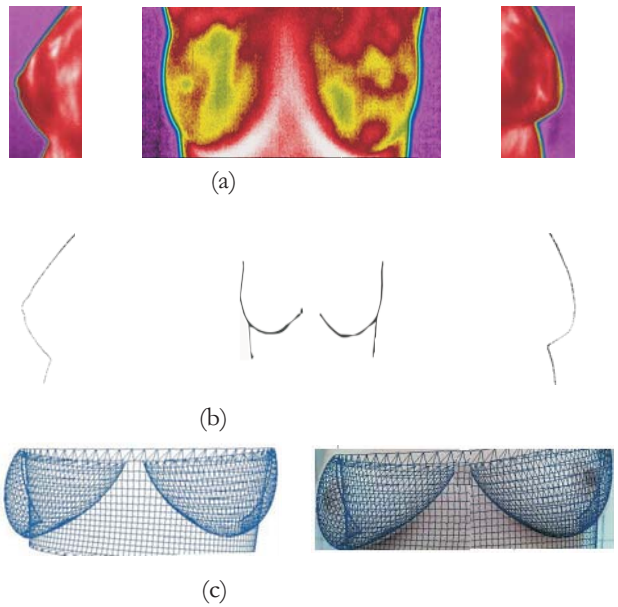

Figure 1-Examples of the reconstruction automatic steps (a), the geometrical model achieved (b) and a comparison of the result and real model (c).

Acknowledgements

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A NEW METHOD TO AID TO THE BREAST DIAGNOSIS USING FRACTAL GEOMETRY

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Introduction: Breast cancer is most common type of cancer in female population and the second most common type in the world [1]. Nowadays, the mortality rates in Brazil caused by this disease remain high [2]. The great number of deaths is due to the usually late diagnosis, which consequently leads to the identification of the disease in advanced stages [1]. The use of infrared images could be an alternative for early detection [3].

Methodology: In order to aid on the diagnosis of breast diseases in early stages the symmetry of temperatures on both breasts are investigates. After the extraction of the region of interest (ROI): i.e. the right and left breast, a new image (subtraction) is generated. Then some features are extracted based on the Hurst Coefficient [4] and the Lacunarity. Thirty six (36) features use the Hurst Coefficient and ninety seven (97) features are obtained by Lacunarity [5]. Figure 1 shows the used scheme. The last step is the classification, where the following techniques: Logistic, Multilayer Perceptron, Simple Logistic, Classification Via Clustering, Classification Via Regression, Decorate, Multi Class Classifier, Logitboost Alternating Decision Tree, Logistic Model Trees, Random Forest, 1-R classifier and Ripple Down Rule are used.

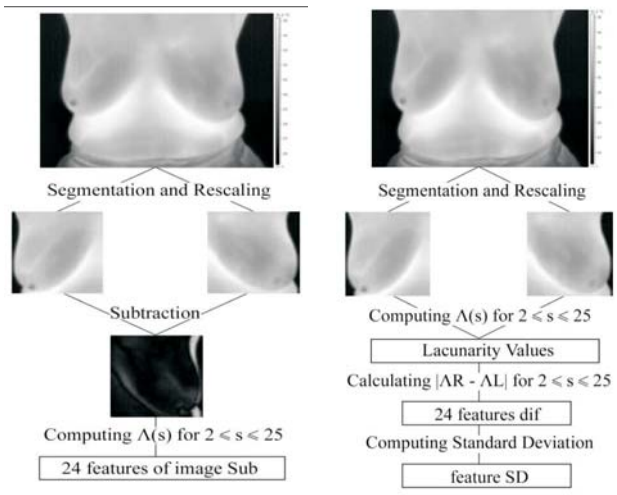

Figure 1
The two main steps of features extraction used for computer diagnosis

Acknowledgements

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USES OF NUMERICAL SIMULATION TO FIND THE BEST EXTERNAL BREAST PROSTHESES AND ANALYSE THE INFLUENCE OF TUMOR DEPTH AND TUMOR SIZE IN THERMOGRAPHIC IMAGES

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Introduction: This paper describes some of the results of the efforts of the Federal University of Pernambuco (UFPE) to study the use of Infrared Image on the early detection of female breast cancer, involving two different research lines. Infrared (IR) images have been taken at the Clinical University Hospital of UFPE since 2006. The protocol used to obtain the patient thermograms was approved by the Ethical Committee of the UFPE and registered at the Brazilian Ministry of Health. Some protocols to obtain IR images were followed [1]. The first research has modeled surrogate geometries obtained from seven external breast prostheses that are quite similar to a real breast. In order to find the surrogate geometry that best fits to the patient, three computational softwares were developed. Temperature profiles were simulated by CFD commercial software and the results reached a good approach to the temperatures showed by the patient thermogram [2]. The second line of research here presented uses the depth and the radius of a hypothetical tumor to calculate breast temperatures through parametric analysis and the Finite Volume Method in a tridimensional geometry obtained from a phantom. Temperature simulation was performed using a CFD commercial software. Some simulated temperature profiles were compared with the patient thermography showing good agreement in maximum temperatures [3].

Methodology: For the first research a coordinate measuring machine (CMM) was used to obtain the point coordinates of the breast prostheses. A CFD preprocessor software has modeled tridimensional volumes from these points. Each volume was stored and used by the temperature simulations. The surrogate geometry that best fits the analyzed patient was chosen by a software developed in the C++ language using least-square method and the moment of inertia in its digital formulation. In the second work a software called PARAMETRICA was developed in the MATLAB language. It can manage the commercial software FLUENT for calculating successive temperature profiles of the referred geometry. The Finite Volume Method was used to solve the Bio Heat Transfer Equation (BHTE).

Results: For the first research the simulated temperature profile by the CFD commercial software achieved the temperatures obtained at the patient thermogram with a major error of -6.45%. The nodules were visualized in the simulated profile. The most important contribution of this work is that the tridimensional geometry used was closer to the real female breast and the points used for the choice of the appropriated surrogate geometry were taken from the patient's thermogram. In the second line of research the analysis from the PARAMETRICA shows some influence of the tumor position and tumor size on the calculated breast temperatures. If the tumor is far from the surface of the breast or when its size is diminished, its image can disappear from the surface of the breast. The opposite effect is observed if the tumor grows in size or when it approaches the surface of the breast.

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CASE REPORT OF THERMOGRAPHY-GUIDED SURGICAL BLOCK IN COMPLEX REGIONAL PAIN SYNDROME TREATMENT

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A diagnosis of Complex Regional Pain Syndrome (CRPS), nerve injury-related or not, that is, Type I or II, is virtually clinical and based on the patient presenting with pain, swelling, sweating and skin color changes [in the affected body part]. However, these alterations are not always readily apparent, especially in the early stages, which can delay definite diagnosis or lead the patient to submit to unneeded surgery. Both situations can worsen the patient's condition.

Objective: Case report and discussion of a patient with CRPS, poorly responsive to drug and surgical therapy.

Case Report: M.E.S., 62 years old, female, presented with pain in feet, more intense in the right foot. In the preceding 3 years she had undergone 4 surgeries on the right foot and 1 on the left for tarsal tunnel syndrome and bilateral plantar digital neuritis, with no pain reduction. On consultation at pain clinic, in spite of pain complaint (VAS score 9) and references to color changes in foot during the day, physical examination of the right foot only showed slight edema, with no difference in skin temperature on palpation. Nonetheless, when complementary testing using infrared thermography was conducted, a 5.4oC temperature difference between distal inferior extremities was found. Further, there was pronounced sympathetic vasomotor instability and lack of vasoconstrictor reflex response from the painful extremity on cold stimulation test of contralateral limb (ΔT 0.3°C). A sympathetic system nerve block was carried out at L2-L3-L4 (1ml lidocaine 2% to each target area), confirming the sympathetic component of the thermographically-identified pain. A week later, a radiofrequency sympathectomy of the L2-L3-L4 sympathetic system (90s, 80°C, 150 mm needle, active tip 10 mm) was performed. One week post intervention, the patient no longer complained of pain and continued not to do so for over 3 months.

Discussion: Infrared thermography may be used as an auxiliary screening method in diagnosing and monitoring CRPS. When the contralateral limb is subjected to cold stress -- immerson in cold water, paradoxal vasodilation occurs, whereby imaging proof of sympathetic nerve instability in the affected limb is obtained. Anesthetic blocks using lidocaine also assist in the diagnosis. Even so, documentation [of findings] using thermographic imaging is safer and more effective since it neither relies on subjective evaluations of pain nor on surgical procedures. When pain complaints resume, even in the case of an anesthetic block, a minimally-invasive radiofrequency sympathetic nerve block is performed, with higher prospects of prolonged pain relief. Compared with the neurolytic block, this procedure allows for more control of lesioning, with lower risk of deafferentation during its course.

CONCLUSION: According to the authors experience, an anesthetic block of the lumbar sympathetic nerve chain is both effective and important in diagnosing CRPS. Thus, prior conduction of a thermographic test is predictive with regard to the indication and effectiveness of an anesthetic block. When indicated, a radiofrequency sympathectomy is found to be the safest, long-term therapeutic method.

AUXILIARY DIAGNOSIS OF POST-RADIOTHERAPY LYMPHEDEMA IN MASTECTOMIZED WOMEN BY THERMOGRAPHY

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After mastectomy and excision or radiation of adjacent axillaries lymphatic nodes, the patient will be predisposed to develop lymphedema. Aiming to adopt thermography as a parameter to post-radiotherapy lymphedema auxiliary diagnosis, this study evaluates quantitatively, through perimetry, and qualitatively through thermograph usage by infrared, women upper limbs with post-radiotherapy lymphedema, determining its sensitivity and specificity. A hospital cohort study was conducted with 6 mastectomized women under radiotherapy in Oncology Center Dr. Ulisses Pinto in Fundação Assistencial da Paraíba Hospital - FAP. According with criteria used to diagnose by perimetry, it was possible to verify lymphedema presence in 4 of 6 subjects of the sample. They are P3, P4, P5 and P6. These 6 subjects, while evaluated by thermography, were diagnosed with lymphedema, making possible to perform, in some cases, early diagnosis of this pathology, besides analyzing with more details in various moments of disease installation. After comparative analysis with perimetry, it was concluded that thermograph sensibility and specificity for lymphedema auxiliary diagnosis was superior in identification of cases that perimetry didn't show enough parameters to diagnose this pathology.

RISK ASSESSMENT OF BREAST CANCER BY THERMOGRAPHY

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If clinical evaluation of the risk of breast cancer by thermography. M.S., 59 years old, postmenopausal women. Your gynecologist has asked the exam because of the doubts caused by differences in the results of imaging studies ever made. Previous examinations, mammograms in both 2002 and 2009 (bilateral calcifications benign BI-RADS II; ultrasound, 2009 (without the presence of cysts, nodules or coarse calcifications, tissue retromamário habitual aspect) and 2009 (hypoechogenic image lobular 1.8 x 1.1 cm in the right region retroareolar BI-RADS 4-A). Clinical examination: palpation of the density in the periareolar region and retroversion visible nipple. No pain, no discharge and no signs of inflammation. thermography breast exam found in the right breast presence of marked hyper-radiation in nipple and periareolar region and irregular vascular distribution. Completion of thermography September 16, 2010: findings highly suspicious for breast cancer in right breast - IR 5. thermography MS After 59 years, she made Doppler ultrasound and core-biopsy. Result: retomamilar region with neovascularization right to study Doppler and peripheral infiltration. Diagnostic puncture-biopsy of October 1, 2010: invasive ductal carcinoma, nuclear grade 1. With the clarification of clinical through thermography and Doppler sonography more puncture-biopsy, the patient will be properly guided by your doctor to treat cancer safely.

HYPERTENSIVE AND NON-HYPERTENSIVE PREGNANT WOMEN FINGERTIP TEMPERATURE COMPARATIVE ANALYSIS USING INFRARED THERMOGRAPHY

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The Brasilian Healt Ministry data points out arterial hypertension (AH) as the major cause of maternal death, representing 35% of 140-160 maternal deaths for 100.000 alive newborns. Its origin remains a cause for discussion. Looking for new elements that may improve the understanding of that pathology, we studied the skin fingertips mean temperature (Tp) of pregnant women, 50 normotense (group A) and 31 hypertense (group B). The values of temperature were obtained using infrared thermography. Pearson correlation coefficient showed positive relationship between mean arterial pressure and systolic pressure (r= 0,95), diastolic arterial pressure (r=0,98) and for Tp (r=0,98). Student t test was statistically significant (p = 0,002) when comparing means of groups A and B. Other statistical tests obtained were: sensibility 80%, specificity de 48%, positive predictive value 49%, negative predictive value 80% and accuracy 60,5%. The chance of a pregnant woman become hypertensive is 1,6 times higher when her Tp is equal or higher then 34,1ºC. The analyzed data indicate that Tp values of pregnant women measured with infrared thermography is statistically smaller in the group of non hypertense and that may it might become a good method to detect pregnant women with high risk to become hypertensive during pregnancy.

THERMOGUIDED EVALUATION OF PATIENTS WITH CHRONIC PAIN BY ANALYTICAL MYOMODULATION (AMM) THEORY

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It is recognized that chronic pain involves a complex network of neurological, musculoskeletal, metabolic, psychological and behavioral phenomena. These feeds back neuro-musculoskeletal changes creating a vicious circle that worsens the intensity and extension of pain. According to this aphorism, the theory of the Analytical Myomodulation (AMM), seeks to justify the constellation of painful process and its chronic course, looking for interrelation between the present biomechanic changes and these phenomena. The Analytical Myomodulation (AMM) is a new neurological therapeutic model, whose theory presents the mapping of 25 muscular groups by its patterns of change related to the presence of strained bands (SB), tension points (TP) and increased muscle tone (MT). The purpose of AMM is not only diagnosis but to guide and monitor the treatment based on these characteristics changes. The aim of this study was to map the AMM patterns by infrared thermography. For images analysis was utilized Regressive Temperature (RT) method. The RT

analysis consists in the study of the involved muscular groups. It is based from the increase of infrared radiation associated with metabolic phenomena in neuro-musculoskeletal disorders. It was examined 3 patients with chronic pain by AMM method. First was clinically mapped the groups (patterns) muscles altered followed by thermography exam. It was captured 18 images per patient. By means of thermographic analysis using RT method the authors concluded that was possible to map the patterns of AMM theory. The authors observed that these patterns were sort according to the patient's clinical past history. Once identified it was possible correlate them with the site of neuro-musculoskeletal pain and its source.

THERMOGRAPHIC FINDINGS IN LIVER PATTERNS OF DISHARMONY --PRELIMINARY RESULTS

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The most important function of liver is governing the free-flowing of the Qi.

Liver stores blood and realize most metabolic reactions in the body. Venous liver blood input comes from spleen, large and small intestines (portal vein) and arterial blood comes from hepatic artery. The increase in the pressure within the portal vein reflects over venous pressure of intestines and spleen, leading to collateral drainage trough abdominal wall veins. If blood doesn´t flows freely it will stagnate and produce heat raising the temperature of superficial vessels. This phenomenon is best detected by infrared imaging and occurs prior to distension of veins and frequently not detectable by other imaging systems. Feeling of distension under the rib-cage or chest, sighing, nausea, abdominal distension, distension of breasts and menstrual alterations in women are some of the symptoms referred to Liver disharmony. In a review of 475 of women cases of liver pattern of disharmony (PD) we found: 1) right sub costal hot area, 2) hot spot overlapping with point SP16 (Fuai) inside the hot area, 3) hot vascular pattern starting in the right groin and decreasing temperature in the direction of SP16 acupuncture point, 4) hot vascular pattern along distal parts of right Gallbladder meridian, 5) hot vascular pattern along distal parts of right Spleen meridian, 6) in more severe or chronic conditions these findings may happen bilaterally. Comorbid conditions as liver fatty disease, increase in cholesterol levels and alterations in portal vein Doppler ultrasound may be present in the case, being useful to evaluate therapy.

INFRARED THERMOGRAPHY MODEL TO STUDY CUTANEOUS TEMPERATURE MODIFICATIONS IN PAWS OF RATS TREATED WITH HOMEOPATHY FROM SODIUM ARSENATE HEPTAHYDRATE.

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This experiment tested the hypothesis that the administration of the homeopathy prepared from sodium arsenate heptahydrate (SAH) in 30% hydroalcoholic solution, according to the Hahnemannian process, using two different potencies: 30cH and 200cH (G2 and G3 groups), is able to change the cutaneous temperature of the paws of Wistar male rats when compared to 30% hydroalcoholic solution (control group - G1). During ten days, three groups of Wistar male rats (n=6), received 10μL p. o. of its respective solution. Infrared thermograms were obtained daily from the paws prior to the treatment. Mean temperature of animals that received SAH were statistically significant in groups G2 (p=0,02) and G3 (p=0,01) when compared to the control group using Student´s t test. The administration of SAH induced a rise in cutaneous temperature of paws of rats when given in potencies of 30cH and 200 cH. The proposed animal model was successful on recording the rat paws skin temperature variations using infrared thermography after receiving homeopathic treatment with SAH.

THERMO-GUIDED ACUPUNCTURE - PRINCIPLES AND PRACTICE

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Thermo-Guided acupuncture is based on the combination of the principles of traditional Chinese medicine (TCM) to infrared thermography (IT). The whole body thermographic imaging allows the location of areas with temperature differences higher then 0.3°C, indicating the presence of dysfunction in veins, arteries, tendons, muscles and so on. These dysfunctions after converted into infrared images can have aspect of points, circular areas, silhouettes that outline organizational structures or artificial body parts. Yang areas have a positive difference in relation to its surroundings while Yin areas have a negative difference. The location of these images shows great overlap with traditional and extra points when compared to acupuncture charts. When the group of infrared findings is compared to meridian charts it is possible to relate with patterns of disharmony (PD) described in the texts of acupuncture. Diagnosis using the eight principles (Hot-Cold, Deficiency-Excess, Interior-Exterior, Yin-Yang) can be complemented by IT, namely: a) the presence of hot spots in hot areas indicate the presence of Hot-Excess, b) the absence of hot spots in hot areas indicate the presence of Hot-Deficiency (false heat), c) notation of Cold-Deficiency (Yang deficiency) will occur in the absence of cold images within a cold area, d) Cold-Excess will occur in the presence of cold images in a cold area, e) The PD will be in the Interior when internal structures of the body are outlined, f) The PD will be in the Exterior when internal structures are not outlined, g) The PD is like Yang in cases of detection of Hot-Excess. IT increases needling accuracy, evaluates the evolution of detected areas and supports the acupuncturist decisions. The treatment of PD diagnosed with the help of IT following the reasoning of MTC may cause such differences of temperature, or the thermal images to disappear.

INFRARED DIGITAL TELETHERMOGRAPHY: A NEW METHOD FOR EARLY DETECTION OF VARICOCELE

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Varicocele results from the abnormal dilation of the veins of the pampiniform plexus and is the most common identifiable cause of male infertility. The prevalence of varicocele reaches 15% in healthy men and 40% in men undergoing treatment for infertility (1). Besides physical examination, various traditional methods of examination, such as Doppler ultrasonography, venography, and contact thermography, are believed to have an important role in diagnosing varicocele (1, 2). Infrared digital telethermography (IDT) is a new method for early diagnosis of this entity. The equipment consists of an E-25 digital infrared video camera (Flir Systems, Boston, MA), which has a sensitivity for temperature

variance of 0.2°C. It is used with QuickView2 software (Flir Systems) for analyzing data. To perform the examination, the patients should stand in a refrigerated room (air temperature approximately 24°C) with the scrotum exposed for 5 minutes before examination. The device records maximum and minimum temperatures of a selected area, along with average and standard deviation. The penis should be held against the abdominal wall. In healthy men the average temperature of the scrotum is symmetric and should not exceed 32_C, corresponding to the colors blue or green (Fig. 1). In varicocele the temperature is higher, usually between 32.5°C and 35.3°C, represented by a reddish color (Fig. 2). Furthermore, a right-left average temperature variation of >0.8°C that involves more than 25% of the hemi- scrotum indicates varicocele (3). Compared with Doppler ultra- sonography, IDT is less invasive; it needs no physical contact between the probe and the skin of the patient, thus avoiding discomfort, possible physical trauma, and psychological embar- rass- ment. It has the advantage of detecting minimal testicular alterations. Our experience in selected cases leads us to believe that IDT is a good method for the diagnosis of varicocele, especially for those patients who are asymptomatic or who have mild symptoms.

EFFECTS OF THE USE OF MIG3 BIOCERAMIC FABRICS- LONG INFRARED EMITTER - IN PAIN, INTOLERANCE TO COLD AND PERIODIC LIMB MOVEMENTS IN POST-POLIO SYNDROME

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The main post-polio syndrome (PPS) symptoms are new-onset weakness, new-onset atrophy, fatigue, cold intolerance, and pain associated with sleep disturbances. The polysomnographic study is the gold pattern to analyze sleep disorders. Objective: To assess pain, intolerance to cold and periodic limb movements (PLM) index before and after the use of MIG3 bioceramic fabrics over 4 weeks.

Method: 12 patients with PPS from UNIFESP/EPM. All patients were submitted to polysomnography and infrared examinations, and answered scales of pain and intolerance to cold (visual analogical scale) before and after the use of MIG3 bioceramics fabrics (lining mattress, t-shirt) for four weeks.

Results: There were significant decreases in pain and Periodic Limb Movements (PLM) index, and an improvement of heart rate during REM and non-REM sleep stages.

Conclusion: MIG3 bioceramic fabrics can help in the treatment of pain and PLM in PPS patients.

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INFRARED THERMOGRAPHY AT CLINIC PRACTICE

Gheorghe Ovidiu Serbu

Romanian Society of Thermography

General practitioners from many European countries, can legally use diverse systems of investigations (ultrasound, EKG, spirometry) which furnish useful information, which can be used along with history of present illness and physical exam to increase the precision and accuracy off a diagnosis. Thermography has the advantage of being totally noninvasive and risk-free, cost-effective, and quick to perform. However putting aside the unavoidable difficulties (the need for special imaging room and few institutions at Europe with thermography certify competency), I will raise this question: what is the place for clinical thermography in family practice? In this panel I will present a few cases (acute appendicitis, carpal tunnel syndrome, herpes zoster, male breast cancer, deep vein thrombosis and diabetic foot syndrome) from a family medicine medical practice, mentioning that there was not a thermographic diagnostic made, but rather a corroboration of clinical data with thermographic images. The presentation of these cases had the purpose of lunching the discussion about the utility of thermography in general practice.

THERMOGRAPHIC EXAMINATION FOR BREAST DISEASES

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

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(A) Prognosis of patients, cancer stage and thermal finding

Thermography is not morphological examination, but functional examination of carcinoma. Its diagnostic accuracy rate is not high, however, it can detect the breast carcinomas, which is not detectable by other morphological examination. Moreover, it is able to forecast a breast cancer generation, and the result of the study about the relationship between the thermographic findings and the prognosis of breast cancer patients showed that the thermographic examination seemed to be useful for foreseeing the prognosis of the patients. The reason of this result is that the thermographic findings are influenced by both the progress stage and the proliferating ability of breast cancers. Thermal transmission and the chemical mediators explain the mechanism of abnormal findings in thermography with relating such function of the tumors.

(B) Mechanism of abnormal findings

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

(C) Process of standardization of diagnostic criteria in Japan

Many kinds of diagnostic criteria and conditions for thermographic examinations had been published over twenty years ago.

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

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

THERMOGRAPHIC IMAGING OF EFFECTS DURING ACUPUNCTURE

Kamayni Agarwal

Center for Palliative Care and Pain Management, Hanseatic Care, Hamburg, Germany

Case history: A 55-year-old lady presented with hypoesthesia of forearms and hands asking for relief by means of Traditional Chinese Medicine. She had used crutches for the past 6 weeks post arthroscopy, and suffered from musculoskeletal pain around the neck and shoulders and cold hands.

Method: Medical examination revealed muscular triggerpoints in the musculature along with a mild sensory loss of hands and forearms not confined to dermatomes and without impairment of motion. Since her cold hands did not respond to warming devices, thermographic imaging was performed before acupuncture and further investigation. She was placed in a special room with laminar flow at a temperature of 24.5°C and an atmospheric humidity of 50% for 30 minutes along with the thermographic device to acclimatize before imaging was performed. A couple of images were taken each from the dorsal and the volar surface. Since no neurologic or orthopaedic pathology could be located, three acupuncture needles were placed generating de-qi-sensation: LI 4, PC 6 and SJ 5. Ten minutes after placing the needles for 20 minutes and 10 minutes after removing them, thermography was repeated.

Result: The patient experienced a warm feeling in her hands within 4 minutes after placing the needles and depicted less numbness. Thermographic images revealed an increase of skin temperature of 2.5°-3.0°C. She received acupuncture three more times until a schwannoma of the cervical spine was diagnosed by MR Imaging that was removed.

THERMOGRAPHIC IMAGING IN HEALTHY HUMANS - WHAT IS "NORMAL" SKIN TEMPERATURE?

Kamayni Agarwal

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Aim: Contactfree thermographic imaging is utilized to detect changes in skin temperature after Interventional Pain Therapy. Recommendations regarding room conditions in a standardized setting exist; though, inter- and intraindividual skin temperature vary a lot. In order to be able to use thermographic imaging in detecting normal or abnormal health states, it is inevitable to collect data on pathophysiology and alterations of skin temperature during medical treatment.

Method: Changes in skin temperature during a 30 minute time-interval were observed in 50 healthy people (29 females, 21 males; age 32.8 years) to aquire information on the average skin temperature in humans and its variation during a defined period. Thermography was performed in a standardized setting as requested by the American Academy of Thermology (laminar air flow, humidity of 50%, room temperature of 23°C, standard clothing, and time of acclimatization 30 minutes). Hands, wrists and parts of the forearm were observed via infrared thermography, and pictures were obtained at standardized points in time, i.e. 1, 2, 3, 4, 5, 10, 20 and 30 minutes after the persons having acclimatized to room settings for exactly 20 minutes.

Results: Data show that changes of skin-temperature occur despite of acclimatization for 30 minutes for at least another 30 minutes as opposed to the findings of Ring et al. 1984 (The Academy of Neuro-Muscular Thermography 1989 and American Academy of Neurology 1990). Furthermore, interindividual differences in temperature are not related to age or sex.

THERMOGRAPHIC IMAGING IN INTERVENTIONAL PAIN MANAGEMENt

Kamayni Agarwal

Center for Palliative Care and Pain Management, Hanseatic Care, Hamburg, Germany

Contactfree 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 small cutaneous temperature alterations. Few data is available concerning a detailed methodology. Evaluating the effect of Interventional Pain Management requires specific tests to monitor sympathetic function. Common techniques include sweat tests, tissue oxygen analysis and Doppler flowmetry. In our department main focus lies on the treatment of sympathetically maintained pain, hence, thermography has become a precious tool to prove the efficacy of the procedure in order to decide whether or not neuroablation is indicated following a strict algorhythm. On the day of admission patients suspected to suffer from sympathetically maintained pain undergo initial thermographic imaging. They are placed in a room at 24.2-24.5°C for 30 minutes along with the device to acclimatize before imaging is performed. On the next day the catheter is placed and imaging will be performed again after acclimatization for 30 minutes at 24.5°C. This procedure is repeated 30 min, 60 min and 180 min after administering high dose local anesthetic via the catheter. Dramatic changes in skin temperature can be detected if pain is maintained sympathetically and if the catheter sits in the right position separated from the patient pronouncement concerning pain alleviation. In case of catheter dislocation, this may easily be sensed without exposing the patient to x-ray or other invasive diagnostic procedures.

THERMOGRAPHIC IMAGING OF EFFECTS OF STELLATE BLOCKS IN PAIN MANAGEMENT

Kamayni Agarwal

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Aim: Blocks of the stellate ganglion may produce dramatic pain relief in patients suffering from neuropathic pain in the head/face, upper extremities and/or chest. This procedure can be performed just using anatomical landmarks. If patients report of lacking pain alleviation, physicians can never be sure if the technique has not been carried out correctly, if other than

desired structures are reached or if the patient is trying to mislead the physician. Various techniques to monitor the spread of the local anesthetic have been proposed - many of them requiring x-ray. Infrared thermography offers a non-hazardous alternative and depicts spread of the local anesthetic more precisely observing the clinical effect.

Method: Patients referred to the Division of Pain Management are routinely examined by infrared thermography, if stellate Blocks are performed. They have to acclimatize in a special room that has been set up for thermography according to the recommendations of the American Academy of Thermology. Pictures are taken before, 30, 180, and 360 minutes after Interventional Pain Therapy.

Results: Dramatic changes in skin temperature can be detected if the procedure is performed correctly and can be correlated to the patient's perception in order to find the appropriate procedure to treat the patient. If other structures than the stellate ganglion are blocked, corresponding changes in skin temperature may be detected. In these cases, elevation of skin temperature matches areas that are innervated by distinct nerves.

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

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Only after infrared thermographic vasomotor mapping has been completed can the distribution of asymmetry be fully determined and the question of which body parts are involved be properly addressed. There many difficult situations in which Infrared Thermography is extremely useful in objectifying the extent or presence of involvement and assist in differential diagnosis. These include RSD & its variants, Thoracic Outlet Syndrome (TOS), Cervical-Brachial Syndrome, Vasomotor headache, Atypical facial pain, the Posterior Cervical Sympathetic Syndrome of 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.

Barre-Lieou is another common diagnostic condition that Medical Thermography is ideally suited for. There is no other diagnostic study that can objectify the presence of vasomotor instability associated with this disorder. In Barre-Lieou the posterior cervical sympathetic chain generates aberrant impulses that result in cervical or facial heat emission asymmetry patterns.

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.

There are several chronic regional pain syndromes that look like RSD but behave quite differently then true RSD. Many of these syndromes will be reviewed and how their thermographic image differs from RSD will be discussed. 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.

AMPUTATION AND SURGICAL RECONSTRUCTION OF FINGERS: RESULTS VISUALIZED BY CONTACT-FREE INFRARED THERMAL IMAGING. A CASE REPORT

Kamayni Agarwal

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This is a case report on a young man who injured his hand on August 30th, 2008 while using a dado blade set (six 1/8" blades clustered together to cut ¾" grooves in boards) on a table saw. The fifth digit ("baby finger") was amputated immediately; the fourth digit ("ring finger") had the bone shattered, nerves twisted and blood vessels damaged. The fourth finger was amputated by a surgeon but he salvaged a tendon and inserted it into the third digit ("long finger") which had a cut down the outside and across the top between the second and third joint. The third joint of this finger was broken thus three pins were inserted to obtain stabilization and removed at six weeks. The second digit ("index finger") hat a cut on the outside from the joint to the tip which was sutured closed. The first digit ("thumb") had a semicircular cut starting in the inside edge of the nail bed wrapping around the palmar side to just distal of the second joint. This cut severed a major blood vessel that travels to the end of the thumb through the pad and cut the nerves. This was also sutured closed.

The course of the trauma was monitored by infrared thermography as vessels were damaged which may lead to impaired perfusion that can be visualized by thermography. Fortunately, no such impairment could be observed. Due to reconstructive surgery altered blood flow can still be detected.

THERMOGRAPHIC GUIDELINES FOR THE PAIN MANAGEMENT OF SPINAL AND PERIPHERAL NERVE DISEASE - PART 1

Ho-Yeol Zhang

Department of Neurosurgery, National Health Insurance Corporation Ilsan Hospital, Yonsei University College of Medicine, South Korea

Diseases of spinal neurosurgery are degenerative spinal diseases, spinal cord tumors, spinal injuries and some kinds of autonomic nervous diseases and peripheral nervous diseases. I am discussing about the thermographic guidelines of diagnoses and treatments of these 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 spinal disease, the thermal asymmetry of the upper or 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 (herniated lumbar disc).

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 (schwan- noma) 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.

THERMOGRAPHIC GUIDELINES FOR THE PAIN MANAGEMENT OF SPINAL AND PERIPHERAL NERVE DISEASE - PART 2

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Diseases of spinal neurosurgery are degenerative spinal diseases, spinal cord tumors, spinal injuries and some kinds of autonomic nervous diseases and peripheral nervous diseases. In this part 2, I am discussing about the thermographic findings of the peripheral nervous and autonomic nervous diseases, and the IR investigations of the travelers and the Korean Society of Thermology.

Carpal tunnel syndrome. I reviewed the operated cases of 6 patients' 12 wrists. Preoperative EMG, thermography and postoperative thermography were analyzed. Temperature measurements were done at the antecubital area and center of palm. The severity of neuropathy is dependent on the hyperthermia of palm. In the case of severe neuropathy, thermography of palm shows the severe hyper-/hypo-thermia. Postoperative 3 to 6 months' thermal change are variant depend on the preoperative severity of median nerve compression. If preoperative EMG shows the mild neuropathic lesion, postoperative 3 to 6 months' thermography changed to more hyperthermic. If preoperative EMG is severe neuropathy, postoperative thermal recovery was faster. Peroperative thermography can predict the severity of median nerve compression. Postoperative thermography shows the degree of physiologic normalization of the hand vasoregulation.

Hyperhidrosis. Surgery of palmar hyperhidrosis is the sympathectomy of T2 and T3 sympathetic ganglions. The role of thermography is diagnostic tool, preoperative and postoperative evaluation and finally, diagnosis of compensatory hyperhidrosis.

Buerger's disease is different from PAOD (peripheral artery obstructive disease). PAOD is artherosclerotic obstructions in multiple areas of artery. But Buerger's disease is entire vessel narrowing of lower leg arteries. So PAOD can do bypass surgery, but there is no possible area to bypass in Buerger's disease. The treatment of Buerger's disease is not many, just for the medications of arterial dilators or lumbar sympathectomy. This case report is one case of lumbar sympathectomy of Buerger's disease. After left side lumbar sympathectomy, left side leg temperature was increased. Lt toe necrosis had been healed immediately after Lt side sympathectomy. Lumbar sympathectomy can increase the toe temperature. It means increased blood flow to toe. And this aids the healing process of skin necrosis or gangrene.

IR camera can be also used to investigations of the traveler liable to committing crime or narcotics abuse. In the Kimpo International airport, my team was tested two small subjects to screen the travelers. Conclusions of 1st test were as follows. Facial thermal temperature can be elevated if traveler lies to marshal of Custom Services, or ingestion of narcotic or alcohols. The screening of the facial temperature of travelers are very effective, high exposure rate (44%), and can detect the temperature change of faces, 6 persons among 7 black list persons. IR camera can be used to screen the travelers for the Custom's baggage checking. Conclusions of 2nd test were as follows. Circumstance temperature of Custom' service area was between 26 to 27 °C And average facial temperature was 33.570 ± 0.4889°C. There was no difference of travelers' facial temperatures between 19 to 83 years old. Japanese facial temperature is about 0.2°C higher than Korean. If we want to use the IR camera as a screening device for the detection of the traveler liable to committing crime or narcotics abuse, we can select and use the temperature of upper 1, 3, 5 or 10 % from the normal distribution curve.

History of Korean Society of Thermology.

In 1991, the Korean Society of Medical Thermology was founded. It had been developed continuously and had held many international thermology conferences. And the members of this Society also had been many other international thermology meetings. Korean Society of Oriental Medical Thermology was divided from Korean Society of Medical Thermology for the more development of their own field. In the 2000, another computational power of medical thermology was born as the name, Korean Society of Diagnostic Thermology. This society was also active for the studying of medical thermology. After 4 years of struggling and competing each other, The "Korean Society of Thermology" was founded at the 11. Dec. 2004. After this unified and new name of Korean Society, we are holding the thermology conferences twice per every year. Now we are also work hardly about the medical thermology and collaboration with other countries again.

23rd Thermological Symposium of the Austrian Society of Thermology Quantitative Thermal Imaging in Medicine

13th November 2010 Raddisson BLU Palais Hotel, Parkring 16, 1010 Vienna

8.00-8.30 Welcome-Coffee

Programme

Chair: Prof Dr. Anna Jung (Poland), Dr.Kevin Howell (UK)

8.30-8.50 **K.Ammer** (Austria)
Evaluation of Infrared Thermal Images from a Patient Suffering from Primary Raynaud´s Phenomenon
8.50-9.00 Discussion

9.00-9.20 B.Kalicki, A. Jung, **EFJ Ring,** M.Saracyn , S.Niemeczyk (Poland/UK)
Thermographic Monitoring of the Hand In Renal Dialysis Patients: Comparison of High and Low Resolution Cameras
9.20- 9.30 Discussion

9.30- 9.50 **R.Vardasca** (Portugal)
The Need of A Standard False Colour Scale For Medical Thermography Analysis
9.50-10.00 Discussion

10.00- 10.30 Viennese Coffee Break

Chair: Prof Dr. Francis Ring (UK), Prof Dr Kurt Ammer (Austria)

10.30- 10.50 **C. Hildebrandt** ; C. Raschner (Austria)
Recording sports injuries with thermography
10.50-11.00 Discussion

11.00- 11.20 **K. Howell**, R.E. Smith (UK)
Temperature of the face in children
11.20- 11.30 Discussion

11.30- 11.50 Gabrhel J, **Popracová Z**, Tauchmannová H, Chvojka Z. (Slovak Republic/Czech Republic)
Thermographic Findings In The Lower Back
11.50-12.00 Discussion

12.00-12.20 **A. Cholewka** (Poland)
Thermal Imaging In Venous Diseases of The Lower Extremities
12.20-12.30 Discussion

12.30-12.40 **R. Thomas** (UK)
Thermography In Monitoring Laser Therapy
12.40-13.00 Discussion

13.00-13.20 **K.Ammer** (Austria)
Thermology international- 20 anniversary
13.20- 13.30 Discussion

13.30 Close

Abstracts

EVALUATION OF INFRARED THERMAL IMAGES FROM A PATIENTS SUFFERING FROM PRIMARY RAYNAUD´S PHENOMENON

K.Ammer

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Introduction: A number of criteria have been proposed in the past for diagnosing Raynaud´s phenomeno by temperature measurements. These include recovery time, percentage recovery, absolute temperature, gradient fingertip to dorsum and combient gradients, which summarises the gradient prior to cold challenge with the gradient at a defined time, usually 20 minutes post cold challenge.

Objective: The validity of all these criteria for diagnosing Raynaud´s phenomenon is unknown. The results of a simple experiment might help to better understand the diagnostic power of the parameters mentioned above.

Methods: A female patient who received the diagnosis of primary Ray- naud´s phenomenon 10 years ago, underwent on three consecutive days thermographic investigations of her hands and fingers.

All studies were performed at the same time in early afternoon and after acclimatisation with bare arms to a room temperature of 24° degrees for 15 minutes. Then the hands were covered with plastic gloves were immersed in water for 1 minute. The water temperature varied from 1 day to the other and was 10, 15 or 20 °C.

Prior to and immediatly after the cold challenge 20 thermal images were recorded at a time interval of 1 minute.

Circular regions of interest (ROI) were defined in a way that the outline of the circle was adjacent to the outline of the fingertip of the little finger. ROIs were positioned on the tip and over the mid of metacarpal bone of each finger. Temperature gradients were calculated by subtracting the metacarpal temperature from the temperature of the finger tip. This method of evaluation was found to be the most sensitive in detecting diagnostic temperature gradients [2]. A combined temperature gradient (CTG) was calculated by summing up the temperature gradient prior to cold challenge with the gradient 20 minutes post cold challenge.

Results: Figure 1 shows that the baseline readings vary from one day tom the other by 1 centigrade. Figure 2 presents the tem. perature gradients before and 20 minutes after cold challenge.

figure1

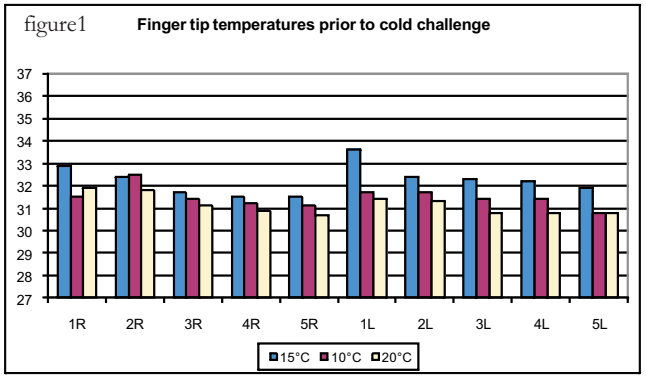
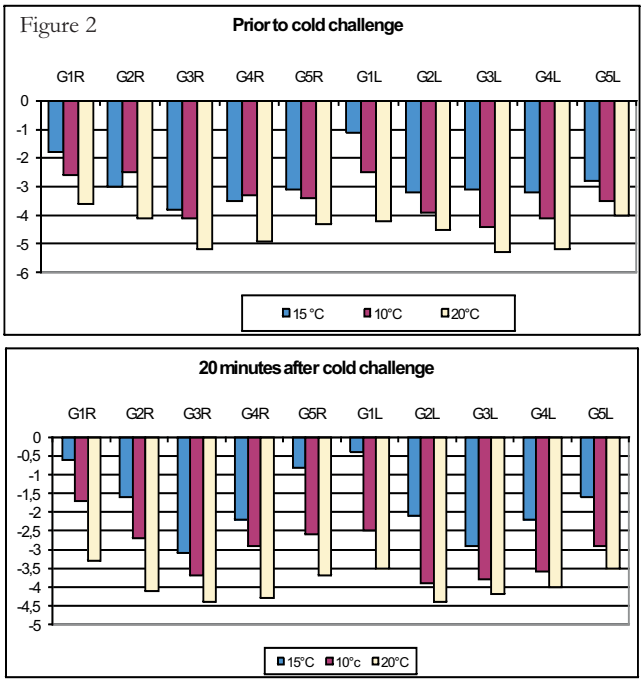


Figure 2



The magnitude of these gradientes is nearly identical. These diagram clearly show that cold fingers cool down after immersion in cold water, the extent of cooling depends on the water temperature and the recover to baseline temperature within 20 minutes.

Conclusion: The diagnostic criteria recovery time and percentage recovery failed to identify the proven primary Raynaud´s phenomenon in this patient. The absolute temperature varies from day to day, but could detect the established low temperature on the finger tips. In case of warm fingers that do not recover after an even mild cold challenge, measurement of the absolute temperature will also miss the disease The performance of the temperture gradient fingertip to dorsum is much better, but will loose his discrimination power in case that the gradients become reverse at different time points. Obviously the best diagnostic criterium for thermographically diagnosed Raynaud´s phenomenon is the combined gradient, which can also identify minor various of vasospastic finger diseasae, when two negative gradients below the threhold of 1 degree cumulated and finally result in a negative value above the cut-off point.

THERMOGRAPHIC MONITORING OF THE HAND IN RENAL DIALYSIS PATIENTS: COMPARISON OF HIGH AND LOW RESOLUTION CAMERAS

Kalicki.B, Jung A, Ring EFJ*, Saracyn M, Niemeczyk S.

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Renal dialysis requires regular cannulation for connection to the apparatus. This is achieved by the insertion of shunts in the arms or groin. After repeated use the risks of arterio-venous fistulae increase. This in turn can lead to vasoconstriction and reduction in peripheral circulation. Thermographic monitoring of hand

temperatures can provide useful information of changes in peripheral circulation. During dialysis it is necessary to use a thermal camera for obtaining objective evidence of peripheral temperatures.

The Flir i5 and i7 cameras are extremely portable, and therefore convenient for use in the Renal Dialysis Department. To ascertain if the results from these low resolution hand held systems are of adequate performance, a group of patients on regular dialysis have been studied in parallel with a high resolution camera FLIR P640.

The main differences in specification are shown in table1

Camera	FLIR i5	FLIR i7	FLIR P640
Resolution, pixels	80x80	120 x 120	640x 480
Thermal resolution	0.1°C	0.1°C	30mKelvin
weight	0.35Kg	0.35Kg	1.9Kg
Visible light camera	NO	NO	YES

Method After 3 months experience with the i5 camera, an i7 was used with a P640 high resolution camera on a group of adult , male and female patients. The palmar and dorsal surfaces of both hands, the dialyzed and non dialyzed while the patient was undergoing the procedure. A cool background was placed under the hand to obtain a clear image. In some cases, cannulae carrying warm blood were lying close to or even crossing the hand or arm. The use of the visible light camera with the p640 camera provided useful documentation of the sometime complex thermal structures around the patient. The images were downloaded to a computer after each recording session and analyzed with FLIR reporter software.

Two regions of interest were selected over the index and middle finger, and a larger region selected over the centre of the dorsal or palmar area. From these selections mean temperature differences from the centre of the hand to the distal areas of the selected fingers was calculated. The identical procedure was followed with the i7 camera, with the exception of the visible light images.

Results. All comparative temperature readings were analyzed from both surfaces of both hands yielding 60 measurements from each camera. The absolute mean values summed were 33.0C from the P640 camera, and the corresponding values from the i7 camera were 32.6C. The mean difference was 0.4 C the averaged signed difference being -0.4C. The maximum difference obtained in one instance was 1.7C, due to difficulties in selecting the region of interest. Many of the readings were less than 0.3C different between the two cameras.

Conclusion. While the P640 gave superb images, and the additional visible pictures were extremely helpful in interpreting the thermograms, the additional weight was the only disadvantage. The i7 camera gave adequate image quality sufficient for later analysis, and provided a convenient instrument for positioning at any angle required at the bedside. AS this instrument is fixed focus, it had to be used at least 0.6meter from the patient.

The lightweight i7 camera is a suitable instrument for remote temperature sensing in dialysis patients.

THE NEED OF A STANDARD FALSE COLOUR SCALE FOR MEDICAL THERMOGRAPHY ANALYSIS

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The frequent use of false color scales in medical thermal images has the objective of being a visual aid for human eye interpretation. However, several scales are being used, which may lead to different subjective interpretations. Is objective of this study to raise the need of uniformity in adoption of an internationally accepted standard false color scale and for that purpose a scale is proposed. A set of IR medical images of different regions of the body containing temperature measurements in grayscale values is used. These images are loaded into MATLAB prototyping software and a range of different false color scales are applied and its differences in subjective interpretation evaluated. The proposed false color scale to be accepted as standard is a mean between the natural color spectral wave distribution and the human eye color perception wave, based in the three main color components (Red, Green and Blue). The adoption of the proposed false color scale will enforce the standardisation of the analysis of medical IR images.

RECORDING SPORTS INJURIES WITH THERMOGRAPHY

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Background: Football is one of the most popular sports in the world (1). High intensity training combined with frequent competitions pushes the locomotor system to its anatomical and physiological limits. Woods et al. stated that young footballers are at a greater risk of slight and minor injuries, overuse injuries, lower leg injuries and muscle strains during the preseason period (2). The so-called "little traumatologies" are very frequent; therefore, their early detection is important. The efficiency, safety and low cost of Infrared Imaging make it an auxiliary tool in medical imaging to detect and locate thermal abnormalities characterized by a temperature increase or decrease found at the skin surface.

The aim of this study was to predict overuse injuries through infrared monitoring of soccer-specific injuries. Traumatic injuries will be observed over time to evaluate the individual healing process.

Methods: We conducted pre-season measurements of 25 football players (mean age 17.6± 3.9 years, height 176.1± 8.1 cm, mass 67.8±9.1 kg) from the Football Academy Innsbruck. After an acclimatisation period of 15 minutes, baseline images of four different aspects of the lower leg were recorded using an infrared camera (VarioCam HiRes Ultimate D Clinic &Portable). Following a 20 minute sport-specific warm-up, recordings on the standing subject were repeated to assess changes in haemodynamics. The software Exam 5.6.2. was used to analyse the thermogram.

Results: 52% of the athletes reported no injuries, 28% had an overuse injury and 20% sustained a traumatic injury within the previous 6 months. Most thermograms of the non- injured athletes showed no asymmetrical pattern. However, side to side differences on structures of the knee were found in 31% of these athletes. Overuse reactions such as diffuse knee pain following training occurred in two athletes. The thermogramm at rest demonstrated symmetrical patterns. Following sport-specific exercise, local side differences on the knee were visible.

Thermograms of traumatic injuries defined the extent of pathophysiological reactions in structures involved. An athlete with an achilles tendon rupture (6 months previous) and a loss of feeling in the toes showed a clear temperature decrease in the affected area. The thermogram of an ankle joint ligament reconstruction indicated high metabolic activity.

Conclusion: The preseason measurements are the first step to create a sport-specific database with individual thermograms. Baseline recordings and images following a sport-specific strain should be conducted to visualise thermal regulatory processes. Repeated follow-up measurements will clarify if symptom-free

asymmetrical temperature distributions are predictive for pre-sy mptomatic identification of overuse injuries. In terms of traumatic injuries such as ligament ruptures, further research will determine if tissue remodelling is still ongoing after symptoms disappear.

References:

1. R. J Shephard; Biology and medicine of football: An update. J Sports Sci 1999;17:757–86.

2. C Woods, R Hawkins, M Hulse, A Hodson; The Football Association Medical Research Programme: an audit of injuries in professional football—analysis of preseason injuries. Br J Sports Med 2002;36:436–441.

TEMPERATURE OF THE FACE IN CHILDREN

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Departments of Rheumatology and *Medical Electronics
Royal Free Hospital, London, UK.

Background: Infrared thermography of the inner canthus of the eye offers the potential to detect febrile subjects rapidly and non-invasively at, for example, airports or hospital entrances during episodes of pandemic fever. Children are a key group likely to spread respiratory infection. The ideal "cut-off" eye temperature for detecting a febrile child will depend upon the temperature distribution across the population of afebrile and febrile children, as well as the reliability of the temperature measurement. Consequently, interest is now increasing in the collection of "normal" facial temperature data in both children and adults, and ISO standards have been published in an attempt to regulate thermal imager specification and application. Nonetheless, facial temperature data in both healthy and febrile children remain scarce, and historically recommendations for fever-screening protocols have been either poorly-applied or ignored by manufacturers and practitioners. Our retrospective study presents facial temperature data from a small group of afebrile children who attended the Royal Free Hospital on multiple occasions for another thermographic research project.

Method: Twenty girls and eleven boys were included in the analysis. Mean temperature from a region of interest of 7x7 pixels was recorded from each subject at the tip of the nose, the forehead above the eyebrow, and the inner canthus of the eye. In a sub-group of 18 of these subjects who attended for thermography on 3 or more further occasions, the analysis was repeated using the thermogram at each visit.

Results:Facial temperatures recorded at first visit are presented below:

	Male		
	Nose	Forehead	Canthus
Median Temp./ ºC	33.5	34.1	35.7
Range / ºC	5.2	1.8	0.9
	Female		
	Nose	Forehead	Canthus
Median Temp/°C	31.8	34.4	35.5
Range /°C	7.8	2.2	1.3

We found no significant temperature differences due to sex, but there were significant differences in temperature between all face sites ($p<0.01$, Mann-Whitney). The inner canthus of the eye was both the warmest site, and the site that exhibited the smallest range across all subjects. We found similar intra-individual variability in temperature on repeated visits: the maximum range of inner canthus temperature was 1.4ºC in a boy who attended on five occasions.

Conclusions: This small study, as an adjunct to the work of others, helps to characterise the variability in inner canthus temperature in afebrile children. For effective fever screening, it will also be necessary to characterise the febrile population. Compared to our figures, other authors have published higher inner canthus temperatures in healthy children. This may be, in part, due to differences in image analysis. However, it should also be remembered that the variation in results between centres is much less than the stated accuracy of most thermal imagers (±2ºC). Co-ordinated fever-screening across multiple sites will require careful calibration and traceability of thermal imagers to achieve a measurement accuracy of a few tenths of a degree Celsius.

THERMOGRAPHIC FINDINGS IN THE LOWER BACK

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[2] National Institute of Rheumatic Diseases, Piešťany, Slovak Republic;
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Introduction The etiology of lower back pain is multi-factorial. It can develop due to a series of organic, non-vertebrogenic diseases, degenerative changes in the spine and functional changes in the joint and musculoskeletal systems. In many patients who suffer from back pain, no morphological findings can be detected even through recent diagnostic methods. The pain information is generated by several factors. Pain in discopathies can arise due to inflammatory mechanisms even without any inter-ve rtebral disc prolapse or nerve root compression. It develops due to pH alteration and the chemical composition of the intervertebral disc.

With accidents and any damage to soft structures, overloading or micro-traumas, various biochemical processes induce inflammation in the damaged structure. Acitvation of thermally active trigger points (TrP) triggers pain that the patient localises either in the lumbar spine or it is propagated in the lower extremities, with an imitation of radicular pain. By the possible irritation of sympathetic nerve fibres in r. dorsalis n. spinalis in intervertebral functional disorders of facet joints in the back area and in n. meningicus recurens (n. sinuvertebralis) in ligamentous lesions in the back induce hypothermal site patterns in the pertinent thermotom of the back area. It is a type of nociceptive sympathetic efference. An indirect effect of neural pathophysiology called nociceptive motor efference, results in increased tone of a muscle or muscle group with an aggregation of acid products of metabolism and shifts in electrolytic environment. This can lead to relative hyperthermia of the area of skin above.

Objective: Thermal images of the lumbar and gluteal areas were analysed retrospectively in a group of 141 patients (77 male, 64 female, average age:43.2 years) suffering from pain in the lumbar and sacral parts of the body. Patients with post-traumatic and rheumatic disorders were excluded. Out of a total of 141 patients, X-rays, CTs and MRIs were carried out. Ultrasound scans and laboratory examinations were performed on patients with past urogenital ailments.

Results: 89 patients, who presented with painful manifestations but without structural and disorders, showed active thermal findings in small sites in the gluteal area caused by local trigger points and over the crista iliaca due to enthesopathy. In a small number of these patients with functional disorders, hypothermal patterns showed over the spine and in the paravertebral area due to nocireactive sympathetic efference in discogenic, facet, muscular and other disorders. The majority of the 28 patients with struc-

tural changes in the lower back area (discopathy, facet syndrome) showed various hyperthermal patterns over the lumbar spine and paravertebral areas.

Conclusion: The thermographic examination is significant for the more specific localisation of affected regions and is helpful in differentiating the inflammatory etiology of low back pain from painful syndromes of a reflexive origin induced either through the mechanism of nociceptive sympathetic efference, nociceptive motor efference or reflexive - autonomic reactions. In this respect, it offers a solid basis for adequate diagnostics and treatment.

THERMAL IMAGING IN VENOUS DISEASES OF THE LOWER EXTREMITIES

Armand Cholewka[1], Agata Stanek[2], Aleksander Sieroń[2] , Zofia Drzazga[1]

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Thermal imaging was used for estimation of lower limbs veins diseases. The studies were conducted for 15 patients (7 women and 8 male in age 62,3 ± 12,9) suffered from venous embolism and thrombosis of veins. The investigations were carried out at the Chair and Clinic of Internal Diseases and Physical Medicine, Silesian Medical University in Bytom. All patients were examined by a physician. They were requested not to smoke, drink alcohol or hot drinks for 4 hours before thermovision studies. The distribution of the skin surface temperature was monitored by using a Thermovision Camera A40M in a special room where temperature was 23±1°C.

Thermograms of tight's showed elongated areas characterizing with higher temperature what can be connected with pathological changes of veins (see Figure 1). Enhancement temperature in some areas of tights seem to be associated with blood stasis due to malfunction of veins valves. Such processes may lead to vein deformation and inflammatory states manifested on the skin surface as areas with higher temperature unlike healthy lower limb. The differences in temperature distribution can be easy correlated with medical diagnosis. Moreover thermal imaging can reveal abnormal ramification of arteries causing blood stasis in the vessels and ist deformation.

The peripheral circulation diseases seem to be very interesting and proper issue to thermal imaging especially for superficial veins malfunction.

THERMOLOGY INTERNATIONAL- 20TH ANNIVERSARY

K.Ammer (Austria)

Austrian Society of Thermology, Vienna; Austria

After the journal Thermology ceased publication in 1990, the idea arose in the newly founded AustrianSociety of Thermology to edit an own journal, which was named Thermologie Österreich. Six and a half volumes were published between 1991 and 1997, encompassing 21 issuesof this first version of Thermology international 27 papers from Thermologie Österreich were cited in the Thompsons database ISI resulting in 34 citations.

Most cited paper from this period was *"Thermological Implication of Vasodilation Mediated by Nitric Oxide" by Michael Anbar, published in Thermologie Österreich 1995, 5(1):15-27*

The third issue of volume 7, 1997, showed the new name of the journal which was European Journal of Thermology, suggested by a number of delegates of the European Association of Thermology during the assembly at the 7th European Congress of Thermology held in Vienna in spring 1997. This short period of this former version of Thermology international lasting from July 1997 to October 1998, was quite sucessfull in terms of receiving citations. 24 papers from the in total only 6 issues of the European Journal of Thermology were listed as cited in ISI, resulting in a total of 43 citations. Most, i. e. 17 times cited paper was " *Fast Dynamic Area Teletherrmometry (DAT) of the Human Forearm With a Ga/As Quantum Well Infrared Focal Plane Array Camera" by M.Anbar, Grenn WA, Marino MT, Milescu L and Zamani K, Eur. J Thermol 1997, 7(3) 105-118*. The paper " An open system for the acquisation and evaluation of medical thermological images"by P.Plassmann& E.F.J. Ring received in total 13 citations underlying the importance of software programmes in medical thermography.

As the journal served from 1999 on as publication organ for the American Academy of Thermology, the European Association of Thermology, the German, Austrian and British Society of Thermology the journal title was changed from European Journal of Thermology to Thermology international. Since 2002 Thermology international is listed in Embase and Scopus. In the last 12 years 66 papers were listed as citations in ISI resulting in 81 citing papers. The paper "*The technique of Infra red Imaging in Medicine"* by E:F.J. Ring & K.Ammer received 22 citations in ISI. Searching for this title in Google Scholar , which includes Citations in Scopus and in socalled gray literature such as theses resulted in 65 hits.

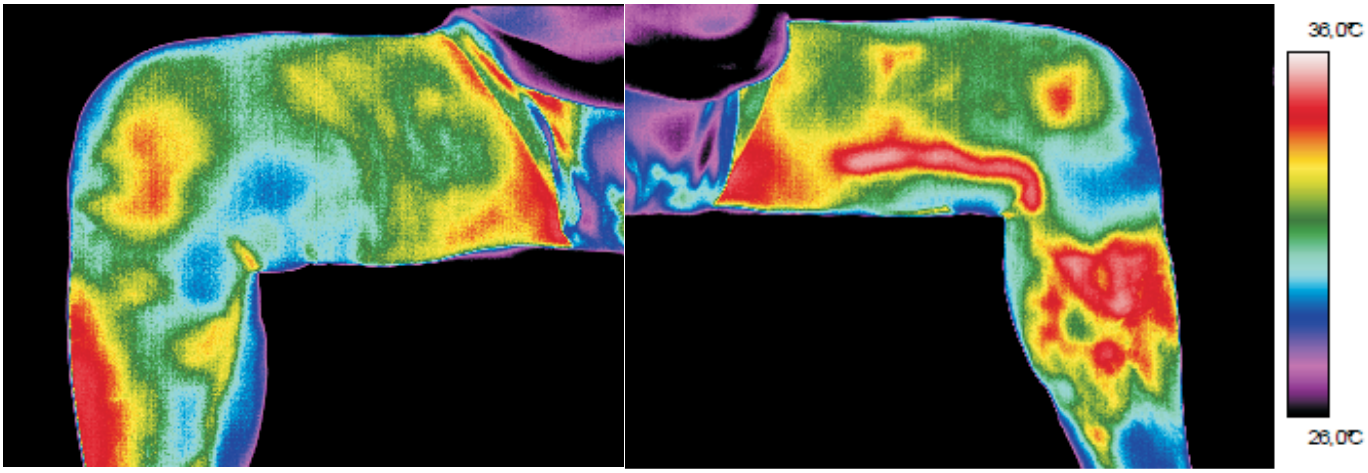

Figure 1.
Thermograms of inside tight's parts of patient suffered from insufficiency of atrioventricular saphena vena magna of lower left limb.

Although the journal thermology international is not yet listed in ISI or Medline, the 2008 index in SciImago Journal & Country Rank for Cites/Doc (2 years), which is equivalent to the ISI impact factor, was 0.87. The subject areas, from which citations were made, changed from clinical medicine during Thermologie Österreich over biomedical engineering for the European Journal of Thermology to biomedical and multidisciplinary engineering, medical imaging, optics and instruments & instrumentation in Thermology international.

Currently a DVD is in preparation, which will include all issues from Thermologie Österreich, the European Journal of Thermology and Thermology international plus the book "*The Thermal Image in Medicine and Biology*" edited by K. Ammer & E.F.J.Ring. The searchable data disk will probably available for purchase in the begining 2011.

THERMOGRAPHY IN MONITORING LASER THERAPY

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The use of thermography in laser therapy has proved to be a useful tool in reducing secondary unwanted damage and to speed up the therapeutic process. The treatment of vascular lesions is prime example where infrared thermography has resulted in a number of advantages including:

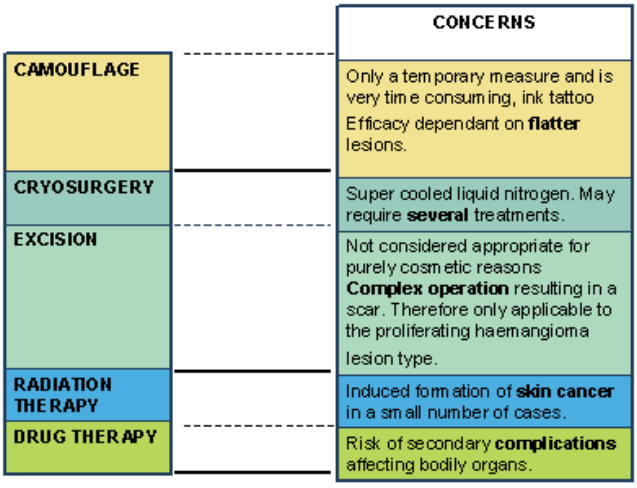
- Reduced risk of infection
- Bloodless surgery, an alternative to the traditional scalpel
- Improved therapeutic results
- Reduction to injury to normal skin
- Safe and portable.

Thermographic monitoring during laser therapy can be used to not only to set-up the laser for optimum performance such as energy density but also to visualise the laser-tissue interaction thereby reducing excessive temperatures and missed treatment areas.

In particular Dye lasers have the following advantages during and post treatment:

General Indicator	Dye Laser in Treating Vascular Lesions
During Treatment	Selective destruction of target chromophore (Haemoglobin) Can vary output parameters Manual or computerised (scanner) procedure Portable
Post Treatment (Desired effect)	Slight bruising (Purpura) Skin retains its elasticity Hair follicles are removed Skin initially needs to be protected from UV and scratching

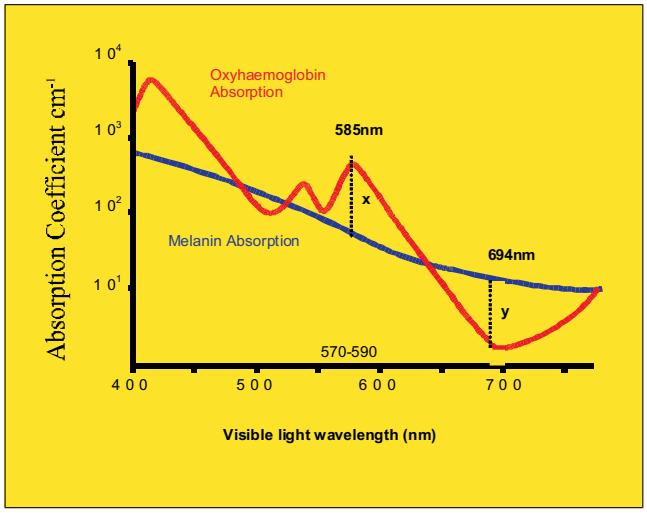
There are a number reasons why thermography is an alternative to traditional methods to treating vascular lesions each with its concerns



Selective Photothermolysis (SP) was developed for the treatment of vascular lesions. SP of blood vessels where the absorption in the oxyhaemoglobin dominates that in the melanin.

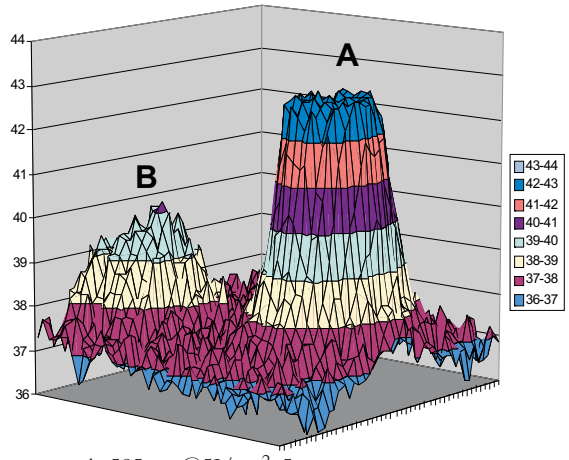
Whilst there will be some absorption in the surrounding skin, the main point is that the absorption rate in the target is in the order of magnitude greater than the other parts of the skin.

The energy needed to raise the temperature of the target is an approximation based on the volume, density and heat capacity of the target. Biological target is destroyed when it reaches the denaturation threshold temperature around 70°C.



Results reveal that various laser parameters such as wavelength (see image to the right), spot size and energy density have a significant impact on laser efficacy and that Infrared thermography is able to measure the effects of changing these parameters directly on the skin.

Thermography is also capable of accurately, repeatably, collecting changing temperatures occurring on the skin surface as a result of thermal diffusion occurring below the surface



A: 585nm @5J/cm^2, 5mm spot
B: 694nm @ 5J/cm^2 , 5mm spot

The selection and correct operation of the infrared radiometer is an essential requirement during laser therapy, for example the following table illustrates some key factors for optimum performance:

Wavelength	Key Factors
Detector	Geometric size of pixel Number of pixels Response Uniformity Cooled Uncooled
Resolution	Spatial (IFOV) Thermal ($IFOV_{meas}$)
Lens	Standard Macro
Emissivilty	0.98
Ambient temperature correction	Should be within 20 to 24°C
Humidity	Ideally 50%

More recent advances in detector technology suggest that there will be significant improvements in image quality such as spatial resolution, more and smaller detail and thermal resolution, highlighting extremely small temperature differences, very sensitively.

Meetings

2010

8th-12th November 2010

InfraMation 2010 in Las Vegas

Venue: Bally's Hotel & Casino

Registration Price: $ 1395

Information

www. inframation.org

Monday – November 8, 2010

8:00 AM - 8:15 AM - Welcome and Opening Plenary

8:00 AM - 12:00 PM - Advanced Imaging Radiometry Clinic

8:15 AM - 9:50 AM - Presentations - Building Science

Freeman, Using Thermography to show What Is Designed as a 5 Star Home is not always Built
Choate, Using Thermography to Evaluate University Campus Structures in Preparation for Weatherization Repair
Grinzato, Automatic U-Value Measurement By Local Thermographic Analysis
Hixson, Cost Effective Infrared Thermography For Roofing

9:50 AM - 10:20 AM - Break

10:20 AM - 12:00 PM – Presentations - Building Science

Biswas, Thermal Integrity Assessment of Building Envelopes of Experimental Houses Using Infrared Thermography
Pusateri, Observing Water Absorption and Evaporation in Stucco through Cracks in Low Permeance Coating Applied Over a Porous Stucco Substrate Using Infrared Thermography
Ko, Can Color Pattern Analysis be used in Classifying Building Surfaces Delamination?
Nowak, Application Of Active Thermography For The Detection Of Material Defects In The Building Envelope

12:00 PM - 1:30 PM - Catered Lunch

1:30 PM - 5:00 PM - IR Clinics (1/2 hour break at 3:00PM)

Building Science Clinic
Indoor Electrical Clinic
QuickReport / BuildIR Software Clinic
ExaminIR Clinic

Tuesday – November 9, 2010

8:15 AM - 9:30 AM - Presentations - Building Science

Sieber, "Rebuilding GREEN vs. ReG-reening/Remediation" A cost benefit analysis utilizing the art of thermography.
Carlton, Moisture Infiltration In Commercial Buildings: Determining the Cause
Danjoux, Visualization of Air Flows With an Infrared Camera. Presentation of a Simple Technique, and Examples of Data Analysis

9:30 AM - 10:00 AM - Break

10:00 AM - 11:00 AM – Keynote Address, Make it Right – *Mike Holmes*

11:00 AM – 12:15 PM –Presentations - R&D

Moellmann, Two-Color Or Ratio Thermal Imaging - Potentials and Limits
Vollmer, Measurements of the Sun and Moon With IR Cameras: Effects of Air Mass
Allen, Synchronized Thermography and PIV (Particle Image Velocimetry) Fluid Flow Measurements

12:15 PM - 1:30 PM - Catered Lunch

1:30 PM - 5:00 PM - IR Clinics (1/2 hour break at 3:00PM)

Energy Auditing Clinic
Mechanical Applications Clinic
R&D Clinic
Lock-In / Stress Analysis NDT Clinic

6:00 PM - 9:00 PM - Welcome Cocktail Dinner Reception & Poster Presentations

Pinno, Improved Sensitivity For Blower Door Thermography Using Image Subtraction
Sawyer, Cold Air In Boston: A High-Rise Wants It Out And A Grocery Chain Wants It Kept In
Hixson, Infrared Thermography Embodies True Green Construction
Danjoux, Lockin Blower Door Technique To Enhance the Thermographic Visualization of Extremely Small Air Leaks.
Jakovac, How Infrared Thermography Drives Building Energy Conservation Retrofit Techniques
Pérez, Thermographic Inspection of Stone Claddings In Real Facades

Vollmer, New Book On IR Imaging: the Ultimate Resource For All Users
Compton, Coating and Characterization of Energetic Materials
Iannone, The Effects of Heat on Firearm Barrels
Sarosi, Evaluation of Reflectivity of Metal Parts By a Thermocamera

Shaikh, IR Thermographic Inspection of complex Emergency Power Supply Equipment in Critical Mega Facilities
Crawford, Consistent Semi-Annual Justification
Street, Predictive and Preventative Maintenance of Powerlines Using Thermographic Technology and the use of Helicopters

Brioschi, IR remote sensing to measure human being stress level.
Brioschi, Automated computer diagnosis of IR medical imaging.
Mirowski, The Corpse flower: A Thermographer's Perspective
Lubieniecka, The Evaluation of Temperature Distribution During Dental Drilling Using a Thermal Imaging Camera
Castro, Thermal Imaging and Fitness
Robson, Coat of Many Colors: Case Examples of Equine Thermal Imaging

Wednesday – November 10, 2010

8:15 AM - 9:50 AM - Presentations – R&D

Geraci, Detection Of Defects In Pipelines Using Transient Analysis Of Thermal Induced Flux
Young, The Critical Role of Infrared Cameras in Remediating Sodium Residue from the Cooling Loops of Experimental Breeder Reactor II at the Idaho National Laboratory
Sarosi, Detection of surface defects on sheet metal parts by using one-shot deflectometry in the infra-red range
Tarin, NDT in Composite Materials with Flash, Transient, and Lock-in Thermography

9:50 AM - 10:20 AM - Break

10:20 AM - 12:00 PM – Presentations – R&D / Condition Monitoring

Mischker, How to Calculate Vapor Velocities Using a GasFindIR Camera
Shue, Thermal Imaging of Power MOSFETs Under Thermal Runaway Conditions.

Moore, Electrical Safety Related Maintenance Practices
Cannamela, CRAC unit evaluation in data rooms

12:00 PM - 1:30 PM - Catered Lunch

12:00 PM - 1:30 PM - Canadian User Group Luncheon

1:30 PM - 5:00 PM - IR Clinics (1/2 hour break at 3:00PM)

HVAC Applications Clinic

Outdoor Electrical Clinic

Reporter 8.5 Software Clinic

Indoor Electrical Clinic

Business Marketing Clinic

Thursday – November 11, 2010

8:15 AM - 9:50 AM - Presentations - Condition Monitoring

Cobert, Infrared Technology Helps Ensure Safety, Compliance and Recovery of Lost Revenues on Offshore Production Facilities

Rao, Assessment Of Bridge Structures Using Infrared Thermography

Madding, Practical Heat Transfer Concepts For Thermographers—Without the Math!

Pace, Beware What You Cannot See; A Practical Application of the Use of IR Windows

9:50AM - 10:20 AM - Break

10:20 AM - 12:00 PM – Presentations - Condition Monitoring

Stockton, Using Thermal Mapping at the Data Center

Allen, Electric Distribution System - Reliability Improvements Program

Dul, Primary Reformer Outlet Header Thermal Imaging

Philipp, Thermal Imaging in the US Navy

1:30 PM - Catered Lunch

12:30 PM - 3:00 PM - Exhibitor Move-out

1:30 PM - 5:00 PM - IR Clinics (1/2 hour break at 3:00PM)

Arc Flash Safety

Managing IR Programs

Optical Gas Imaging

Equine Veterinary Clinic

Friday – November 12, 2010

8:15 AM - 9:50 AM - Presentations - Condition Monitoring / Life Sciences

Gray, 5 Years Of Infrared

Coen, Application of infrared imagery for understanding wildfire dynamics

Johnson, Infrared Thermography: Its Use And Application For Detecting Infectious Diseases In Wildlife And Domestic Animals

Agarwal, A Randomized Single-Blinded Placebo-Controlled Clinical Trial For Assessing Effects of Acupuncture at Hegu (LI4) by ontact free Infrared Thermography

9:50AM - 10:20 AM - Break

10:20 AM - 12:00 PM – Presentations - Life Sciences / New Applications

Henneman, The Benefits of Using Thermal Imaging in Evaluating Injuries in Performance & Working Dogs

Mercer, Pre-, Intra-, and Post-Operative Use of Dynamic Infrared Thermography (DIRT) Provides Valuable Information On Skin Perfusion In Perforator Flaps During Reconstructive Surgery.

*Hidalg*o, Detecting A H1N1 in Tocumen International Airport in Panama

12:00 PM - 12:10 PM - Summary/Closing remarks

13th November 2010

23rd Thermological Symposium of the Austrian Society of Thermology

Venue: Raddisson Blue Palais Hotel Vienna, Austria

Speakers:

Prof. Dr. Francis Ring, UK
Dr. Kevin Howell, UK
Prof. Dr Rod Thomas, UK
Dr. Ricardo Vardasca, Portugal
Prof. Dr. Kurt Ammer, Austria
Dr Jozef Gabrhel, Slovak Republik
Dr. Armand Cholewka, Poland
Mag. Carolin Hildebrandt, Austria

Information
Prof K. Ammer, MD, PhD
Austrian Society of Thermology
Hernalser Hauptstr 209/14
Email: KAmmer 1950@aol.com

3rd-4th December 2010

Rheumatological Symposium in Piestany including a session on Infrared Thermography

Venue: Rheumatology Research Institute Piestany

Speakers in the Thermography session:

Pro. Dr. Francis Ring, UK

Prof. Dr. Kurt Ammer, Austria

Prof. Dr. H.Tauchmanova, Slovak Republik

Information:
VURCH, Rheumatology Research Institute Piestany

2011

April 2011

15th National Congress of the Polish Association of Thermology in Zakopane

Abstract deadline: January 15th, 2010

Deadline for hotel reservation; March 1st, 2010

Registration fee: 200 □

Further information

Prof Dr. Anna Jung

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

April 30th, 2011

CRPS/RSD & Thermal Imaging Annual meetings of the South Carolina Medical Associations in Greenville, South Carolina

Programm Director: Dr. Robert Schwartz,

Information: www.piedmontpmr.com

17-19th June 2011

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Information: www.cindorusp.com

6th-8th July, 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),

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Notification of the acceptance of abstracts will be forwarded to the authors until 30 December, 2010. The full text of all accepted papers will be included the CD-ROM Proceedings to be presented to the participants at the Conference.

INFORMATION

Application Forms and abstracts/papers should be sent to:

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MATE Secretariat, House of Technology, III. 318.

H-1372 Budapest, POB. 451., Hungary

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2011: www.mate-net.hu/03menu/03index.htm and
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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

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