CRPS/RSD: Diagnostic/Technical Advances in the Understanding of Autonomic Function

Venue

NYU Medical Center 550 First Avenue
New York, NY 10016

Target Audience

Physicians and allied health professionals who have an interest in the diagnosis and management of chronic pain

Course Description

The diagnosis and management of Reflex Sympathetic Dystrophy (RSD)/Complex Regional Pain Syndrome (CRPS), Rheumatological disorders, Vasomotor disorders, Thoracic Outlet Syndrome, Sports Injuries and Migraine headaches will be presented with an emphasis on the role of Computerized Infrared Imaging (CII) /Thermography.

Correlation with other modalities (MRI/EMG etc) will be presented as well as a discussion of how to set up a Thermography laboratory and associated costs. A diverse faculty with an expertise in pain management drawn from the fields of rehabilitation medicine, neurology and veterinary medicine will be presenting.

Statement of Need

Patients with chronic pain are often referred too late for successful treatment. Similarly, patients with RSD/CRPS are often diagnosed too late for successful rehabilitation. There is a need for practitioners to better understand the role of CII/Thermography as a diagnostic tool in the evaluation of chronic pain, and, specifically, to better understand how such technology can be used in making an early diagnosis of RSD/CRPS. The American Academy of Thermology recognizes a current and ongoing need for practitioners to understand that CII is the only non-invasive technology available to image and map disorders of thermoregulation.

Learning Objectives

Utilize Computerized Infrared Imaging (CII) to effectively diagnosis and manage chronic pain in order to improve patient outcomes

Employ CII to make an early diagnosis of RSD/CRPS in patients to allow for prompt rehabilitation

Apply CII to properly diagnose patients with migraine headaches so they can begin appropriate treatment.

Agenda

8:00 am Registration and Continenal Breakfast

8:50Introduction The Power, Beauty and Vision of Thermography .- Mathew H. M. Lee, M.D., M.P.H.

9:00Thermography-Introduction, History and Represen tative Cases- Jeffrey M. Cohen, MD Course Director

9:15 AAT Guidelines for Neuro-musculoskeletal Thermography - Robert Schwartz, MD

10:00 Infrared Thermographic Vasomotor Mapping and Differential Diagnosis - Robert G. Schwartz, MD

10:45 Coffee Break

11:05Thermograpgy in Migraine Headaches and Trigeminal Neuralgia - Srini Govindan, MD

11:35 Thermography and Chronic Regional Pain Syndrome Bryan O'Young, MD

12:05 Q & A Round Table

12:20 Lunch

1:20 Stress Thermography-Functional Cold H_2O Autonomic Challenge Testing- Timothy Conwell, DC

2:05Thermographic Evaluation of Neurovascular System Ram Purohit, DVM, PhD, DACT

2:50 Coffee Break

3:05 Practical Issues in the Establishment of A Clinical Thermology Facility - Philip P. Hoekstra, III, PhD

3:35Advancements in medical IR high sensitivity applications:fusion IR imaging and 3D IR/MRI softwares - Marcos Brioschi, MD

4:10Q & A Round Table

4:30 pm Adjournment

Faculty

NYU Faculty

Jeffrey M. Cohen, MD
Clinical Associate Professor of Rehabilitation Medicine
Department of Rehabilitation Medicine
New York University School of Medicine
Medical Director
Kathryn Walter Stein Chronic Pain Laboratory
Rusk Institute of Rehabilitation Medicine

Mathew H. M. Lee, MD
Howard A. Rusk Professor of Rehabilitation Medicine
Chairman, Department of Rehabilitation Medicine
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Bryan O'Young, MD
Clinical Associate Professor of Rehabilitation Medicine
Department of Rehabilitation Medicine
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Guest Faculty

Marcos Brioschi, MD
Pain Center. Department of Neurology. University of Sao Paolo Medical School. Sao Paolo, Brazil

Timothy Conwell, DC
Director, Colorado Infrared Imaging Center
Denver Colorado

Srini Govindan, MD
Neurologist, Neuropathologist and Nuclear Medicine
Department of Neurology, West Virginia University School of Medicine.Wheeling, West Virginia

Philip P. Hoekstra, III, PhD
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Professor Emeritus
Department of Clinical Sciences
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Auburn, Alabama

Robert G. Schwartz, MD
Medical Director,
Physical Medicine & Rehabilitation
St. Francis Community Hospital
Director, Piedmont Physical Medicine and Rehabilitation
Greenville, South Carolina

Abstracts

HISTORY OF THERMOGRAPHY, CLINICAL INDICATIONS FOR THERMOGRAPHY AND REPRESENTATIVE CASES FROM THE RUSK INSTITIUTE OF REHABILITATION

Jeffrey Cohen
Department of Rehabilitation Medicine,
New York University School of Medicine

The history of thermography begins in antiquity. An overview of the clinical use of temperature measurement for patient care will be presented. This talk will date from the twenty-ninth century B.C. in which the Egyptians used the scanning capacity of their fingers to determine heat to the present day computerized infrared imaging systems. Next, an overview of the role of thermography in the evaluation of common musculoskeletal, neurological and vascular conditions will be presented. This will be based upon a review of the literature and highlight clinical areas where thermography is felt to be a valuable diagnostic tool and those areas where it is not recommended. Finally, three representative cases from the Rusk Institute of Rehabilitation Medicine's Kathryn Walter Stein Chronic Pain Laboratory will be presented.

AAT GUIDELINES FOR NEURO-MUSCULOSKELETAL THERMOGRAPHY

Robert G. Schwartz

Piedmont Physical Medicine and Rehabilitation Greenville, South Carolina

Infrared thermography of the extremities and spine is performed to provide an overview of the location, extent and severity of vasomotor abnormality. The thermographic evaluation can be performed from the cranium to the base of the spine (inclusive of all segments) and torso to the extremities, extended to the fingers and toes.

The guideline was prepared by members of the American Academy of Thermology (AAT) as a guide to aid the neuro-muscular thermologist and other interested parties. It implies a consensus of those substantially concerned with its scope and provisions. The guideline shows the following 7 chapters:

1. Patient Communication and Preparation

2..Patient Assessment

3.Examination Guidelines

4.Review of The Infrared Thermography Examination

5.Presentation Of Exam Findings

6. Exam Time Recommendations

7.Continuing Professional Education

INFRARED THERMOGRAPHIC VASOMOTOR MAPPING AND DIFFERENTIAL DIAGNOSIS

Robert G. Schwartz

Piedmont Physical Medicine and Rehabilitation Greenville, South Carolina

When performed with proper technique and under controlled conditions, thermography (Computerized Infrared Imaging or CII) is the test of choice for mapping of vasomotor instability and asymmetry. The findings provide important clinical insights into those structures that generate aberrant sympathetic responses for pain syndromes such as Reflex Sympathetic Dystrophy (RSD), Complex Regional Pain Syndrome types I and II (CRPS), Thoracic Outlet Syndrome (TOS), Cervical Brachial Syndrome, Fibromyalgia, and Barre- Lieou. In addition, the presence of abnormalities and the distribution of findings can be invaluable in differential diagnosis of these conditions.

The medical community has demonstrated increased awareness of sympathetic pain syndromes over the last decade. New interventions and approaches toward alleviating symptoms in those afflicted have been tried, some with success. Even better results can be achieved through a greater understanding of which structure is initially responsible for generating the condition.

THERMOGRAPHY IN MIGRAINE HEADACHES AND TRIGEMINAL NEURALGIA.

Srini Govindan

Department of Neurology, West Virginia University School of Medicine.Wheeling, West Virginia

The Presentation will focus on Imaging Extracranial / Facial blood flow in Migraine Headaches and Trigeminal Neuralgia, under 1) Anatomy, Functional/ Physiological, 2) Angiosomes, 3) Referred pain and trigeminal neurovascular control. 4) Thermography and Extracranial blood flow Criteria for Trigeminal/ Facial blood flow imaging, 5) Extracranial vascular receptors, 6) Pathophysiology, 7) Protocal for Migraine and Facial Neuralgia, 8) Clinical case Presentations, 9) Future Applications.

1) Anatomy/ Functional, Physiological.
Correlating thermography images clinically, allows us to incor-

porate in the words of Michael Salmon, functional anatomy (the internal and external carotid territory angiosomes) with physiologic anatomy (clinical state dependent activation of perivascularly located mast cells and its neurosensitizing and vasoactive mast cell mediators).

2) Angiosomes

The basic anatomy of the cutaneous vessels, coupled with an appreciation of the factors that influence its structure in different regions of the body has clinical application in correlating thermography findings. The works of Manchot, Salmon and Taylor helps us to understand the blood supply to the skin and the underlying deep tissues and segregate the body anatomically in to three-dimensional vascular territories that are named "angiosomes". Forty angiosomes have been described, which can be subdivided further into smaller composite units. Forehead-Nose Thermal Ratio is based on Angiosomes. In the words of Michael Salmon, between anatomy and physiology there in room for functional anatomy, for a physiologic anatomy. Uematsu and Goodman have documented skin temperature symmetry and asymmetry, physiologic anatomy, which along with mast cell heterogenicity/ function will form a basis for using angiosomes in interpretation of thermograms, in the context of functional anatomy to image/ correlate thermal patterns of angiosomes during dysfunction, physiologic anatomy, focal/ regional or systemic.

3) Referred pain and trigeminal neurovascular control.

The pain from cephalic vasculature is referred to superficial or surface structures such as skin and underlying tissue mediated through the trigeminovascular system.

4) Thermography and Extracranial blood flow Criteria for Trigeminal/ Facial blood flow imaging,

Imaging the extracranial blood flow using dynamic thermography testing meets the extracranial microcirculation measurement criteria by its ability to 1) Image and monitor the primary vasoactive response of the individual, based on pre-existing vasomotor tone/ the vasomotor capacitance of the individual. 2) Evaluate the biological limit of vasomotion, i.e, Vasoconstriction/Vasodilation,3) Provide the methodology to document the effect of agonistic and antagonistic drugs on the extracranial blood flow/ vasomotion under the regional control of trigeminovascular system, 4) Help to understand the control processes that may occur in response to dynamic conditions by using a protocol involving changing rather than static conditions such as superimposed vasomotor and pharmacological challenges, and 5) Visualize blood flow changes in real time. The dynamic nature of extracranial vasomotion appears to be predictable within the physiological limits of vasoconstriction and vasodilation.

5) Extracranial vascular receptors:

Extracranial vascular receptors react differently to vasomotor stress. Clinical case studies also indicate differences in the vaso-re active properties of the external carotid artery in humans. Different vasoactive properties of the extracranial vascular receptors may have a role in its capacity to alter extracranial flow independent of the metabolism by microcirculation arteriovenous shunting.

6) Pathophysiology:

Cranial microcirculation is under the trigeminal neurovascular control. The rich innervation of the vasculature and meninges of the brain provides a dense plexus of mainly unmyelinated fibers that arise from the trigeminal ganglion and to a lesser extent the upper cervical dorsal roots. The pharmacology of the trigeminovascular system is complex. The peripheral branch consisting of the cranial circulation and dura mater receives sympathetic, parasympathetic, and sensory nerve fibers, all containing their own characteristic neurotransmitters. Sympathetic nerve fibers arising from the superior cervical ganglion supply the cranial vasculature with neuropeptide Y (NPY), noradrenaline (NA), and adenosine triphosphate (ATP). Parasympathetic nerve fibers arising from the sphenopalatine and otic ganglia as well as carotid miniganglia, supply the cranial vasculature with vasoactive intestinal peptide (VIP), peptide histidine isoleucine (PHI), Acetylcholinesterase (AChE), peptide histidine methionine 27 (PHM, human version), pituitary cyclase-activating peptide (PACAP), and other VIP-related peptides. Sensory nerve fibers arising from the trigeminal ganglia supply the cranial vasculature with substance P (SP), calcitonin gene-related peptide (CGRP), neurokinin A (NKA), and PACAP. Bipolar trigeminovascular afferents innervating the cranial structures project centrally and synapse on second order neurons in the trigeminal nucleus caudalis (TNC), which is the key relay center for transmission of information to higher brain structures.

7) Protocal for Migraine and Facial Neuralgia,

Should be based on symptomatic or asymptomatic, in remission/ exacerbation, effect of other vasoactive drugs, type of administration, oral/ nasal spray/ subcutaneous or transdermal, half life of neuropeptide implicated in the pathophysiology, site action of the drug, presynaptic/ post synaptic or smooth muscle.

THERMOGRAPHY AND COMPLEX REGIONAL PAIN SYNDROME

Bryan O'Young, Jeffrey Cohen

New York University School of Medicine

During the last 2 decades, there has been an expanding role for the use of thermography in the diagnosis of Complex Regional Pain Syndrome (CRPS). As pain management becomes an important part of the clinician's role and as CRPS has often been an elusive diagnosis, there is an increased recognition and appreciation of thermography. The session will review the important role of thermography for the diagnosis of patients with CRPS and in the facilitation of its treatment. The session begins with the discussion of the general principles relative to CRPS and its diagnosis. This is followed by a review of the common diagnostic tools used in confirming CRPS. The session concludes with a series of case studies reviewing the role of thermography in diagnosing and facilitating the management of CRPS.

THE ROLE OF COLD WATER AUTONOMIC FUNCTIONAL STRESS TESTING IN THE EVALUATION OF PATIENTS WITH PRESUMPTIVE CRPS-1

Timothy D. Conwell, DC

Colorado Infrared Imaging Center, Denver, Colorado

Complex Regional Pain Syndrome Type 1 (CRPS-1) is a clinical diagnosis based on IASP criteria describing signs and symptoms of the disease. Internal and external validation research suggests problems with over diagnosis using the IASP criteria. Cold water autonomic functional stress testing is helpful in evaluating the function of the ANS vasoconstrictor reflex in patients with presumptive CRPS-I. Cold water autonomic functional stress testing is performed by utilizing dynamic subtraction imaging software that is available on most medical IR programs. Real-subtraction imaging is achieved by choosing a starting reference image, then choosing to view only the differences from the re -ference to the current image. If the individual pixel temperature rises, the difference will be shown in color; if the temperature drops, the image will be displayed in shades of gray. All thermal data have a dynamic range of 12 bits enabling the user to view .05-degree difference in a 0-50 ^{o} C temperature range. ANS stress testing is performed by imaging the symptomatic and contra-l ateral asymptomatic distal extremity for five minutes while an

asymptomatic limb is placed in a 12-16° C cold-water bath. The immersion of a non-involved limb activates autonomic thermoregulatory function. If autonomic function is intact, there is vasoconstriction in all four extremities due to the central vasoconstrictor reflex. If the autonomic vasoconstrictor reflex is inhibited or there is autonomic failure, then an axon vasodilatation reflex will occur. This reflex will be visualized by a warming of the symptomatic distal extremity, and on occasion the bilateral asymptomatic distal extremity, during the five-minute cold-water autonomic functional stress test. In normal healthy asymptomatic patients or posttraumatic patients with limb pain without CRPS-1 the ANS vasoconstrictor reflex is intact with the expected cooling of the distal extremities when a non-involved extremity is placed in a cold-water bath. Evaluating the function of the vasoconstrictor reflex through cold water autonomic functional stress testing provides an objective method that increases the sensitivity and specificity of evaluating patients with presumptive CRPS-1.

THERMOGRAPHIC EVALUATION OF NEUROVASCULAR SYSTEM

Ram C. Purohit [1, 2]

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The purpose of this study is to present clinical uses of thermography in the diagnosis of neurovascular conditions in various animal species. Cutaneous circulation is under sympathetic vasomotor control. Thus, the nerve injuries and nerve compression can result in skin surface vascular changes that can be detected thermographically. Inflammation and nerve irritation may result in vasoconstriction, causing cooler thermal patterns in the affected areas. Whereas transaction of a nerve and /or damage to the extent that there is a loss of sympathetic tone, which causes vasodilation can provide warmer thermal patterns in the affected areas. This rational becomes more complicated with different types of nerve injuries, and the duration of injuries. Biphasic changes in peripheral circulation of affected areas occurs, depending on the duration and extent of the injuries.

Painful conditions associated with peripheral neurovascular and neuromuscular injuries are easy to confuse with spinal injuries associated with cervical, thoracic, and lumbosacral areas. Similarly, inflammatory conditions such as osteoarthritis, tendonitis and other associated conditions may be confused with other neurovascular conditions. Thus several studies were done by Purohit et.al, (1-5) which have demonstrated the efficacy of infrared thermography in the differential diagnosis of neuro-va scular conditions.

References

1. Purohit RC, McCoy MD. Thermography in the diagnosis of inflammatory processes in the horse. Am, J. Vet. Res., 1980; 41: 1167-1174.

2. Purohit RC, DeFranco B. Infrared thermography for determination of cervical dermatome patterns in the horse. Biomed. Thermology 1995; 15: 213-215.

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4. Purohit RC. History and research review of thermography in veterinary medicine at Auburn University. Thermology International. 2007; 17(4): 127-132.

5. Purohit RC. Use of Infrared Imaging in Veterinary Medicine. Biomedical Engineering Hand Book, 3rd Edition. Edited by JD Bronzino, Pub. CRC Taylor & Francis 2006: 35 (1-8).

PRACTICAL ISSUES IN THE ESTABLISHMENT OF A CLINICAL THERMOLOGY FACILITY

Philip P. Hoekstra, III, Ph.D.

Abnormalities in the patterns, emission levels and behavior of skin temperatures provides a practical adjunctive technique in the assessment of many peripheral neuropathies. While certain ambient conditions must be controlled, patient preparation is minimal and a variety of modern thermographs provide an ready assessment of many significant peripheral neuropathies. Establishing an imaging laboratory may only require a few modifications to an existing facility and selecting equipment, software and technique commensurate with the specific application. Adequate training of a technician and the thermologist is essential to the successful application of neurologic thermology.

ADVANCEMENTS IN MEDICAL IR HIGH SENSITIVITY APPLICATIONS: FUSION IR IMAGING AND 3D IR-MRI/TC SOFTWARE.

Marcos Leal Brioschi, PhD. MD

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InfraredMed Clinics - www.infraredmed.org

The measurement of temperature variation at the surface of the body, provided by high sensitivity infrared imaging (IR), is becoming a valuable auxiliary tool for diagnosis and investigation of functional changes of the skin by accurate thermal mapping of static and provoced vasomotor patterns. These neurovascular dysfunctions may be caused by breast and thyroid tumors, reflex sympathetic dystrophy/complex regional pain syndrome, thoracic outlet syndrome, cerebral and peripheral vasomotor disorders, rheumatological disorders, fibromyalgia syndrome, sports injuries, headaches and also during cardiac bypass surgery.

Most of these diseases are characterised by particular or related anatomical changes, but as a 2D technique IR does not provide sufficient anatomical information to differentiate in cases with unclear anatomical background. However, multimodal image registration and fusion with anatomical imaging, as magnetic resonance (MRI) or computer tomography (CT), may overcome this difficulty and provide additional information for diagnosis. Combining anatomical and physiological information into one image dataset may ease the clinical analysis and decision.

In this paper, a new method of registering and merging 2D IR and 3D MRI/CT is presented. Registration of the images acquired from the two modalities is necessary since they are acquired with different imaging systems. Firstly, the body volume of interest is scanned by a MRI/CT system and a set of 2D IR of the same body is acquired at orthogonal angles. Registration of these two different sets of images is achieved by creating 2D MRI/CT projections from the reconstructed 3D MRI/CT volume and alignment with the IR. Once registered, the IR is then projected over the 3D MRI/CT. After the 3D reconstruction, the user can rotate the object in any direction (3 axes - x, y and z - in the clockwise and anticlockwise directions). Slicing of the image, scaling (increase and decrease of the image) and transparency voxels function become possible. The software has been validated using seventeen sets of medical images from different modalities (MRI/CT). The data obtained by merging both imaging techniques, allows the determination of the extent of anatomic and physiological compromise separately, thus leading to a better and more adequate disease approach. The programme developed to assess the proposed method to combine MRI/CT and IR resulted in a new tool for fusing two different image modalities. Such a tool may help medical doctors to understand the anatomical and physiological background of diseases in a single imaging process.