

Infrared Thermal Imaging As A Tool In Pain Management -An 11 Year Study.

Part II: Clinical Applications

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Summary

ITI is a neurophysiological tool providing diagnostic and therapeutic information in patients suffering from neuropathic pain with neurovascular involvement. This information cannot be obtained from anatomical tests (e.g., MRI or CT).

Bales Scientific Thermal Processor (Bales Scientific, Walnut Creek, CA)(762 patients) and Agema Cameras (Flir)(2,503 patients) were used for this study of 3,265 successive patients. A review of our experience with Infrared thermal imaging (ITI) and its role in pain management was conducted, and compared with the recent medical literature. The study was limited to the role of ITI in the management of chronic pain syndromes.

ITI is helpful in proper localization of hyperthermic foci due to iatrogenic permanent damage to thermosensory nerves, such as seen after repetitive sympathetic ganglion blocks; or due to sympathectomy or prolotherapy. As the result, the physician stays out of harms way by not causing further permanent damage. In addition, ITI identifies the spread of complex chronic pain syndrome (CRPS), pointing to the need for treatment of such spread. It helps differentiate migraine from neuropathic occipital neuralgia - two diseases requiring to contrasting treatments.

ITI has not been proven useful in evaluation of cervical and lumbar radiculopathies, stroke, and transient ischemic attacks. ITI can differentiate cervicogenic headaches from migraine. ITI is a useful prognosticator for diabetic foot pain, sparing some patients from amputation. ITI can spare patients from unnecessary carpal tunnel, spinal disc, and TMJ surgeries by identifying the original source of neuropathic pain. If ITI shows diffuse hyperthermia in the extremity already treated with repeated sympathetic ganglion blocks (virtual sympathectomy), such patients should be spared from undergoing further ganglion blocks. The hypothermic extremity after sympathectomy proves the futility of this and other ablative treatments such as chemical sympathectomy, or neurolytic blocks.

Key Words - CRPS, Headache, Sympathectomy, Thermography

Infrarotthermographie als Hilfsmittel im Schmerzmanagement-in 11 Jahres Studie, 2.Teil:Der klinische Einsatz der Infrarotthermographie

Die Infrarotthermographie liefert als neurophysiologische Untersuchungsmethode diagnostische und therapeutische Informationen über Patienten, die an neuropathischem Schmerz mit neurovaskulärer Begleitsymptomatik leiden. Diese Information kann durch keinen anatomischen Test (z.B.NMRI, Ct) zur Verfügung gestellt werden.

Ein Bales Scientific Thermal Processor (Bales Scientific, Walnut Creek, CA)(762 Patienten) und Agema (Flir)Kameras (2,503 Patienten) wurden in dieser Untersuchung an 3265 aufeinander folgenden Patienten verwendet. Ein Überblick über unsere Erfahrungen mit der Infrarotthermographie wird gegeben und der rezenten medizinischen Literatur zu diesem Thema gegenüber gestellt. Die Untersuchung wurde auf die Bedeutung der Infrarotthermographie im Management von Schmerzpatienten beschränkt. Die Infrarotthermographie hilft in der Entdeckung hyperthermer Zonen, die durch wiederholte iatrogene Schädigung der thermosensiblen Nervenfasern entstehen und die bei wiederholten Sympathikusblockaden, Sympathektomie oder therapeutischer Gewebe-Sklerosierung vorkommen. Durch solche Veränderungen gewarnt,

warnen, kann der Arzt weitere Schädigungen vermeiden. Die Infrarotthermographie kann die weitere Ausbreitung Schädigungen vermeiden. Die Infrarotthermographie kann die weitere Ausbreitung eines komplexen chronischen Schmerzsyndroms (CRPS) anzeigen und auf eine notwendige Therapie dieser Ausbreitung hinweisen. Die Infrarot-Technik kann auch für die Differenzierung zwischen Migräne und neuropathischer Okzipitalneuralgie hilfreich sein, zumal diese Krankheitsbilder völlig unterschiedliche Behandlungen benötigen.

Die Infrarotthermographie ist wenig brauchbar in der Beurteilung von zervikalen oder lumbalen Radikulopathien, von Schlaganfall oder transitorischen ischämischen Attacken. Man kann aber mit ihrer Hilfe cervikogenen Kopfschmerz von der Migräne unterscheiden. Die Infrarotthermographie hat prognostische Bedeutung bei Fußschmerzen von Diabetikern, und hat so manchen Patienten eine Amputation erspart. Ebenso können auf Grund von Infrarotbildern nicht notwendige Operationen wegen eines Karpaltunnelsyndroms, einer Bandscheibe oder chirurgische Eingriffe im Kieferbereich vermieden werden, da die Ursache eine neuropathischen Schmerzgeschehens eindeutig gefunden werden kann. Wenn die Infrarotthermographie eine diffuse Hyperthermie bei Patienten nach wiederholten Sympathikusblockaden zeigt, sind weitere Blockaden nicht mehr angezeigt. Eine hypotherme Extremität nach Sympathektomie beweist die Entbehrlichkeit dieser und anderer destrukturierender Behandlungen wie z.B. die chemische Sympathektomie oder Nervenblockaden.

Schlüsselwörter - CRPS, Kopfschmerz, Sympathektomie, Thermographie

The Role of ITI in Selection of Nerve Blocks

ITI provides indispensable information which guides the physician to stay out of harms way, and to prevent iatrogenic trauma. One example is the role of ITI in selection of proper nerve block modality. Traditionally, the nerve block of choice in CRPS has been stellate ganglion nerve blocks. After more than a dozen stellate, or lumbar ganglion nerve blocks, the repetitive needle insertion traumatizes the ganglion enough to result in permanent hyperthermia in the extremity "Virtual Sympathectomy" (1). In such patients, ITI of the extremity shows permanent hyperthermia in face of no pain relief. Kozin, in his review of 500 patients treated with sympathetic ganglion blocks, reported "the majority of patients have transient or no significant pain relief" (2). Another meta-analysis of retrospective and prospective randomized controlled trials of 1144 patients revealed the local anaesthetic sympathetic blockade was as ineffective as placebo in treatment of CRPS (3).

Outcome: ITI identified the "virtual sympathectomy" phenomenon, and spared the patients from further damage by canceling the procedure (1) (Table 1). Repetitive ganglion nerve blocks are routinely applied for diagnosis (4) and treatment of neuropathic pain such as complex regional pain syndrome (CRPS). However, Hogan et al (5), have reported only 27% of stellate ganglion block achieved the goal of ipsilateral warming to exceed the contralateral skin temperature. This 27% success is not worth the traumatic complications of ganglion blockade.

Moreover, they noted (5) that cervical paratracheal blocks frequently failed to produce evidence of sympathetic interruption to the arm. The sympathetic ganglion blockade done in peripheral occlusive vascular disease or CRPS maybe potentially dangerous and harmful (1, 2,3,6)

Sympathectomy

The sympathectomy results in partial hyperthermia, with compensatory contralateral extremity hypothermia, this result in the spread of pain in the contralateral extremity. Out of desperation, sympathectomy has been applied for treatment of causalgia since 1916 (7). The literature review of sympathectomy literature for treatment of CRPS shows high rates of failure. Welch et al (8) showed 13% successful results of sympathectomy in 8.4 years of long term follow-up. In contrast, Jebara and Saade, on their short-term sympathectomy follow-up of 26-60 days among teenage soldiers showed very good results (9). Obviously, ablation surgery provides temporary palliative relief. The rest of the literature review shows random follow-ups and results (10). The high percentage group has been wartime soldiers which have been diagnosed early, undergone surgery within a few days, and sent home to be lost to follow-up (10-31). Realizing that children and teenagers (such as soldiers), show a strong plasticity and healing power as compared to adults (32,33), and realizing that early diagnosis and treatment is more successful (34,35), explain the beneficial, albeit temporary, results of wartime sympathectomy. In contrast, the

Table 1
The influence of treatment on CRPS stages during 2 years or longer follow-up in 824 patients. Amputation or sympathectomy deteriorate the disease from stage I to stage III.

Characteristics of treatment (824 patients)	Stage I **** number of patients	Stage II number of patients	Stage III number of patients
History of Amputation * 11 Patients (1.3%)	0 (0%)	2 (19%)	9 (81%) (P=0.025)
Chemical Sympathectomy 13 Patients (1.5%)	0 (0%)	2 (15.4%)	11(84.6%)
Surgical Sympathectomy 22 Patients (2.6%)	0 (0%)	3 (13.6%)	19 (86.4%)
Surgical Treatment ** 295 Patients (36%)	24 (8%)	106(36%)	165 (56%) (P<0.001)

(*) Many patients had more than one treatment modality which change the total percentage.

(**) Sympathectomy; rotator cuff; thoracic out syndrome; compression neuropathy; exploration; etc.

(***) Stage I = Dysfunction; Stage II= Dystrophy; Stage III= Atrophy.

(****) According to the type of treatment stage III may reverse to stage I and vice-versa.

Table 1A. Surgical and Non-Surgical Group

	Stage I	Stage II	Stage III
Surgical Group 320Patients	24.7% 79 Patients	33.13% 106 Patients	59.8%* 135 Patients
Non - Surgical Group 528 Patients	31% 164 Patients	36% 190 Patients	33% 174 Patients

* Note high percentage of stage III in the surgical group

sympathectomy done in stage III CRPS (Table1) has been reported to show zero percent relief (36). Usually, by the time the physician resorts to the sympathectomy procedure, the patient is in advanced stages of the disease. In such late stages, the nervous system has lost its plasticity and cannot respond properly to surgical sympathectomy (37,38). More over, the disease spreads (1,37,39-44) to other parts of the body; hence a regional sympathectomy will not be of any benefit to the patient.

Outcome: ITI showed failure of sympathectomy to relieve the vascular dysfunction Thermal imaging done in patients who underwent surgical or chemical sympathectomy showed a high percentage of surgical failure(45,46).

Prolotherapy and Articular Facet Blocks

Articular facet joint blocks and prolotherapy (injection of sclerotic agents to ligament surrounding the joints) act as new sources of trauma and pain originating from the injured vertebral facet joint. In contrast, spinal epidural and paravertebral blocks do not cause chemical (sclerotic) damage due to injection of hyper-

tonic glucose or phenol as in the case with prolotherapy. These blocks should not be mistaken for articular facet injections. The facet injections should be avoided to prevent harmful facet joint damage. According to Cheema (47), paravertebral nerve block provides effective pain relief for both sympathetically maintained pain and sympathetically independent pain. This is in contrast to articular facet (zygoapophyseal) blocks which are fraught with painful joint injuries (due to needle traumatizing

Table 2
Stages of CRPS

Stage I:

Dysfunction: with thermal changes, neuroinflammation, neurovascular instability, neuropathic pain, vasomotor and flexion spasm

Stage II:

Dystrophy: hair, nail, and skin trophic changes; bouts of hair loss, alopecia, skin rash, spontaneous subcutaneous bleeding, ulcerative lesions, edema, and entrapment neuropathy

Stage III:

Atrophy:as well as fluctuating vital signs, visceral neuroinflammation, chest pain, neurovascular instability.

the joint). Bogduk et al (48) have reported only 40% pain relief from radiofrequency treatment of the facet joints. The same applies to prolotherapy which is done by injection of sclerosing agents (such as phenol) into the ligaments surrounding articular facet joints.

Outcome: Thirty-six patients had undergone Prolotherapy before they were referred to our Clinic. ITI showed focal hyperthermia in the

area of Prolotherapy. None had effective long-term relief from this prolotherapy.

Distal Extremity Needle Insertion

In the area of original nerve damage, the hyperthermia points to damage and paralysis of vasoconstrictive function of sympathetic system (1) The hyperthermia area surrounded by hypothermia usually points to the apex of damaged ther-

Table 3. Neurophysiologic tests for neuropathic pain and somatic pain.

Tests	Somatic	Sympathetic	Para-Sympathetic	Nerve Fiber Type	Clinical application	Limitations	Advantages
EMG; NCV	+			Somatic, myelinated nerves	Study of efferent spinothalamic nerves	It cannot study the thermoreceptor or vasomotor function	Neuro-muscular and myelinated somatic nerve study
Infrared Thermal Imaging (ITI)		+		Micro-vascular and C-thermoreceptors	Sympathetic function	Shows old and new pathologies indiscriminately	A total body regional study
Laser Evoked Potential (LEP)		+		Poorly myelinated C-fibres; A δ	Study of peripheral and central neuropathic pain	Mainly research	Study of C, A β and A δ fibres
Microneurography (MCNG)		+		Post ganglionic sympathetic efferent C-fibres	Research on sympathetic efferents	Invasive, time taking, and painful	A research tool
Quantitative Sensory Test (QST)		+		C-thermoreceptors vs spinothalamic tactile nerves	Accurate test for thermoreceptors vs tactile somatosensory nerves	Studies a limited area	Sensitive study of C-thermoreceptors vs somatic fibres
Quantitative Sudomotor Axon Reflex Test (QSART)			+	Para-sympathetic; cholinergic, sudomotor nerves	Sweat function	Studies a Limited area. It cannot study the thermal function	Sudomotor function
Somatosensory Evoked Potential (SSEP)	+			Somatosensory nerve fibres	Identifies sensory nerve tracks	Not an autonomic test	Harmless
Scintigraphic Triphasic Bone Scan (SBS)	+			Deep chemoreceptors fibres	Informative in early stages	Only diagnostic in 25-55% of patients	Harmless

mosensory nerve resulting in heat leakage, as well as accumulation of substance P (49-51), and nitric oxide(52,53). This is an important therapeutic clue to help avoiding further trauma. Traumatic procedures such as surgical exploration, nerve blocks, botulinum toxin injection, capsaicin, or EMG needle insertion should not be applied to the damaged hyperthermic area in the extremity which may lead to further damage and aggravation of the condition (54-56).

Amputation

If at all possible, amputation should be avoided (57). All 11 painful amputee patients in our series (Table 1) who were referred to us after they had undergone amputation showed marked deterioration post-op. The surgical stump was the source of multiple neuromas with severe causalgic and ephaptic (11) CRPS II type of intractable pain. Amputation changed the CRPS from type I to type II by forming innumerable neuromas and nerve impingements in the surgical stump. Amputation should be avoided by all means due to its side effects of aggravation of pain and tendency for spread of CRPS. Dielissen et al (58) reported the results of amputation in 28 RSD patients who had undergone 34 amputations in 31 limbs. Only 2 of 28 patients reported partial pain relief. In 26 of 28 patients, stump involvement with RSD made it impossible to wear a prosthesis (57). ITI can identify the proper level of the extremity undergoing amputation (59). This spares the patient from losing any excess tissue in the amputee stump (59).

Outcome: ITI provided information that prevented amputation in 5 of 6 patients referred to us for evaluation and for consideration of amputation. Of the 5 patients, 4 showed enough warmth and intact circulation to prevent amputation. The 5th patient was found to suffer from diabetic neuropathy with multiple pathologic right foot fractures aggravated by 2 years of non-weight bearing. Under proper analgesia, the patient was instructed to start weight bearing. After 3 months, the fractures healed enough to avoid the necessity for amputation.

Neck and Back Pain

The 1970's and 1980's literature reflects confusing reports on diagnostic value of ITI in cervical and lumbar radiculopathies, back pain, disc herniation, and sciatica (54,56,60-66).

More recent literature has reported that ITI has no consistent diagnostic value for the neck and back injuries (67-71). One reason may be the inconsistent delta-T measured by liquid crystal contact thermography (72) making it difficult to arrive at accurate "normal" values.

In the present study, the ITI done in patients suffering from failed spine, neck or back pain, and pain in the extremities revealed conflicting results - especially when compared with the thermal imaging tests done on the same patients in other laboratories. The confusion has its roots in technical limitations, and improper clinical applications of the test(67,68). Harper (73) and Chafetz (74) have successively reported 56% and 40% abnormal ITI of spine in the "normal" controls. In our daily lives, the spine undergoes minor injuries. Such preexisting minor injuries may show persistent minor abnormalities on ITI, contaminating the control studies. Lack of a consistent control standard handicaps the value of ITI in diagnosis of spine pathology. There have been repeated attempts to compare the physiological test of ITI with anatomical tests such as MRI and CT (75). This is an illogical comparison. ITI cannot be expected to diagnose disc herniation because disc bulging and herniation cannot be clearly represented on ITI. Conversely, MRI cannot be expected to identify micro-neurosensory pathology.

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Complex Regional Pain Syndrome (CRPS, RSD)

ITI can facilitate early diagnosis of Complex Regional Pain Syndrome (CRPS) (76), and can achieve a higher recovery rate among CRPS patients (10,11, 34,77) by virtue of early diagnosis of the disease. CRPS cannot be accurately diagnosed by a single test. CRPS is a clinical diagnosis when the following four principles are met:

1. Neuropathic, hyperpathic, or causalgic pain.
2. Vasomotor disturbance, flexor spasm, or tremor.

3. Inflammation at some point in the course of the disease.

4. Limbic system dysfunction in form of insomnia, agitation, depression, and poor memory (37,78).

Tests such as ITI are mainly helpful to obtain information regarding the nature and extent of the disease, and to guide the clinician in proper management of pain (11). ITI has the advantage of providing a comprehensive picture of the entire body temperature (79). In acute stage, the epicenter of the damaged area is usually hyperthermic (11,80). After a few weeks, the hyperthermic area shrinks. In some cases (80) the hyperthermia persists due to permanent damage to sympathetic nerve fibers (1). This is a harbinger of poor prognosis. The hypothermic area surrounding the hyperthermic epicenter of the damaged nerve reflects up-regulation and supersensitivity of sensory nerves to norepinephrine (81-84).

In chronic stages (85), the disease is manifested by a dysfunctional rather than an up-regulated sympathetic system (11,86-90). The neuro-vascular instability contributes to confusion and misunderstanding of ITI changes in CRPS. For example, spread of vasoconstriction to other extremities maybe mistaken for other diseases such as Raynauds Phenomenon (90). The ITI, like any other test, cannot be expected to show 100% diagnostic sensitivity. Even with the cold water stress ITI testing (76,89,91), it is sensitive in 93 % of the patients, specific in 89 %, positive predictive value (PPV) of 90%, and negative predictive value (NPV) of 94% (76). Recently, Herrick et al (90), have found cold stress ITI useful to diagnose patients suffering from fracture who are at risk for CRPS.

Other diagnostic tests in CRPS

Lee and Weeks (91), in their meta-analysis of scintigraphic bone scan (SBS) showed this test to be positive in no more than 55% of CRPS patients (71,91). EMG and NCV (92,93), or CT and MRI cannot be expected to detect the microscopic perivascular nerve dysfunction in CRPS. Even if a coincidental disc bulging is seen on MRI, surgical procedure in the inflamed region is apt to severely aggravate the CRPS (51,52,200,201). Quantitative sudomotor axon reflex test (QSART) (202) (Table 3) studies the post-ganglionic cholinergic sudomotor function of the sympathetic system (94-97), not the thermoregulatory function. Laser evoked

potential (LEP) (Table 3) is a sensitive test for the study of capillary circulation (44,101-103). It studies a small area of the body thereby limiting its overall extent of information. Quantitative thermal sensory evoked response test (QST) (44,104,105) (Table 3) is sensitive and useful in studying the functions of c-thermoreceptors and A-beta mechanoreceptors in CRPS (104). This test identifies the threshold of somatic (spinothalamic)cold or heat touch sensation - versus neuropathic (sympathetic) cold or heat pain sensation.

Bilateral temperature changes in CRPS

The temperature difference between the two extremities (ΔT) should not normally exceed more than 0.4 -0.6°C (54,56). In early stages of CRPS, the ITI shows more than 0.50° C difference. In later stages, the temperature difference gradually disappears. The ΔT between the two extremities is not statistically significant in CRPS patients. In contrast, comparing the same CRPS patients with non-CRPS group, the CRPS extremities were significantly colder than the control group (106). The cut off line to discriminate the patient from the control group was 0.6°C for accurate predictability of CRPS diagnosis (106). The equalization of function is due to symmetrical representation of autonomic changes at hypothalamic and spinal cord levels (107). Other pathologic changes such as asymmetrical foci of hyperthermia identify the site of the injury. These

hyperthermic foci are usually a sign of damage to the nerve fibres causing hyperthermic epaptic (in contrast to synaptic)(108) electrical discharges between the adjacent sensory nerve fibres. Frequently, the injured side may show a hyperthermic focus, compensated by the contralateral normal side undergoing moderate hypothermia(109).

Cryotherapy for CRPS

Repetitive ice application may result in chilblains (or perniosis) due to inflammatory areas of hyperthermia secondary to long term frost bite type of nerve damage by application of ice. The ITI helps diagnose this condition to discontinue the destructive cryotherapy. Basbaum (117), and others (118-121) have demonstrated lesions affecting large myelinated axons secondary to ice exposure. These lesions are in the form of Valerian degeneration and segmental

demyelination (117,118,121). The cryotherapy causes iatrogenic hyperthermia with islands of permanent hyperthermia due to frostbite nerve damage mentioned above.

Outcome: ITI was helpful in identifying the areas of thermosensory nerve damage, and as well as diagnosing the phenomenon of CRPS spread.

Diabetic Neuropathy and Diabetic Foot

In advanced stages of diabetic neuropathy, the disease is complicated by neuroinflammatory changes, fractures (Charcot's foot), and by foot ulcers (122-125). The ITI changes in these patients are the prototypical examples of nerve damage causing irreversible hyperthermia in different degrees. Armstrong et al (122) have utilized ITI as the predictor of early sign of deterioration of ulcers and trophic fracture. They have used the high delta-T of 2° C between the involved and contralateral extremities to initiate therapeutic intervention.

Outcome: In our studies, in all 11 diabetic foot patients hyperthermic foci were observed. These 11 patients were referred to us for a second opinion before amputation. None of these patients ended up with amputation. ITI played a pivotal role in sparing these patients' extremities. The recognition of neuroinflammatory phenomenon (101) in these patients led us to treat them with weight-bearing, mobilization, nerve blocks, I.V. Mannitol, physical therapy, etc., sparing these patients from amputation as well as relieving neuroinflammation and pain with nerve blocks and I.V. Mannitol (100gm/500cc D5W treatment)(126,127).

Tennis Elbow

Outcome: ITI is useful in diagnosing traumatic lateral epicondylitis (128,129), or tennis elbow. The ITI showed a focalized hyperthermia at the lateral epicondyle in 53 of 56 patients (95%)(128). Similar finding of hyperthermia is also noted in tarsal tunnel entrapment neuropathy. These areas of hyperthermia should not be aggravated by needle insertion. Any trigger point injection or nerve block should be performed proximal to the hyperthermic area. Injections aimed at the foot, ankle, hand, or wrist causes further trauma and up-regulation of the sympathetic system leading to a source of pain, and further thermal dysfunction (37).

Thoracic Outlet Syndrome (TOS)

Outcome: Another frequently over-diagnosed and over-treated syndrome in neuropathic pain is Thoracic Outlet Syndrome (TOS)(130). Due to the inflammatory nature of neuropathic pain, especially in CRPS in upper extremities, brachial plexitis is frequently mistaken for TOS and is improperly managed by surgery. The surgical procedure becomes a new source of neuro-pathetic pain, further deteriorating the condition (130,131). ITI has been instrumental in identifying the nature of pathology in distal portion of the extremity in form of ephaptic hyperthermia - pointing to the original source of pathology rather than the secondary inflammation of brachial plexitis. ITI spared such patients from surgery for TOS in 14 of 824 CRPS patients with presumptive diagnosis of TOS (37).

Cervicogenic Headaches

ITI can help diagnose and differentiate cervicogenic headaches from migraine. The cervicogenic headache shows areas of hyper- and hypothermia in the distribution of posterior sensory nerve branches of C2 through C4 nerve roots, and occipital nerves. Nerve blocks in these areas provide excellent relief (11,37). On the other hand, radiofrequency damage to articular facet (48,132,133), or rhizotomy (134) generates a new source of algogenic pathology, hyperthermia and more severe pain. Stimulation of the peripheral ends of the cut dorsal roots dilates cutaneous blood vessels (135). The retrograde activation of cutaneous sensory nerves leads to focal vascular changes causing neurogenic inflammation (136,137) due to the release of pro-inflammatory chemicals (50-53, 116, 138-159).

This vasodilation and inflammation explains the hyperthermia in the area of nerve injury. The trigeminal vascular sympathetic function is influenced by many factors including, but not limited to, chemical changes in the blood (160), craniovascular circulatory changes (161, 162), and stimulation of trigeminal nucleus by referred pain originating from the posterior nerve branches of the C1 to C4 nerve roots (163).

Outcome: ITI helps identify the craniocervical hyperthermic areas, and differentiate this headache from migraine. Where as in migraine headaches thermal fluctuations are quite unstable, in cervicogenic headaches the hyperthermia

is present in the occipital nerve region and the craniocervical junction (11). These two types of headaches require two opposite forms of treatment. Sumatriptan aggravates cervicogenic headaches; conversely nerve blocks do not usually relieve the true migraine headaches.

Migraine Headaches

Unfortunately the term migraine has been relatively loosely applied to any type of neuro-vascular headache, migraine or otherwise. This results in contamination of studies done on this subject. The ITI has been reported as having no value for evaluation of true, generic migraine headaches (160,164) excluding cervicogenic, TMJ, and Trigeminal nerve injury headaches. The migraine headaches cause craniofacial thermal fluctuations which are unstable and change in different stages of the migraine attack (115). Hypothermia over the ophthalmic branch of the trigeminal nerve has been reported on ITI of migraine patients (160). It is seen mainly during the acute attack as a transient phenomenon. Mathew et al (165), have reported thermal symmetry in 78% of headache-free volunteers. However, this symmetry can also be present in a high percentage of migrainous patients as well.

Outcome: More studies are needed regarding the role of ITI in true migraine.

Temporomandibular Dysfunction(TMD)

ITI sheds more light on the complex subject of temporomandibular dysfunction (TMD): In painful, clicking type of TMD, McBeth et al, showed ITI to have a diagnostic sensitivity of 87% (166). This was in contrast with normal controls showing normal specificity of 86% (166). ITI and liquid crystal thermographies were usually normal in between flare ups of trigeminal neuralgia or trigeminovascular facial pains (167). During the symptomatic attacks ITI showed hot or cold spots in over 80% of patients (84,167): The hot spots are more likely due to TMJ pathology (168,169) or facial sinusitis (170).

Thirty-three patients who had undergone TMJ surgery followed by persistence and spread of neuropathic pain were referred to us for diagnosis and treatment in the past six years. Two main factors - careful history taking and ITI - solved the puzzle, and explained the reason for poor recovery.

Outcome: The ITI revealed an abnormal sympathetic dysfunction in the cervical (16 patients), lumbar (9 patients), and thoracic spine regions (7 patients). Only one patient had shown no spinal involvement - instead the patient was found to suffer from maxillary bone osteonecrosis and abnormal thermal changes in the Trigeminal nerve distribution.

Conclusion

A properly performed ITI, provides diagnostic therapeutic information not obtained by EMG, NCV, CT, or MRI. This information is indispensable in helping to arrive at an accurate diagnosis, and in identifying the pathologic areas. It helps the physician to avoid further invasive blocks or surgical procedures.

Lack of such information leads to misdiagnosis, and to labeling the patients for being a malingerer, or as suffering from conversion reaction.

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