

Clinical use of thermography in the diagnosis of soft tissue lesions

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Thermography is a non-invasive method of recording and interpreting the distribution of surface temperature. First used clinically in the diagnosis of breast disease, thermography has been spreading steadily in a variety of diagnostic applications. Various investigators claim that thermography: 1) can document soft tissue injury, infection and inflammation, 2) has a place in pre-employment screening for back disorders and high risk backs, 3) is more sensitive than electromyography in the diagnosis of disc disease and radiculopathy, 4) is exceedingly more accurate than myelography in judging a patient's disc problem, and 5) may be a useful supplement to present clinical methods for objectively documenting soft tissue trauma in the patient with low back pain. This review attempts to evaluate the state of thermography today and assess its value in the diagnosis of musculoskeletal pain.

KEY WORDS: thermography, skin temperature, pain syndrome, chiropractic

La thermographie est une méthode non envahissante d'enregistrement et d'interprétation de la distribution de la température superficielle. D'abord utilisée cliniquement dans le diagnostic des maladies du sein, la thermographie se répand de plus en plus, dans toute une gamme d'applications aux fins de diagnostic. Divers chercheurs affirment que la thermographie: 1) peut documenter les blessures, les infections et les inflammations des tissus mous; 2) peut servir au filtrage des troubles du dos et des dos à risques avant l'embauche; 3) est plus sensible que l'électromyographie dans le diagnostic des maladies des disques et de la radiculopathie; 4) est infiniment plus précise que la myélographie dans l'évaluation du problème de dos d'un patient; et 5) peut être utile comme accessoire aux méthodes cliniques actuelles dans la documentation objective des traumatismes des tissus mous chez le patient affligé de douleurs du bas du dos. Cet article veut évaluer l'état de la thermographie aujourd'hui et sa valeur dans le diagnostic des douleurs musculo-squelettiques.

MOTS-CLEFS: thermographie, température de la peau, syndrome de la douleur, chiropratique.

Introduction

Thermography is a non-invasive method of recording and interpreting the distribution of surface temperature. Two systems of medical thermography are in current usage. Electronic (tele or noncontact) thermography consists of scanning mirrors which reflect the infrared (heat) radiation on an infrared-electronic transducer. The infrared pattern is then displayed on a black and white and/or color CRT from which it can be photographed. Contact Thermography uses liquid crystals which are cholesterol derivatives that selectively reflect polarized light in a narrow region of wave length. This review will focus on the latter mostly. The crystals have strong molecular rotary power and specific color-temperature responses that are utilized in color thermography.^{1,2} At the beginning, the adaptation of liquid crystals to thermography was hampered by the necessity of preparing the skin with black, water-based paint in the form of a spray prior to the actual application of liquid crystals to the skin.^{1,3} Rigid plastic plates subsequently replaced skin preparation and spraying, but the unyielding plates precluded uniform contact of these liquid crystals with the skin particularly when the crystals were applied to the spine and extremities. The resultant thermograms were, therefore, inadequate.⁴

A new thermographic technique for breast examination utilizing liquid crystals embedded in elastometric sheets has been reported.^{5,6} The sheets were individually contoured to the body by means of a vacuum. Results via this method compared favorably with both mammography and clinical examination.

By modifying this technique, it was possible to apply it for thermographic examination of the spine and extremities. The currently reported adaptation also employs flexible, elastomeric Flexi-Therm sheets containing thermally sensitive liquid crystals which can now be contoured to the torso and extremities by means of a new device, an "air-pillow". Uniform skin contact with resultant consistently reliable thermograms has been achieved.⁴⁻⁶

Liquid crystals have definite colour responses to temperature changes. The temperature ranges most frequently used for back thermography are 30 to 33°C, 31 to 34°C and 32 to 35°C. The predominant colors of a liquid crystal thermogram (red, brown, yellow, green, light blue, and dark blue) represent 1°C intervals in order of from the coldest to the hottest color.^{1,2,4,7}

Technique

For optimum and reliable studies, all examinations should be performed in an air-conditioned, draft free room. The skin temperature of the back should be stabilized by sponging with water and cooling for ten minutes. Patients should refrain from smoking and from taking medications on the day of the examination, since both may effect the skin temperature.⁸

Routine views of the lumbosacral region and lower extremities consist of separate images of the lumbar region: buttocks, anterior, lateral, and posterior aspects of both thighs; the anterior, lateral, and posterior aspects of both lower legs, including the ankles; and the torsal aspect of the feet, including

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Figure 1: This represents the thermograph of a patient with chronic distress in the left infrascapular region. A focal decrease in the vascular emission is evident at the inferior portion of the left scapula. This corresponds to the cutaneous distribution of the lateral dorsal division of T6 and to the patient's complaint.

the toes. Routine images of the cervical spine and upper extremities include views of the posterior neck, both posterior shoulders, posterior forearms, anterior forearms, ulnar and radial aspects of the forearms, and the dorsal aspects of the hands and fingers. If an abnormal thermographic image is seen, the process should be repeated at least three times in succession to confirm the reliability of the abnormal image.⁶ Special attention is given to the body dermatomes.⁹

The clinical applicability of thermography

In many ways, thermography seems ideally suited as a diagnostic imaging technique. Firstly, it is non-invasive, and is therefore preferable from the patient's point of view. Secondly, it involves no ionizing radiation and is thus relatively safe. This is important in cases where frequent monitoring is necessary or if there is any likelihood of the patient being pregnant.¹⁰ It is, however, only fair to keep its application in proper perspective. By definition, thermography is concerned with the measurement of temperature and heat emission from the surface of the skin. The interpretation of thermograms is therefore dependent on our appreciation of the relative effects, in both health and disease, of the underlying circulation on the temperature of the skin. For this reason, thermography seems to be best confined to the investigation of the cutaneous circulation directly, or to relatively superficial pathological conditions which affect peripheral blood flow.^{7,10-12} Examination of the internal organs,

such as those of the digestive and respiratory systems, is better left to ultrasound and radiography. This review in fact is limiting itself to the investigation of soft tissue lesions only.

Thermographic results

A normal thermogram of the extremities shows symmetrical heat emission, whereas root lesions of the spine have been associated with temperature changes in the corresponding dermatomes and myotomes. The temperature changes may be related to reflex sympathetic vasoconstriction within affected extremity dermatomes and metabolic changes or muscular spasm in corresponding paraspinal myotomes.⁴⁻⁶ As a rule, temperature changes appear as zones of hypothermia at the levels of the affected extremity dermatomes.^{4-6,13-15} However, fairly frequently, it is not unusual to see hypothermia at the level of the affected dermatomes, especially in the hands and feet.¹⁵ Both hypothermic and hyperthermic reactions are abnormal, since there should be no significant temperature difference between the extremities of normal individuals, save perhaps the occasional increase in temperature in the dominant arm and posterior forearm of very muscular males.^{4-6,15} In the spine, root compression syndromes usually show lumbosacral hyperthermia and cervicothoracic hypothermia of the ipsilateral adjacent paraspinal myotomes.⁴ Musculoligamentous injuries of the spine and osseous lesions without root compression seem to have thermographic changes localized to the spine¹⁶ and not necessarily associated with changes in the extremities.

Temperature changes at particular dermatomes and myotomes reflect a fairly accurate picture of referred pain in root compression syndromes.^{13,14,17} A normal thermogram of the spine is characterized by a central zone of decreased heat emanation in the region of the spinal processes from the cervical spine down to the lower lumbosacral spine. The intergluteal fold is also hypothermic since it is not in contact with the liquid crystal sheaths.⁴⁻⁶ The sacroiliac joints may show symmetrical localized increase heat emission.^{12,18} A positive or abnormal thermogram should show some evidence of asymmetric increased heat production in this zone or decreased heat production lateral to the midline along the cervical, thoracic and upper lumbar spine.⁴

Value of thermography in soft tissue lesions

Lindholm, Myllyla and Sarvaranta¹⁹ reviewed the thermograms of 174 hospital patients with sciatica, which revealed a significant correlation between decreased temperature of the distal part of the affected limb and the probability of spinal nerve root compression. The highest order of preponderance for "coldness" was related to the group of patients whose symptoms were confined surgically as those of a herniated disc. The follow up thermograms of 30 patients, 4 months postoperatively showed correlation between normalization of the temperature and relief of symptoms.

Uematsu and Long²⁰ reviewed the thermograms of 101 patients with chronic pain in a variety of locations of the body.

There were 17 abnormal thermograms. All but one demonstrated coldness in the area of pain. Tichauer²¹ found asymmetric warm areas in the paralumbar area and cold gluteal patches in a high percentage of cases. Hendler, Uematsu and Long²² used thermography to evaluate 224 consecutive patients that had received psychiatric diagnoses. Abnormal results were found in 43 patients (19%), leading to diagnosis of reflex sympathetic dystrophy, nerve root irritation and thoracic outlet syndrome.

Edeiken¹⁸ found that low back patterns on thermograms alone were noted to be 75% accurate when compared to surgically confirmed abnormal herniated lumbar discs. In the same series by comparison, myelography was about 84% accurate. Where abnormal lumbar patterns are combined with thermographic study of the extremities, the procedure has been found to be 93% accurate¹⁴. The thermogram combination of low back plus extremity findings has been determined to be 90% accurate when compared to the myelogram 84% accuracy in surgically confirmed cases.²

Wexler correlated the thermographic spine patterns and extremity dermatome changes, and standardized the thermographic examination of the spine to include the extremities as an integral part of the study.^{14,15} In his series of 86 patients, he found that thermography of the spine and extremities was 92% accurate, as compared to physical findings, while electromyography was only 83% accurate. Rubal, Traycoff and Ewing⁷ used liquid crystal thermography on 62 hospitalized patients for low back pain and 22 college students with no previous history of back pain and found that the thermograms of patients with discogenic lesions and acquired lesions were significantly greater ($p < .05$) than those of the pain free subjects. Tenderness to palpation was associated with elevated skin temperature in 80 percent of the patients studied. That study suggested that liquid crystal thermography may be a potentially useful tool for localizing soft tissue trauma in patients with low back pain. Pochaczewsky⁴ found that thermographic accuracy in diagnosing spinal root compression syndromes was greatly improved when a simultaneous study of extremity dermatomes was included as part of the routine liquid crystal thermography evaluation of the spine. That was documented in over one third of the surgically proven positive patients in whom liquid crystal thermography patterns in the lumbosacral region were either normal or inconclusive. A correct liquid crystal thermography was made, however, due to definite abnormal thermographic patterns in the extremities that adhered to known anatomic dermatome distributions. The author concluded that a high degree of anatomic diagnostic accuracy may be achieved with liquid crystal thermography that is comparable to or better than realized by myelography.⁴⁻⁶

Thermographic pitfalls

Several participants at the recent Third International Congress of thermography in Bath, England²³ warned thermographers that they should find out what drugs their patients have been taking before attempting to interpret seemingly abnormal heat

patterns. Dr Jan Frens of the University of Utrecht in Holland noted that many drugs act on the hypothalamus and other brain centers involved in controlling the body's thermoregulatory system. He found that methysergide maleate, an agent used for the prophylaxis of migraine, causes a skin temperature decrease of as much as 10°C because it is an antagonist of serotonin, which regulates heat loss. Vasodilators, in contrast, produce a distinct heating effect that likewise could easily cloud the interpretation of a thermographic reading. Also, by blocking infrared emissions, many nonmedical ointments can push the temperature up or down depending on contents. Smoking can also affect the thermographic study⁸, especially if done on the same day prior to the thermographic assessment.

When a positive thermogram is obtained, a further repeat study of the same region is recommended at all times in order to increase the reliability of the study. The interpretation of thermal pathology related to pain requires a considerable experience in reading thermographs and knowledge of pain syndromes so both can be correlated with clinical findings.²⁴

Indications

Thermography of the spine and extremities seems to be useful in numerous conditions.^{4-6,16,20} It may play a role in the selection of patients who require myelography. It may help to confirm clinically suspected spinal root compression syndromes as seen in association with herniated discs and osteophyte formation. It may help in spinal stenosis including lateral recess stenosis and spondylolisthesis and hypertrophy of vertebral facets. It may graphically document pain in spinal musculoligamentous injuries even though X-rays were unremarkable. It may also be useful in sports injuries assessment.²⁵

Conclusions

This article has outlined briefly many of the current clinical applications of thermography in the assessment of soft tissue lesions. It seems that despite some of its early shortcomings, thermography has been grossly underestimated to date, and definitely deserves an unprejudiced reappraisal. The entire apparatus for liquid crystal thermography costs only a small fraction of the price of a conventional electronic thermographic unit. The former can be routinely used in most private practices as another tool for the diagnosis of soft tissue lesions.

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