Neuromuscular Thermography: An Analysis of Criticisms

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Introduction

Technological assessments of the neuromuscular applications of thermography have been prepared recently by various organizations, including the American Medical Association (AMA), the Joint Council of State Neurosurgical Societies of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons, the Office of Health Technology Assessment of the U.S. Department of Health and Human Services, and the American ?Academy of Neurology (AAN). Several of these evaluations, in part or in total, have been critical of the medical usefulness of thermography. In addition, other published papers have unfavorably reviewed the clinical role of thermography.

In the light of the literature as well as my own clinical experience as a neurologist, I will examine the significant points and issues raised by this criticism, including clinical usefulness, abuse/misuse, published reports, and community acceptance of thermography. In addition, I will confront contradictions in the criticism of thermography as well as the role of political pressures in the assessment of thermography.

Clinical Usefulness

All discussions of thermography agree that the procedure is a non-invasive and safe method having no adverse biological effects. Further, most evaluations indicate that infrared thermal imaging is an accurate, sensitive method of displaying cutaneous temperature distribution.

In my clinical experience and as reported by others, thermal imaging of the cutaneous temperature distribution is an important aid in the diagnosis and management of various neuromuscular causes of pain, such as nerve root impingement[1-3] reflex sympathetic dystrophy,[4-6] and other painful problems, such as myofascial injury' and stress fracture.* However, reports critical of thermography question the clinical value of the method. Critics consign thermography to a role as an adjunctive test or screening method, or cite its supposed nonspecific results and poor sensitivity.

Adjunctive Test

Some evaluations of thermography state that it is an "adjunctive test" requiring "other procedures . . . to reach a specific diagnosis."[8,27] The 1989 report[9] from the Office of Health Technology Assessment (OHTA) of the U.S. Department of Health and Human Services, for example, concludes that "most investigators recommend thermography only as a screening tool, as an adjunctive diagnostic device, and not as a primary diagnostic guide." The OHTA report raises a question about the difference between an "adjunctive test" versus a "primary diagnostic guide."

Ideally, a medical diagnostic test is designed to supply unique anatomical, physiological, or biochemical information regarding body functioning.

Therefore, it is difficult to separate an "adjunctive" from a "primary" test. The terms suggest that an "adjunctive" test is subordinate to a "primary" method, but such a differentiation may not be obvious or even valid. When an electromyographer performs a needle electrode examination, the resulting electrical signals indicate only the physiologic state of the muscles tested. If denervation potentials are recorded from specific muscle groups, such as the lumbar paraspinals, peroneous longus, anterior tibial, and posterior tibia1 muscles, the examiner makes certain assumptions and concludes the presence of an L5 radiculopathy. In this sense, the EMG is really an adjunctive test. The diagnosis is made by the clinical skills and acumen of the electromyographer, not by the EMG. A radiologist examining a head CT (computerized tomographic) scan observes a spherical, enhancing, well-contained mass with little edema, loosely attached to the inner table of the skull. A meningioma is diagnosed. The observations and conclusions are based solely upon examining film showing differences in cranial tissue density as revealed by multiple radiographic sections. The CT scan does not give a tissue diagnosis. Since a specific diagnosis can be made

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only by pathological examination, is not the CT scan "adjunctive"? In reality, is not all diagnostic testing "adjunctive" to the clinical presentation, which requires the interpretative skill of the reading or treating physician? If the above instances are indicative of "primary" tests, I submit that a thermographer who diagnoses a cold extremity on a thermogram from a patient with chronic severe pain as reflex sympathetic dystrophy, is using a "primary diagnostic guide." Findings of thermal asymmetry are as diagnostic to the thermographer as are muscle injury potentials to the electromyographer and tissue-density differences are to the radiologist.

Nonspecijc Results

Closely associated with the concept of adjunctive testing is that of nonspecificity. For example, So et al." characterized their findings as "nonspecific" in their study of lumbosacral radiculopathy. Critics indicate that the reason that thermography is adjunctive is its limitation to "cutaneous temperature."[8] They contend that thermographic results cannot be interpreted with certainty because they are based upon a nonspecific function, the temperature of the skin.

This point ignores the importance of vasomotor changes in response to neurovasomotor injury, a concept that was demonstrated as early as the 1940's by Richter, who revealed changes in skin resistance in response to peripheral nerve injury.[11],[12] Richter's work indicated that autonomic disruption in injury produces identifiable alteration of the sweat response, as measured by galvanic skin resistance. Because of its effect on the cutaneous microcirculation, sympathetic disruption in a peripheral nerve[13] causes clear thermal changes in the distribution field of the nerve.[14] This thermal information is clearly revealed by thermography and is not easily obtainable by any other method. An experienced thermographer is able to recognize the pattern and distribution of vasomotor changes in response to nerve injury, leading to a differential diagnosis in specific situations in a given clinical context.[15]

Screening Method

Some statements regarding the adjunctive role of thermography indicate that it should be considered "only"[9] as a screening tool, particularly in detection of a radiculopathy. This wording minimizes its clinical value. Other diagnostic methods are considered helpful because of their ability to document the existence of a problem without supplying any further information. For example, evoked potentials, such as brainstem auditory evoked potentials (BAEP), provide physiologic information regarding the integrity of central neural pathways, but they do not indicate the nature of the possible abnormality. As stated by Aminoff,[16] "in patients with central brainstem lesions, BAEPs may indicate that a lesion is present but do not indicate its nature." In this respect, the BAEP is a screening tool, requiring further diagnostic testing if it indicates abnormal findings. The BAEP is an accepted procedure, and its use to screen for the presence of a lesion is valid. Similarly, since thermography is a sensitive screen for radiculopathy'** or other painful syndromes with a resultant vasomotor alteration, screening seems to be a reasonable, acceptable role for it.

Poor Sensitivity

Several reports question the sensitivity of thermography in radiculopathy, contending that thermal imaging does not give precise anatomical localization. The AAN report,[17] for example, notes that "lack of precision of thermographic localization may have influenced other investigators to report that the test was not sensitive or specific." So and his coworker Aminoff[10] report that while their results "found thermography was similar in sensitivity to conventional electrodiagnostic studies" correlating "well with the presence of clinical and EMG abnormalities," they had "serious questions about the localizing value of thermography." Despite the overall positive results of their study, these authors concluded that thermography was of "little diagnostic value."

While the mechanism is unclear, thermography is a sensitive method for demonstrating the presence of a radiculopathy.[1–3] A recent study by Jinkins et al.[18] demonstrated with magnetic resonance imaging (MRI) the varying degrees and directions of herniated lumbar intervertebral disks and anatomical relationship to their autonomic nerve supply. The article includes a detailed discussion of the somatic and autonomic innervation of the lumbar spine. This review supports the scientific basis by a vertebrogenic mechanism of the sympathetic changes observed in the lower extremities as identified by thermal imaging.

At times, the distribution of the thermal abnormality does not fit precisely with the anatomical level of the lesion. For example, a patient with a herniated L4-5 disc may have a hypothermic response in the posterior leg, an Sl distribution. However, other techniques that measure physiologic responses also do not always have clear anatomical correlation. Evoked response studies, such as the BAEP, for example, are sometimes abnormal at a level or side that does not correlate with an anatomical lesion.[19,20] This difficulty with BAEP was discussed by Aminoff,[16] and he concluded that the "main value of the technique is to establish that the lesion exists rather than to define its precise location," It seems inconsistent that the same individual would criticize the

usefulness of thermography because "our study has raised some serious questions about the localizing value of thermography." Other inconsistencies between a physiologic and an anatomical study have been described, such as lack of correlation between the EMG and lumbar CT scan*l as well as EEG and CT scan of the head.**

In their paper, So et al." conclude that since EMG provides better localizing information, thermal imaging is not helpful. Such attempts to impose electromyographic principles on thermography, whose physiologic basis is different, are inappropriate. On an individual case basis, I have found that at times the EMG, and at other times thermography, is more helpful in revealing a radiculopathy. Rather than being competitive, thermography and EMG are complementary, each providing its own unique physiologic information.

Abuse/Misuse

Some critics of thermography raise the issue of the abuse and misuse of the procedure, particularly for financial gain. The AAN report," for example, states that "some respondents reported excessive and inappropriate use of the technique." Edeiken, in an unpublished position paper,[23] asks "Why then is thermography used so frequently in a number of states? Most certainly the motivation is based on profit and financial return." Several papers from the legal literature describe thermography as a "lucrative",[24] "profit-making fad" and "booming . . . business."[25]

My personal experience with thermography is contrary to these statements and impressions. Considering overhead expenses and lease payments, my own laboratory typically runs at a monthly break-even level and often at a loss. I conduct thermal imaging studies not for "financial return," but because the results provide useful information for patient diagnosis and management. My participation in meetings and seminars of such organizations as the American Academy of Thermology and the Academy of Neuro-muscular Thermography, has impressed me that others share the same dedication. Their motives are not "financial return," but scientific truth and good medical care.

Unfortunately, there certainly is a minority of practitioners who look upon thermography as a financial opportunity and abuse their privilege and position for financial gain. But abusive people tend to be abusive, whatever their method. Greed is a human flaw, not a problem peculiar to thermography. Other diagnostic procedures are not immune to this problem. We have all observed instances in which testing-EMG, EEG, x-rays, CT scan, blood work-has been "over-utilized" by others for financial gain. This issue was specifically addressed in a "Controversies in Neurology" section of an issue of *Archives of Neurology* dealing with evoked potentials. In his paper on the abuse and misuse of evoked potentials as a diagnostic test, Kimura[26] notes that "abuse and misuse are common with any new diagnostic procedure." He discusses the problem of the "profitability" issue as well as diagnostic methods "to compensate for low income generating capacity" of a neurologist.

While these issues are of general concern, to specifically cite them as criticisms of thermography is inappropriate. If a technological assessment is to include considerations of "excessive and inappropriate use," then all diagnostic modalities should be removed from clinical use, for all have been abused by unethical or overzealous practitioners. The point is that a technological assessment must be based upon objective scientific review, not prejudicial opinion. Concerns regarding abuse should be handled in an entirely different forum.

Published Reports

Some criticism regarding the clinical use of thermography is directed toward the literature, citing certain perceived deficiencies. The OHTA report[9] states that "evidence of the technology's clinical effectiveness has not been tested rigorously in prospective, controlled clinical trials." The AMA report*' calls for "well-controlled, blinded studies." Other papers[10]*[35] cite lack of a "control group" as a shortcoming in many thermographic studies.

The issue of prospective and blinded studies, particularly as related to the sensitivity of thermography in identifying a radiculopathy, has been discussed at length. 2V28 While most thermographic studies have been retrospective, that does not invalidate their results with regard to imaging studies.*'**' In the case of radiculopathy, several prospective and blinded thermographic studies have been reported (see refs. 1,3,30,31). Since their results are very similar to those of retrospective, unblinded studies, one validates the other.

The cited lack of "controlled" studies is problematic. The established normal condition is thermal symmetry between homologous surface body parts.[32]-[34] Presumably a "control" would be a normal, symptom-free individual. Since the normal has already been established, the insistence that each study include "controls," i.e. "normals," is superfluous. A study" that is critical of this point in the thermography literature failed to include an EMG control group in its comparative study of thermography and EMG in radiculopathy. This omission is arbitrary and inconsistent. Those studies that have included controls simply further validated the principle

of thermal symmetry of the body and added nothing to the results (see refs. 2, 3, 10, 36-38). On the other hand, any novice to thermography who is establishing a laboratory should run a number of normals, perhaps fifty subjects, before embarking upon clinical evaluation.

Community Acceptance

Apparently peer acceptance is a criterion for scientific validity, since some critical reports cite thermography's lack of "peer acceptance,"[23] stating that thermography "does not appear to have achieved universal clinical acceptability."[8] In a usage poll of orthopedic surgeons, Ash[38] reported that only 2% of 316 responders used thermography and found it helpful. The design and interpretation of this survey, conducted by an openly avowed courtroom opponent of thermography, have been analyzed and criticized by a distinguished statistician.[40]

That thermography is not as widely utilized as other diagnostic procedures does not detract from its clinical utility. "Universal" acceptance has nothing to do with scientific validity. The lowly graduated thermometer was not accepted as a useful medical device until 200 years after its development.[41]

The medical community tends to be a conservative, skeptical group. Experience has been that as physicians see how thermographic studies are helpful in the evaluation of troublesome patients, particularly those with RSD, they are more likely to refer those patients for consultation. Furthermore, at the academic level, thermography laboratories have been established at several institutions, such as the Johns Hopkins University School of Medicine, Georgetown University School of Medicine, Albert Einstein College of Medicine, the University of Minnesota School of Medicine, Mt. Sinai School of Medicine, Texas Tech University, and the University of Nevada School of Medicine. Clearly, these academic laboratories demonstrate a certain level of peer acceptance.

Contradictory Statements

Curiously, contradictory statements are widespread in the technological assessments of thermography. The body of the OHTA report,[8] for example, cites many papers indicating the sensitivity, specificity, and predictive value of thermography. However, the abstract states that "thermography lacks sensitivity, specificity or predictive value." The same report discusses at length the significance of thermography in the diagnosis and management of RSD. However, again, the abstract states that "unassailable data are lacking to indicate that thermography provides a useful guide to monitor the effect of treatment of any disease entity." Reading these statements, it is difficult to believe that both parts of the report were written by the same person.

Similar observations are possible about the AAN report." The statement that "thermography is useful in neurologic practice" is at odds with the later conclusion that "thermography is of limited value." Also in the same report, statements are made that "EMG and thermography may reveal . . . root or nerve abnormalities" and that "knowing that radiculopathy is present is helpful in diagnosis and treatment." Further on, the statement is made that "thermography may provide characterizing information in those cases in which it would be helpful to know whether nerve root or segmental nerve is or is not affected and confirmation of involvement is needed." However, the same report concludes that it "does not support the use of thermography as a screening test for patients with neck or back pain" and that thermography "has not been shown to provide sufficient reliable characterizing information . . . to accept it as a proven evaluative procedure for the clinical diagnosis or characterization of . . . neck or back pain and/or cervical, thoracic, or lumbosacral radiculopathy." These inconsistencies and contradictions are difficult to understand.

Political Pressures

Political pressures and influences permeate all aspects of human existence as different factions and opinions strive to prevail. Thermography is not immune to these influences, and, unfortunately, political pressure has had a negative effect upon thermography. This is evident in the technological assessments of thermography by specialty organizations. For example, a favorable evaluation by a distinguished society of neurosurgeons[42] was withdrawn in response to a request from opponents of thermography within a prominent neurological society. Furthermore, an article not supporting the use of thermography in nerve entrapment syndromes[36] published in Neurology, the journal of the American Academy of Neurology, was issued accompanied by a press release.[43] In addition, the paper was presented as the lead article and as an "Expedited Publication," a distinction that would be expected only with a truly noteworthy report, such as a cure for Alzheimer's Disease. In fact, during the years that I have belonged to the MN, I can recall only a few "expedited publications."

In a recent private discussion, a prominent academic neurologist further demonstrated to me the insidious effect of political pressures. The neurologist indicated that he found thermography interesting and would like to pursue it, but he feared that if he did, it would harm his academic position and aspirations.

My experience as a contributing panel member of the MN Therapeutics and Technology Assessment Subcommittee provided first-hand insight to the impact of negative political forces on an assessment of thermography. A statement was submitted by each neurologist on the panel, representing a wide spectrum of opinion on thermography. A consensus statement was then compiled reflecting those opinions as well as the literature. However, several consecutive drafts of the assessment were submitted for approval to the Practice Committee of the MN, each more negative than the preceding one. The MN had predetermined its position and was unwilling to accept the opinions of its own panel or the literature. The final report, which is to be published at this writing, was so unacceptable to me that I withdrew my name as a contributor.

Summary and Conclusions

In reviewing the various negative opinions and critical statements concerning thermography, several points become clear. First, more studies need to be published in the "mainstream" literature of our respective specialty journals. Much of the supportive literature has been confined to thermography journals, while our colleagues are reading negative reports in more widely distributed specialty journals. Second, influential political factors are seeking to undermine the clinical use of thermography. Finally, while some criticisms are offered because of genuine concerns, many are based upon a political agenda and prejudice.

Skepticism is vital to the process of scientific inquiry. We need to keep asking questions, modifying our concept as new facts and information develop. Certainly we do not have all the answers, but we do know that thermography has an important place in patient evaluation. Criticism supported by facts and data is welcome, but criticism based upon inaccurate statements, political motivation, and prejudice has no place in a climate of scientific inquiry and intellectual honesty.

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