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Medical thermography: what is it? And its applications.

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Abstract— Thermography is a method still fresh in our medical practice. The author explained how is the modern medical thermography approach that is applied today as a means of a complementary radiologic diagnostic study. One of the basic indications and clinical uses of infrared (IR) imaging is documentation of soft tissue pathology, particularly in conditions which cannot be demonstrated on radiologic tests, electroneuromyography or laboratory workup. Medical infrared imaging (MII) can recognize and document a wide range of Rehabilitation Medicine applications that include: neuropathic pain diseases, tissue inflammations, post-stroke abnormalities, spinal cord injuries, rheumatologic disorders, sports injuries, poor extremity vascular perfusion, low back pain causes and vasomotor changes related to chronic pain conditions as myofascial (MPS), fibromyalgia (FMS) and complex regional pain syndromes (CRPS). The IR imaging findings represent an objective mean to document TP, thus corroborating with the subjective patient's complaints. The documentation of TP by IR imaging is important to introduce the most adequate treatment directed the pain cause as well as to evaluate its response. Thermography can extend the clinical evaluation.
Keywords: thermography, Medical infrared imaging (MII), complex regional pain syndromes (CRPS), fibromyalgia (FMS)

Resumo — A Termografia é um método ainda está recente em nossa prática médica. O texto deste trabalho explica como é a abordagem termografia médica moderna que é aplicado hoje como meio de um estudo de diagnóstico radiológico complementar. Uma das indicações básicas e as utilizações clínicas de infravermelho (IR) de imagem é a documentação da patologia dos tecidos moles, particularmente em condições que não podem ser demonstradas em testes radiológicos, eletroneuromiografia ou exames laboratoriais. Imagens médicas com infravermelho podem reconhecer e documentar uma ampla gama de aplicações de Medicina de Reabilitação, que incluem: doenças de dor neuropática, inflamações dos tecidos, anormalidades pós-acidente vascular cerebral, lesões medulares, doenças reumatológicas, lesões esportivas, má perfusão vascular extremidade, dor lombar causas e mudanças vasomotores relacionadas com condições de dor crônica como miofascial (MPS), fibromialgia (FMS) e síndromes de dor regional complexa (CRPS). Os achados de imagem IR representam um objetivo a intenção de documentar TP, corroborando assim com as queixas do paciente subjetiva. A documentação do TP por imagem IR é importante introduzir o tratamento mais adequado dirigido a causa da dor, bem como para avaliar a sua resposta. A termografia pode estender a avaliação clínica.
Palavras-chave: termografia, imagens médicas com infravermelho (MII), síndromes de dor regional complexa (CRPS), fibromialgia (FMS)

1. BASIC CONCEPTS

Medical infrared imaging (MII) provides a non-radiating and contact-free method to display sympathetic skin vasomotor response, inflammation or vascular skin perfusion. Skin galvanic impedance, vasomotor and sudomotor functioning can be assessed through infrared skin response studies. The efficiency of new high definition MII systems make it a valuable auxiliary for detecting thermal abnormalities characterized by increases or reductions in skin heat [1]. The aim of this study was to explore the potential of MII for detecting specific thermal patterns in patients submitted to procedural rehabilitation interventions including therapeutic exercise, neuromusculoskeletal re-education, functional training and self-care, manual therapy techniques, acupuncture and home management.

2. THERMAL IMAGE ACQUISITION PROTOCOL

MII were obtained following the standard protocol, recommended by AAT and ABRATERM [1,2]. Patients were instructed not to palpate, rub, scratch or press their skin at any time until completion of entire MII examination. Following acclimatization of 15 min in a room with mean temperature of 23ºC and relative humidity of 60% was scanned disrobe full body with a 640x480-array infrared camera (T650sc, FLIR, USA), spectral range of 7.5-14 µm. MII produced a thermal map of human body surface with differences until 0.03ºC. The emissability value of skin considered was 0.987. Since pain causes alteration in skin blood flow, the development of pain is associated with alteration in surface temperature in the involved body structure by somatosympathic skin nervous reflex. In this study, 3 groups were analyzed: ***Group A: Myofascial Pain Syndrome (MPS).*** MII plays an adjunctive role in diagnosis of musculoskeletal disease including structures as muscles, tendons, ligaments, joints and capsules. Sprains, strains, tears, contusions and myofascial trigger points (MTP) are conditions involving these structures and look as well shaped hyper-radiant and hot spots images [3]. For this study were selected 304 patients with MPS during rehabilitation acupuncture therapy. ***Group B: Fibromyalgia syndrome (FMS).*** Brazil has 4 million patients with FMS [1]. A total of 226 FMS patients and 34 normal volunteers had been selected according to ACR criteria and evaluated by MII. ***Group C: Neuropathic pain.*** Were evaluated thermatomes of 100 patients with nerve damages (peripheral, central and spinal cord injury-SCI) with moderate/severe pain in the extremities or trunk. Thermatomes means the skin area linked with autonomic nerves and has patterns like dermatome. CRPS is often misdiagnosed because it remains poorly understood and there is no proper diagnostic tool except MII cold stress test. A delay in diagnosis and treatment in CRPS can result in severe physical and psychological problems. Early recognition and prompt treatment provide greatest opportunity for recovery. We evaluated 30 cases of CRPS with cold stress test. All groups' analyses were performed using SPSS® 19 software (IBM, USA) and the reliability coefficients were based on Pearson's chi-squared test. A level of $p < 0.05$ was considered statistically significant. The study was approved by Ethic Scientific Committe of FMUSP.

3. RESULTS

All patients of **group A** imaged before acupuncture had hot spots corresponded to painful areas that represented active MTP during clinical examination (**Figures 1b,1c**). They could be corroborated by local sensitivity and confirmation of patients' complaints. The cold referred pain areas showed be thermally asymmetric with corresponding side. Latent TP, which were not objective complaints of patients during MII assessment, were also detected as mild hot spots. The presence of active and latent TP was confirmed by algometry and ultrasonography (US). After acupuncture there was alteration of thermal profile, showing an immediate sympatholytic effect. MII sensitivity and specialty were 79 and 50% respectively compared with only 65 and 18% by clinical palpation of MTP in **group B** ($p<0.05$). When associated with MII the palpation sensitivity reached 93% in FMS. All MTP were documented by US. In **group B**, was possible to create by multiple linear regression an agreement classification for thermal distribution in FMS patients on basis of axial hyper-radiating image in "mantle form" associated with hypo-radiation impression of extremities. The test demonstrated that these regions correlated to predict FMS presence ($R^2=0.94$). It had significant thermoregulatory skin distribution difference between all patients with SFM and normal

controls (**Figures 1a,1d**). Being that it was possible to classify them by means of MII and to establish quantification criteria of the presence or not of the illness. Based in clinical criteria of ACR for SFM the clinical correlation with MII was possible and demonstration of one props up MII diagnosis and monitoring. Also the authors identified 3.7% cases of arthritis (RA) in **group B**. There was no difference in VAS Pain between FMS sufferers with or without RA (6.17±2.5, p>0.5). MII identified early RA in FMS patients, also 7 cases with sacroiliitis (**Figures 1e,1f**). Heat is associated with many rheumatologic conditions and inflammation is major one of those conditions. RA will be detected, identified and objectively quantified as hot painful joint area by MII. MII has its role especially in detection of disease without realized symptom, so makes early treatment possible, evaluation of medication efficacy and decision of disease stage. In **group C**, MII documented thermal abnormality along nerve root dermatome as hyper-radiation in the distal cutaneous in acute stage by decreased sympathetic tone and hypo-radiation as the nerve regenerated or denervation of smooth muscle in arterioles. Also MII proved valuable as an aid in evaluation of disability claims, helping to rule out malingering cases and to document C-fiber neuropathy associated with diabetes (**Figure 1g**). Low back pain caused by lumbar stenosis produced hyper-radiation at the anatomical level of stenosis by afferent reflex of synovial reaction and also hypo-radiation along nerve root dermatome manifested by sympathetic system (**Figure 1h**). Therefore it helped to find the origin of the problem with positive correlation with other diagnostic studies (EMG, TC, MRI) in patients with disease associated with spinal nerve root fiber abnormality as disc disorders and herniation. MII had sensitivity of 90% compared to conventional electrodiagnostic studies. In SCI the autonomic hyperreflexia resulting from stimulation occurred after 2.6 weeks in patients that had injuries at T7 or above. A massive reflex vasoconstriction was seen with stimulation. Compensatory vasodilation occurred above the lesion. MII facilitated CRPS diagnosis, and achieved a higher recovery rate among CRPS patients by virtue of early diagnosis of the disease with cold water stress test, all cases presented with paradoxical vasomotor instability response (**Figure 1i**).

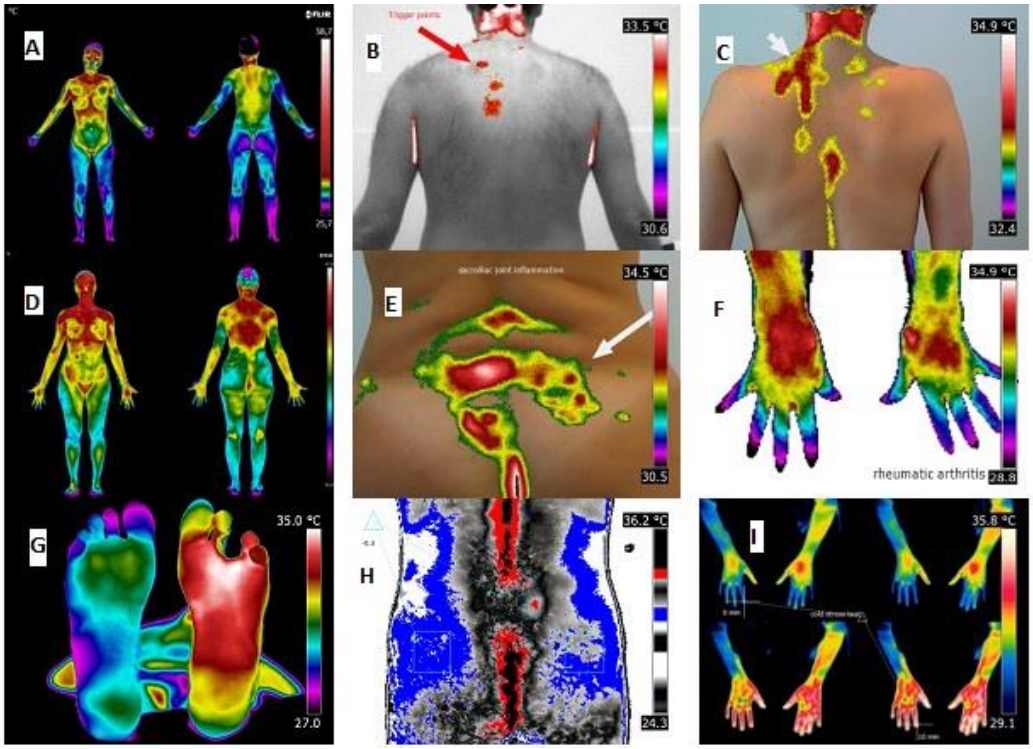

Figure 1. Medical infrared images patterns of patients in rehabilitation: **A.** Normal full body; **B. and C.** Myofascial trigger points; **D.** Fibromyalgia "mattle" sign; **E.** Sacroiliitis; **F.** Wrist arthritis; **G.** Peripheral diabetic neuropathy; **H.** Lumbar disc herniation L4-L5; **I.** Positive CRPS cold stress test.

4. Discussing the Applications in Medicine

MII represents an objective measure capable of documenting MTP that could be corroborated by local palpation, quantitatively measured by pressure threshold over the involved area and US. Early diagnosis is valuable because successful therapy of muscular and fascial diseases depends on prompt treatment of the acute injury. Delay in therapy decreases the chances for complete healing and prolong recovery. The aim of this technique is not to be a substitute for clinical examination but to enhance it. It should be used by Rehabilitation Medicine team in the office setting. Based on the advantages of MII as non-invasive, non-radiating detection modality, it should be applied as pre and post-scan assessment and imaging documentation during patient rehabilitation.

The myofascial trigger points (TP) are involved as much pathologies of hyperextension/hyperflexion cervical injuries, disc injuries, and overuse injuries. From the extreme of malingerer to the frustrating dilemma of intractable chronic myofascial pain, the documentation of this alteration is in the majority of the cases subjective and a dilemma.

The IR imaging is a diagnostic test which objectively documents TP in the form of hyperradiant hot spots. These hyperradiant spots corresponding to areas of pain usually represent active TP in clinical examination. They can be corroborated by local tenderness in the region, thus confirming the patient's complaint. The areas of pain are presented as thermal asymmetry between corresponding areas of opposite sides of the body. Latent TP, not subject to patient complaints at the time of IR imaging examination, are detected in the form of hyperradiant spots. The presence of these latent TP can be documented by abnormal pressure threshold measurement in these areas. There was an alteration of the skin thermal profile after TP local anesthesia/dry needling demonstrating an immediate neurovegetative sympathetic response.

5. Conclusions

MII can recognize and document a wide range of Rehabilitation Medicine applications that include: neuropathic pain diseases, tissue inflammations, post-stroke abnormalities, spinal cord injuries, rheumatologic disorders, sports injuries, poor extremity vascular perfusion, low back pain causes and vasomotor changes related to chronic pain conditions as myofascial (MPS), fibromyalgia (FMS) and complex regional pain syndromes (CRPS).

The IR imaging findings represent an objective mean to document TP, thus corroborating with the subjective patient's complaints. The documentation of TP by IR imaging is important to introduce the most adequate treatment directed the pain cause as well as to evaluate its response. Thermography can extend the clinical evaluation.

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