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# Evolution of Acupuncture for Pain Management

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Acupuncture has been in existence for thousands of years. A well-accepted practice in Asia, it was initially met with great resistance in the West. However this situation has changed dramatically with the advent of greater public awareness, clinical efficacy, low side effect profiles, and research evidence. Over one million practitioners provide acupuncture outside of China. In the United States, over 11,000 physicians, both MDs and DOs have an interest.<sup>1</sup> The growing number of acupuncture schools opening up around the world is an indication of increasing utilization. With this “renewed” interest in an ancient but “alternative” treatment, came many variations of the original theme found in the Chinese Classic, the Huang Di Nei Jing (Yellow Emperor’s Classic of Internal Medicine), which is one of the oldest medical textbooks in existence. Today, it is not uncommon to find practitioners combining different acupuncture techniques and ideas.

At the same time, there is a growing interest in complementary medicine. This is partially due to the limitations of contemporary Western medicine in addressing many chronic conditions, especially chronic pain. Recent statistics reveal that chronic pain is a growing problem despite the wide variety of treatments available. In addition, high side effect profiles from many of these treatments cause increasing morbidity and mortality.

## Acupuncture and Pain Management

As with all forms of practice (art, music, literature, etc), acupuncture has gone through an evolution. For the sake of brevity, this article will not be an extensive explanation of traditional acupuncture or its numerous variants since there are many references available on that topic. Nor will it cover the use of acupuncture to treat systemic disease. Our present focus is on acupuncture’s use in pain management.

There are many purposes for this review. One is to address the evolution of acupuncture for pain management with a historical perspective from the oldest philosophies of traditional Chinese acupuncture found in the Huang Di Nei Jing

to the most recent use of deep muscle “acupuncture” known as Intramuscular Stimulation (IMS) or Trigger Point Needling (TPN), which uses modern scientific principles. In fact, this modern version, although sharing in philosophy, differs so much in practice that it may not be considered acupuncture at all. In addition, other basic and clinical research findings relevant to acupuncture are cited.

There is a great deal of wisdom on the ancient ideas of vital energy, balance, and harmony serving as a foundation upon which to build. Likewise, there is great value in the understanding of physiologic processes. Science can further refine established, empirically observable principles and replace old ideas with newer ones that work better in our contemporary context. Views from both the East and West remain valid. I will use East and West as metaphorical descriptive terms for the sake of clarity. In fact, throughout this review, one will notice how East and West have come together on more than one occasion. Inherent in this discussion is how old philosophies and new technologies can work together to produce a whole greater than the sum of its parts. Ancient philosophies are being confirmed with modern science. So today, not only is East meeting West, but science is meeting philosophy.

Another purpose is to propose a new model to help explain chronic pain. The definition of health by the World Health Organization (WHO) is described as the balance between self, external agents, and the environment. Although Western medicine has made great strides in treating pathogens (external agents) and traumatic injuries (environmental) it has not made a great impact on treating the self. The health system is inherently unbalanced, and this may partly account for the fact that the top 10 causes of death in the United States have not changed drastically over the past 10 years and are mostly related to lifestyle. The new model of pain proposed here is designed to bring healing to the self. This is an area where Integrative Medicine can play a large and productive role.

Pain is the second most common cause of loss of work in the United States, the common cold being first. It is one of the most common presenting complaints to the family care office. Yet, with all the advances of technology and treatments, it still remains a major problem in our society and continues to worsen. A new understanding of modern applications of acupuncture can have profound individual and societal impact through the respectful representation of the different

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views of acupuncture and how modern Western ideas can complement eastern wisdom. It must be emphasized that many of the ideas presented here are not new. It would be incorrect to say that anything has really been “discovered.”

## East vs. West

Eastern medicine is based on holistic patterns, empirical observation, and nonlinear logic. Western medicine is based on reductionistic theory, linear causality, and scientific theory. Said differently, Eastern medicine prefers observation of outcomes over explanatory theories. It looks at processes and their empirically observed outcomes as being the most important. Western medicine rejects empirical observations that do not fit with its current scientific theories. It reduces phenomenon to explain cause and effect. To step back and take a larger view of these philosophies, you can say that Eastern views represent processes, and Western views represent the steps within those processes. In that respect, Eastern and Western views are actually looking at the same things, but from different perspectives, both inherently valuable in their own way and related to each other.

## Maps vs. Territory

A distinction should be made between maps and territory. They are not synonymous. A map is simply a representation of a territory. Maps are used to help us navigate territories. However, they are inherently limiting and can work against us. A territory is multidimensional, and a map is two dimensional at best. When interpreting a globe into a map, something is lost in translation. A multidimensional entity cannot be fully represented in a medium with lesser dimensions. Similarly, the maps of the human body, whether they be meridians or nerves, are inherently limiting, and this consideration should be made when viewing scientific data. The maps used by the East and West are different perspectives and ways of explaining the same phenomenon. Even the strictest and most rigorous scientific study is simply a map.

## Background and Theory of Traditional Chinese Medicine

Around 200 B.C., the basic ideas of Chinese medicine were recorded in the classic work the *Huang Di Nei Jing* (Yellow Emperor’s Classic of Internal Medicine), including the first record of acupuncture. This is said to be the oldest medical textbook in the world. It was written from even earlier theories by Shen Nung, the father of Chinese medicine. Shen Nung documented theories about circulation, pulse, and the heart long before European medicine had any concept of them. The Chinese doctors of that time saw humans as an integral part of nature, not apart from it as is the case many times in Western medicine. These ideas were based upon the Tao, which the Chinese viewed as the expressions of natural law. Tao is a constant force that creates all things. A basic tenet is the polarity between Yin and Yang within the context

of the Tao. The original meaning of Yang was the sunny side of the hill, while the Yin symbolized the shady side. These opposites complement each other in a dynamic process. On a larger scale, the universe is seen as a complex network of related processes influenced by Yin and Yang.<sup>1</sup>

## Qi, the Life Energy

A vital factor is the flow of life energy called Qi. Qi is omnipresent in nature and in all life processes and is comprised of the Yin and Yang. The functions of the organs and organ systems are brought about by the Qi inherent in each. Chinese medicine describes 11 organs. These organs are more descriptive of functions rather than anatomy. The organs are divided into six Yang (small intestine, large intestine, stomach, urinary bladder, gallbladder, and “Sanjiao”) and five Yin organs (lung, heart, spleen, kidney, and liver)

## Diagnosis and Examination

The diagnostic system is based upon the Yin–Yang polarity and the five phases or elements. These include wood, fire, earth, metal, and water and were developed in the third century B.C. to allow for further categorization within the Yin–Yang paradigm. These phases are interrelated in that they can stimulate but also inhibit other phases. This is not unlike the way Western medicine views the neuroendocrine feedback mechanisms. Organs are classified according to these phases. For example, liver is a wood organ, heart is a fire organ, spleen is an earth organ, lung is a metal organ, and kidney is a water organ. Disease is seen as deficiencies or excesses of the Qi flowing within the body and is described as patterns of disharmony or Chinese syndromes. There are eight diagnostic criteria or four opposed couples. These are Yin–Yang, Interior–Exterior, Deficiency–Excess, and Cold–Heat. Symptoms are analyzed with reference to these eight criteria.

The Chinese method of examination uses four components. These are visual observation or looking (Wang zhen), listening and smelling (Wen zhen), questioning (We zhen), and examination/palpation (Qie zhen). The Chinese physician works through this process to decide the appropriate treatment for restoring the normal flow of Qi, which is usually a multimodal approach involving not only acupuncture but also herbs and moxibustion. It is not a “cookbook” method, but individually tailored to each patient.

## Meridians and Acupuncture Points

The Qi flows through channels of meridians, which can be blocked, thus causing imbalances of energy in organs and organ systems. The basic tenet of acupuncture is the balancing of the Qi by dissolving these blockages. A pair of meridians consists of a Yin and Yang channel, for example, lung and large intestine meridians, which run parallel to each other. They are also known as coupled meridians because, in the periphery, they are connected by Luo connections. Yang channels run laterally or dorsally and Yin run medially or ventrally. The 12 meridians belonging to the 11 organs are known as the master meridians. Together with the Luo connections, this network is known as the Jing-Luo system. In

addition to the 12 main meridians, there are other meridian systems.

Within these meridians are points. Points with particular functions are grouped together forming 13 categories. Point location is vital to the success of acupuncture. There are several methods of point location. Every point is located with its own specific method. Some can be located with several methods. These methods include palpation of tender points also known as Ah Shi points, use of anatomical landmarks, various methods of measurement using finger breadth, body proportions, and postures (eg, LI.11 Quchi is located at the lateral end of the transverse crease when the elbow is flexed at a right angle), and, in more modern times, skin resistance through the use of commercially available devices. In addition, about 20 rules of point selection are used. Once selected, the needles are placed in the points, which are usually superficial, and retained for 10-25 minutes. However in certain instances they can be retained up to 1 hour. In the Chinese system a maximum of 20 needles are used in a session, however, in Korean and Japanese versions, more can be used. The needles used can vary from 26 to 34 gauge. Once the needles are inserted, patients can feel a De Qi sensation. This has been described as numbness, tingling, pressure, soreness, distention, heat, or cold. This signifies the dissolution of a blocked meridian. The sensation can radiate throughout the meridian until the Qi is stabilized. Methods used to speed this process include twirling and/or electrical stimulation of the needle.

The basic idea of acupuncture is that blocked meridians cause an imbalance of Qi. The use of needles to dissolve the blockage restores health. The needles are placed in points, which lie within the affected meridians. This basic idea has evolved to include variations of traditional Chinese acupuncture (Japanese, Korean, European), other forms of acupuncture including electroacupuncture, Chakra acupuncture, laser acupuncture, sonopuncture, auricular acupuncture, as well as related variants such as acupressure, cupping, reflexology, and ART (Awareness Release Technique) to name a few. All of these variations have been regarded within the realm of "alternative" medicine.

## Acupuncture in the West

Acupuncture was introduced in Europe during the 16th century. Acupuncture was actually a Western term, while the Chinese referred to it by many names. It was not widely accepted until recently because of the differences in perspective. As stated earlier, Eastern medicine prefers observation of outcomes over explanatory theories. Western medicine rejects phenomena that does not fit with its current scientific theories. However, it was discovered that nerves were conductors of electricity, as demonstrated most elegantly by Galvani.<sup>2</sup> This finding may be seen as a Western explanation of an Eastern empirical observation.

Painful muscle points, now known as trigger points, were described in the 7th century during the Tang Dynasty. This condition has been described by many practitioners and many cultures throughout the years. In the 20th century,

trigger points were first formally described in Western medical literature. Although this phenomenon was not a new one, it was not described in detail until Dr. Janet Travell, MD, published her ideas in a number of articles starting in 1942. David Simons, MD, later partnered with her and their collaboration culminated with their text *Myofascial Pain and Dysfunction, the Trigger Point Manual* published in 1983. This work has become a landmark text for trigger point practitioners. Trigger points were described as locally tender points associated with focal areas of muscle shortening termed "taut bands." When palpated, trigger points can feel like small nodules within muscle and may refer pain distally.<sup>3</sup> It was believed that they represented focal areas of muscle injury, which caused pain through an essentially normal peripheral nervous system. Trigger points were met with much skepticism initially, but now represent a widely accepted concept.

Unlike acupuncture point location, trigger point location involves traditional Western medical history taking and physical examination. The underlying cause of trigger points has never been clearly elucidated until recently. The old theories suggest that the trigger point itself was a nociceptive agent. More recent findings suggest that it is an epiphenomenon of denervated muscle and will be discussed later. The idea that blockages in Qi being a causal factor has not held up in the formal trigger point domain. Studies have shown that many trigger points do in fact overlap with acupuncture points.<sup>4</sup> In clinical practice, dry needling trigger points have been used as an alternative to injections.<sup>5</sup> The long debate as to whether "wet" needling or "dry" needling is more effective has been quelled somewhat with the realization that both methods are equally effective after extensive reviews of the literature.<sup>6-8</sup> With the idea of dry needling of trigger points, or nonacupuncture points, comes the next step in the evolution of dry needling.

## East Meets West: New Ideas in Pain Management

The next big advance in needling treatments came from Chan Gunn, MD. Through his decades of clinical and scientific work, he bridged the gap between East and West, while developing an effective treatment. In the early 1970s, he worked for the Workers' Compensation Board of British Columbia. He was frustrated by the unsatisfactory results of conventional treatments for pain. The treatments were based upon a model of pain that suggested pain was a signal of tissue injury conveyed to the central nervous system (CNS) via a healthy peripheral nervous system (PNS). However, it failed to explain the variety of pain syndromes encountered on a regular basis. Oftentimes, patients with severe pain did not have overt signs of tissue injury. His first discovery was that patients who were disabled for long periods of time had tenderness in muscles belonging to affected myotomes.<sup>9,10</sup>

These patients did not have evidence of tissue injury. It was these tender points that differentiated mechanical low back strain, which heals spontaneously, from chronic low back pain syndromes. Next, in a study of patients with tennis

elbow, he showed that elbow pain was secondary to spondylosis and cervical radiculopathy. Treating the neck, not the elbow, resulted in long-term relief in 88% of the patients.<sup>11</sup> A study of shoulder pain yielded similar results and pathology.<sup>12</sup> A pattern began to emerge. Patients with pain, but no signs of injury, had sensory, motor, and autonomic manifestations of peripheral neuropathy. This was a new concept at the time and it was met with much resistance since the accepted model implied that peripheral muscle injury conveyed pain signals through a healthy PNS. Although Gunn was not trained as an acupuncturist, he had great knowledge of Eastern medical philosophies and treatments and became interested in acupuncture. He noticed that most acupuncture points corresponded to known neuroanatomic entities such as muscle motor points.<sup>13</sup>

## Cannon and Rosenblueth's Law of Denervation

Dr. Gunn discovered “The Law of Denervation Supersensitivity” by Walter B. Cannon, MD, and Arturo Rosenblueth, MD, and realized that this was a unifying principle that explained his clinical observations. This physiologic law was essentially “lost” because Dr. Cannon died before it could be published. Why it was not published posthumously is a mystery. It should be noted that Dr. Cannon had a deep appreciation and understanding of Eastern concepts, from which he developed the physiologic concepts of homeostasis, which borrows from the Eastern philosophy of harmony and balance within the body. He also described the “fight or flight” response, which described the relationship between the sympathetic and parasympathetic nervous systems, borrowing from the concept of Yin and Yang.

The Law of Denervation Supersensitivity states, “When a unit is destroyed in a series of efferent neurons, an increased irritability to chemical agents develop in the isolated structure or structures, the effect being maximal in the part directly denervated.”<sup>14</sup> The various structures initially described included skeletal and smooth muscle, spinal neurons, sympathetic ganglia, adrenal glands, sweat glands, and even brain cells.<sup>14</sup> These denervated structures essentially overreact to a wide variety of chemical and physical inputs. In other words, normal physiology and integrity of all innervated structures are dependent on the flow of nerve impulses from an intact and fully functional nerve to provide a regulatory or trophic effect. When this flow of trophic factor is blocked by whatever mechanism, innervated structures are deprived of trophic factor. Atrophic structures become highly irritable and develop abnormal sensitivity to otherwise normal stimuli. Cannon’s original work was based on total denervation, but it is now known that such physical trauma is not necessary. Any circumstance that impedes the flow of motor impulses for a period of time can rob the effector organ of its excitatory input, causing disuse sensitivity in that organ and in the associated spinal reflexes.<sup>15</sup> For this reason, disuse

supersensitivity is now the preferred term over denervation supersensitivity.

A practical observation of this law will be provided to deepen understanding and to demonstrate that this transcends solely medical applications. Everyone experiences this phenomenon on a daily basis. When one goes to sleep, his or her eyes are deprived of visual stimulus from the light. Upon awakening, extreme sensitivity to light occurs, which is reduced as the eyes receive more visual stimulation from the light until a comfortable level is achieved. Another application would be regarding drug tolerance. When certain medications are given, for example, opioids, patients will develop a tolerance over time. Doses will need to be increased until the same therapeutic effect is achieved. This occurs because constant stimulation produces *less* sensitivity to the stimulus. This is the essentially the Law of Supersensitivity in reverse. The major breakthrough here is an opportunity to help explain chronic pain by applying a universal physical law, which helps to hold together what heretofore has been a highly fragmented view of pain. This law in effect is the Western application of the concept of Qi and, like Qi, it is universal and can be applied to all systems.

It has been shown that any process that inhibits release of acetylcholine (Ach) can result in supersensitivity. Botulinum toxin applied to the surface of a muscle causes supersensitivity. Botulinum toxin inhibits release of Ach from motor nerve endings and in fact creates a chemical denervation with an intact nerve. Mileti and associates removed a sartorius muscle and bathed it in a saline solution with Ach. After several days, the Ach was washed out, but the muscle was supersensitive to Ach. This raises the question as to what trophic factors are responsible for maintaining normal muscle function.<sup>16</sup>

Further research has yielded other discoveries. Denervated skeletal muscle has a threshold to Ach that is much lower than normal. Kuffler explored this finding using an isolated nerve–muscle fiber preparation. He observed that only the end-plate of a normal muscle responded with a depolarization of applied Ach. The dose to achieve this was relatively high. However, he found that the sensitivity of denervated muscle to Ach increased by 1,000 to 10,000 times. Years later, Thesleff observed that not only the end-plate region was responsive to Ach, but also the whole membrane of the denervated muscle responded. This is similar to the physiology of fetal muscle. Before innervation, the whole muscle membrane is sensitive to applied Ach. As the muscle receives its nerve supply, the zone of innervation shrinks to include only the end-plate zone.<sup>16-20</sup>

## Clinical Applications of Cannon's Law: The Radiculopathy Model for Pain

Dr. Gunn then applied this law and created a radiculopathy model to explain chronic pain. He realized that most of the chronic pain patients he studied had signs of peripheral neu-

ropathy including sensory, motor, and autonomic abnormalities. In addition, patients with peripheral findings always had involvement of related spinal muscles and structures. Using the law of physics and his clinical observations, he realized that lesions of the nerve root or radiculopathy could explain these findings. For the sake of clarity, radiculopathy will denote any *functional* abnormality of the nerve root that can be caused by disuse and/or structural issues.

The fact that associated reflexes are also affected is an extremely important point. The reflexes affected by radiculopathy are the proprioceptive reflexes that control muscle length and tension. When these reflexes are robbed of trophic factor or Qi, they become hyperreflexive, which accounts for muscle shortening. This can be explained by understanding the basic physiology of nerves. The laws of physics determine that the largest fibers in a nerve should be affected first and the smallest affected last. The largest fibers are the afferent type Ia and Ib, and the efferent alpha motoneurons.<sup>21</sup> With this being said, radiculopathy should manifest first as shortened muscles by two mechanisms, afferent and efferent. First, the large type I afferent fibers that are responsible for muscle length and tension would be affected. This sensitization will then affect the gamma loop, resulting in an upregulation of the gamma reflex, or a hyperreflexive shortening. This would be similar to a hyperreflexive knee jerk. The second mechanism is an efferent one involving the large alpha motoneuron. When sensitized, it can also cause muscle shortening.<sup>22</sup> Focal sarcomere contraction has been described in animals, which can explain the palpation of trigger points as nodules, “knots,” or taut bands within muscle.<sup>23</sup> The large fibers are emphasized here to describe how the abnormal proprioceptive reflexes explain muscle shortening and why painless muscle shortening is the earliest finding. It should be noted that all the fibers can be affected with radiculopathy.

Muscle shortening or contracture is commonly mislabeled as spasm. Spasm is a contracted muscle with motor activity. Contracture is the evoked shortening of a muscle fiber in the absence of action potentials. It is important to note that contracture is electrically silent, therefore it cannot be detected by EMG. Contracture may or may not occur along its entire length. Local shortening is probably what causes the trigger point phenomenon. If the action potential is large enough (or fast enough) to trigger the all-or-none spike, contraction of the entire muscle will result.<sup>16,24</sup>

Dr. Gunn’s interest in acupuncture led him to use acupuncture needles placed in these supersensitive muscles, which in many cases reversed the abnormalities by restoring the neural flow to the respective denervated structures.<sup>25</sup> He called this treatment Intramuscular Stimulation (IMS). It has also become known as Trigger Point Needling (TPN). For consistency, it will be referred to as IMS for the remainder of this review. The treated points had many common characteristics but were not always traditional acupuncture points.<sup>26</sup>

Other epiphenomena of radiculopathy include collagen degradation. It has been shown that denervation results in the disorganization of collagen fibers due to disruption of the electromagnetic field, which produces the disulfide bonds

## Clinical Findings of the Radiculopathy Model

- Acupuncture points are nearly always situated close to known neuroanatomic structures such as motor points of musculotendinous junctions
- Points that are found to be effective usually belong to the same segmental level(s) as the presenting symptoms or injury
- These points usually coincide with palpable muscle bands or trigger points that are tender to digital pressure
- Tender points are distributed in a segmental or myotomal fashion, in muscles supplied by both anterior and posterior primary rami, indicating radiculopathy
- Muscles with tender points are unfailingly shortened from spasm and contracture
- Virtually all conditions that respond to needling demonstrate signs of peripheral neuropathy, which are not well known and therefore frequently missed
- Symptoms and signs typically improve when the tender and tight muscle bands are needled

that hold the fibers together.<sup>27</sup> This results in frailer collagen and reduced quantities in the soft and skeletal tissues. This in turn contributes to accelerated degeneration in weight-bearing and activity-stressed parts of the body, including the spine and joints, which can become a cause for pain. It also predisposes these structures to injury addition. Enthesopathic thickening of tendons is possibly a compensatory mechanism for this weakness.<sup>25</sup> This collagen degradation has been found to be reversible with application of constant current.<sup>27</sup>

Neuropathic muscle is inherently more fragile than normal muscle due to collagen degradation.<sup>27</sup> This makes the neuropathic muscle more susceptible to injury. Reinohl and co-workers<sup>28</sup> showed that sensitization can occur from the release of substances from injured muscle, including adenosine triphosphate (ATP), bradykinin (BK), 5-hydroxytryptamine (5-HT, serotonin), prostaglandins, and potassium (K<sup>+</sup>). Microscopic analysis also shows that dystrophin is disrupted, further confirming disruption of the microfilament apparatus and tissue injury.<sup>29</sup> These substances can irritate muscle nociceptors/C fibers and also induce release of calcitonin gene-related peptide (CGRP) from the motor nerve terminal, which increases motor endplate activity.<sup>30</sup> Microdialysis sampling techniques at active TrPs showed elevated CGRP levels and an acidic pH compared to inactive (asymptomatic) TrPs and normal control subjects.<sup>31</sup> The common thinking is that pain is a peripheral phenomenon caused by tissue injury. This tissue injury then causes release of neurotransmitters, which send afferent information via the nociceptors through a healthy PNS back to the CNS, which results in peripheral and central sensitization. However, Cannon’s Law of Super-sensitivity and the radiculopathy model suggest that radicu-

lopathy, which sensitizes the associated structures, results in a neuropathic muscle predisposed to injury and, once injured, releases substances that can further sensitize an already sensitized PNS and CNS.

It has been shown that denervation results in a 1,000- to 10,000-fold increased sensitivity to Ach.<sup>16,32</sup> This is due to the fact that denervated muscle has a larger zone of innervation. In normal muscle, the zone of innervation is located at the motor point where the nerve enters the muscle. Within this very narrow zone are active Ach receptors. Once this neural flow is disrupted, all of the Ach receptors in the muscle become active, resembling an embryonic muscle state. The activation of the additional Ach receptors acts as a compensatory mechanism for the decreased neural flow of Ach. Once the flow is restored, the extra receptors return to a dormant state, with the receptors in the original zone staying active. This phenomenon lends further merit to Cannon's law and helps explain the muscle sensitivity found on exam.

This new radiculopathic model for pain that results in segmental sensitivity has been adopted by a few,<sup>8,33,34</sup> however, this paradigm still remains a very minor factor in the current thinking about pain. The predominant thinking in chronic pain still focuses on pain generators, usually in the peripheral muscles or skeletal structures, also known as nociceptors, or chemical imbalances either centrally or peripherally, which conduct afferent pain signals in a healthy PNS, not in abnormal function of the PNS itself. In addition, it is commonly thought that pain initially arises from small fiber rather than large fiber pathology. The radiculopathy model helps to explain simple and complex pain syndromes such as fibromyalgia and CRPS. Application of this model easily explains these "complex" pain syndromes as clinical manifestations of radiculopathy of varying degrees.

## The Relationship of Spondylosis to Radiculopathy

Dr. Gunn postulated that radiculopathy is a sequelae of spondylosis.<sup>35</sup> Spondylosis is the universal structural disintegration and morphologic alteration that occurs in the intervertebral disc, with pathoanatomic changes in surrounding structures. These changes result in narrowing of the neural foramina, which increases the probability of damage to the exiting nerve root.<sup>36</sup> The resulting radiculopathy accelerates the spondylosis through collagen degradation of the surrounding structures innervated by the affected dorsal branches as mentioned earlier, and a vicious cycle is set into play in which radiculopathy worsens spondylosis, which worsens the radiculopathy and so on. During this process, compromised nerves conduct abnormally. These abnormally conducting nerves, when in contact with "normal" nerves, will cause the normal nerves to conduct abnormally, and another vicious cycle can ensue. This phenomenon is well documented in the neurology and electromyography literature.<sup>37</sup> In addition, neurogenic edema can occur in the denervated structures, further compromising the nerve root, which, like the phenomenon above, results in a vicious cycle

whereby radiculopathy worsens trophedema, which worsens radiculopathy.

A presumption in this model is that, since spondylosis is universal, so is radiculopathy. It is just a matter of degree. Dr. Gunn coined the term "prespondylosis," which described the process of spondylosis, which has an inherently progressive, but waxing and waning quality.<sup>35</sup> This helps to explain why some symptoms "just come and go." In addition, Sola described the concept of an "injury pool."<sup>38</sup> This states that major and minor injuries can accumulate in a segment, predisposing it to injury. This explains why some patients present with severe pain syndromes from minimal or no prior injury. Stated differently, if a nerve becomes neuropathic, even the most minor incident can cause pain. A practical example will be used for clarification. For example, if a car tire has a small leak, it will eventually go flat, causing "symptoms." The harder the tire is driven, the faster it will go flat. Once air has leaked beyond a certain threshold, even "normal" driving can cause a large problem. The flat tire is equivalent to spondylosis, the leakage of air prespondylosis, and the wear and tear of driving an injury pool. This also explains why pain can continue beyond a reasonable amount of time.

## Central Mechanisms

Peripheral sensitization can result in central sensitization. Several phenomenon occur as a result. These include increased spontaneous activity of dorsal horn neurons, increased response to afferent input, expansion of receptive field size, reduction in threshold, and prolonged afterdischarges. Central sensitization leads to a cascade of molecular events such as activation of the *N*-methyl-D-aspartate (NMDA) channel, increased intracellular  $Ca^{2+}$ , wind-up/wide dynamic range (WDR) neuron sensitization, and other phenomenon.<sup>39-45</sup> In addition, pain pathways have been linked to the limbic system, which helps to explain the emotional component often associated with chronic pain, and that, with the reduction of pain, the emotional state often improves.

Expansion of the receptive field size is a common clinical presentation where pain radiates to several segments. This phenomenon is explained by the dispersion of the primary afferent input through propriospinal connections in the adjacent layers 5 and 6 of the dorsal horn. This area also contains the wide dynamic range (WDR) neurons, which have a significantly larger receptive field than the primary afferent neuron. Increases of nociceptive information can lead to recruitment of more WDR neurons, which expands the receptive field. In addition, prolonged afterdischarges occur due to the loss of normal inhibitory effects of A- $\beta$  fibers on A delta and C fibers. This manifests in a longer than customary duration of pain.<sup>25</sup> Expansion of the receptive field size can also be caused by radiculopathy. With radiculopathy, some motor nerves live and some die. The surviving neurons will territorially invade the "dead" space. This will result in giant waves on EMG.<sup>37</sup>

Wind up is frequency dependent. Low frequency (0.1 Hz) C fiber input gives a constant response from dorsal horn

neurons. Frequencies greater than 0.5 Hz can give rise to hyperexcitability, which can last for many minutes after the stimulus. In wind up, C fibers release substance P, neurokinin A, and excitatory amino acids (glutamate and aspartate) onto dorsal horn neurons. Two types of receptors are present on the dorsal horn, neurokinin and NMDA. The binding of amino acids to the NMDA receptor depends on its prior activation by the binding of substance P to the neurokinin receptor. The release of substance P may lead to recruitment of a second receptor type (NMDA) and cause an exaggerated response to further stimulation. The sensitized cell undergoes other biochemical changes, as indicated by the expression of the gene *c-fos*. Products of *c-fos* expression are involved in the regulation of neurotransmitter and nerve growth factor synthesis.<sup>25</sup>

## Physical Signs of Radiculopathy

The patient's history can provide information that can assist in the diagnosis. In addition, the physical examination can also provide easily measurable signs that are present with radiculopathy. As mentioned earlier, radiculopathy can manifest as motor, sensory, and autonomic disturbances. Each of these can be uncovered with a thorough physical exam. To fully understand the physical manifestations of radiculopathy, one must acquaint themselves with nerve fiber diameter and function.

### Motor Signs

As mentioned earlier, the first manifestation of radiculopathy will be *painless* muscle shortening. This can explain the "latent" trigger point. Clinically, shortened muscles are easily measured with proper range of motion testing and well-accepted orthopedic tests such as the FABRE. As the radiculopathy continues, however, shortening could worsen and the other physical signs mentioned below will occur. Patients will often assist in the exam by pointing to the worst areas.

Shortened muscles can cause local biomechanical derangements. Shortened muscles pulling on tendons can result in tendinitis or enthesopathy. Increased pressure across a joint can cause osteoarthritis. Increased pressure across the paraspinals can cause disc herniation. If the force is large enough, the disc can impinge on a nerve root. Prolonged muscle shortening will also result in compression of muscle nociceptors. This helps to explain the idea held by many that "muscle" or "myofascial" pain is caused by small fiber nociceptors within the painful muscle. These phenomena are often regarded as the causes of pain, but in the radiculopathy model they are all results of a series of progressive events starting with radiculopathy. The increased stress on these structures plus the collagen degradation can contribute to and result in lesions such as herniated discs, torn ligaments, tendons, and cartilage. Muscle shortening will also produce regional biomechanical problems or postural deficits, such as rounded shoulders, scoliosis, kyphosis, and valgus and varus deformities. These biomechanical issues can further compound the factors that cause pain.

### Sensory Signs

The sensory component of radiculopathy presents as allodynia. Allodynia is described as a painful sensation in tissues to normally nonpainful stimuli. Clinically, even digital pressure over a variety of muscles and tissue will reveal the affected segments to be significantly more tender than nonaffected segments.<sup>10,12</sup> The mechanism is supersensitivity, which results in the increased Ach receptive field within the muscle, as well as compression and sensitization of the internal muscle nociceptors and stress on surrounding structures. Tissue injury can result from undue stress from long-standing compromised neuropathic muscle causing the release of painful algogenic substances. Skin rolling or the "pinch and roll" test can be an effective means of detecting segmental sensitivity as well as scratching the skin with an irritable object such as the end of a paper clip.<sup>5</sup> However, these tests offer no therapeutic benefit.

### Autonomic Signs

The autonomic component presents in a number of ways. Affected areas can have an increased pilomotor response (piloerection), increased sudomotor response (hyperhidrosis), an increased vasomotor response (vasoconstriction, and sometimes vasodilation), dermatomal hair loss, and neurogenic edema, a.k.a. trophedema from increased permeability in blood vessels leading to neurogenic edema and a "peau d'orange" effect in the skin. The trophedema can also be confirmed by the "matchstick" test, whereby a firm blunt instrument, such as the tip of a matchstick, will produce a lasting indentation and erythema in neuropathic segments.<sup>25</sup> The mechanism for neurogenic edema is based upon tumor necrosis factor (TNF), which makes it nonpitting, compared to the more popular types of edema seen in fluid overload states such as congestive heart failure. Therefore, a blunt object must be used to elucidate this finding. The significance of TNF will be explored later under "Neurogenic Inflammation and the Vagus Nerve." As with the other findings, segmental areas of abnormality can be diagnosed when using these physical signs.<sup>25</sup>

To summarize, radiculopathy first presents as painless muscle shortening. This can progress to include any or all of the motor, sensory, and autonomic signs mentioned above.

## The Needle's Role in Healing

Needling therapy offers many unique advantages over other types of therapy. First, it causes local bleeding. This bleeding promotes healing directly to the affected segment(s) by delivering numerous growth factors, most notably platelet-derived growth factor (PDGF).<sup>46</sup> PDGF attracts cells, induces DNA synthesis, and stimulates collagen and protein formation: it is, in fact, the principle mitogen responsible for cell proliferation. The implication is that new tissue can form as a result.

In addition, when the needle pierces the muscle, it creates a *current of injury*. This occurs as a result of the disruption of cell membranes of individual muscle fibers. This results in

brief outbursts of electrical potentials or injury potentials, also known in the electromyography literature as “insertional activity.” This phenomenon was first described by Galvani.<sup>2</sup> More recent studies have measured the current to range from 0.1 to 500  $\mu\text{A}/\text{cm}^2$  in a freshly amputated fingertip.<sup>32</sup> However, unlike external forms of stimulation, such as massage, heat, ultrasound, and cold, the effect of the piercing is long lasting due to the injury. This constant stimulation can be provided for many days after the initial injury, although with time it will dissipate. It has been described previously that constant electrical stimulation can reverse the effects of supersensitivity caused by nerve injury over a 21-day period.<sup>47</sup> This as well as other effects of radiculopathy can be reversed through the application of constant current, as is the case with the current of injury produced from a needle puncture.<sup>47,48</sup>

The needle can also prove to be a useful diagnostic tool. Standard diagnostic tools such as x-ray, CT scan, or MRI cannot detect supersensitive muscles resulting from radiculopathy. In fact, these tests can be misleading by revealing chronic lesions that are not clinically symptomatic, thus leading the physician to treat asymptomatic abnormalities. In fact, significant studies show a poor correlation with these diagnostic tests and patient symptoms, yet they are still widely accepted and performed. Careful EMG analysis done with minimal contraction can be beneficial if polyphasic wave forms are detected, which are indicative of reinnervation caused by nerve injury.<sup>37</sup> However, this technique of EMG analysis is not widely done.<sup>33</sup> In addition, contracted neuropathic muscle is electrically silent. So pragmatically speaking, there is no good, widely used diagnostic tool for detecting affected neuropathic muscle, and the tests available can be costly and ineffective. Piercing a supersensitive muscle, which results in a needle grasp, localized twitch response, and De Qi phenomenon, as well as the resistance of an overly shortened muscle, and resolution of neuropathic signs provides both diagnostic and therapeutic value. In fact, immediate symptom resolution after piercing these areas can be both diagnostic and therapeutic for neuropathic muscle while at the same time have the positive side effect of symptom relief.

## Clinical Applications

Knowledge and application of Cannon’s Law through the radiculopathy model can yield more effective treatment. Since this model assumes dysfunction of the nerve root resulting in supersensitivity of the relatively denervated muscles and associated structures, treatment should be focused on increasing neural flow of trophic factor, which will result in desensitization and resolution of neuropathic signs. Knowing this, a variety of treatments can be effective. Physical therapy, therapeutic exercise, manipulation, and dry needling all stimulate muscle spindles and GTOs as well as skin receptors. Massage activates tactile and pressure receptors; heat and cold act on thermal receptors.<sup>25</sup> Electrical stimulation also decreases sensitivity.<sup>47</sup> All these stimuli are sensed

by their specific receptors, transduced into nerve impulses, and relayed to the dorsal horn.

Stimulation can also be applied directly to the spinal cord. Spinal cord stimulation (SCC) has been shown to normalize withdrawal response thresholds in a rat model. The mechanism is believed to be caused by inhibition of glutamate and aspartate release at NMDA receptor sites and activation of local GABAergic mechanisms.<sup>49</sup> Studies are varied as to the efficacy of SCC and, since it is a surgical procedure, it does come with a higher side effect profile than dry needling. It is generally used in postlaminectomy or “failed back” syndrome.<sup>29</sup>

IMS offers a unique opportunity to apply many aspects of Cannon’s law into a diagnostic and therapeutic tool. Unlike acupuncture points, whose localization was outlined previously, the selection of trigger points to be needled uses Western forms of diagnosis. The muscles that exhibit the most signs of denervation are needled. To review, the signs are muscle shortening, taut bands, trigger points (motor), allodynia and supersensitivity (sensory), trophedema, piloerection, hyperhydrosis, and dermatomal hair loss (autonomic). These areas are located by visualization and palpation. The paraspinal muscles corresponding to the affected myotome should also be needled.<sup>11,12</sup> For example, a patient presents with low back and hip pain. The physical exam reveals neuropathic signs in the gluteus medius, maximus, and paraspinals of the L5-S1 distribution with tender trigger points or taut bands in the most affected areas. These trigger points and taut bands should then be needled. As these areas are needled, the patient will experience the De Qi phenomenon, muscle grasp, and twitch responses in the most neuropathic muscles. Instant resolution of symptoms is common. Needling of these nonacupuncture points would make IMS an entirely different entity from acupuncture, related to it by philosophy only. It also suggests that trigger points are epiphenomena of radiculopathy.

## The De Qi Phenomenon

When the needle is placed in the affected muscle, the De Qi and muscle grasp phenomenon is experienced. Western literature has described De Qi as achy, soreness, numbness, fullness, distention, heaviness, or pressure. The original Chinese description is quite different, the translation being loosely “hungry muscle.” No exact translation is available. When a needle penetrates the hungry muscle, it “grabs” it until it’s “been fed enough,” then let’s go. This restores the Qi, by “feeding” the “hungry muscle.” The mechanism has been detailed in the past<sup>50</sup> and is surprisingly close to the original description, which was done without the use of modern scientific methods. Needling a supersensitive muscle results in a barrage of afferent input. This results in magnified *alpha efferent* output, which causes intense local muscular contraction around the needle, causing a needle grasp or De Qi.<sup>50</sup> Twirling the needle stimulates the proprioceptors even more, which helps to reset the hyperreflexive gamma loop faster. This results in eventual relaxation of the neuropathic muscle and dissolution of the De Qi, as well the other neuropathic



## Research in the Field of the Use of Acupuncture and Related Treatments for Chronic Pain Have Been Extremely Difficult to Perform

- Chronic pain is a complex problem that often has psychological as well as organic pathology and dysfunction.
- Chronic pain syndromes are often complicated by previous surgeries, failed treatments, drug dependence, and side effects.
- Selection of reliable and valid outcome criteria is difficult. The study is meaningful only when long-term follow up is conducted.
- It is difficult to accurately classify pain syndromes. Application of Cannon's law and the radiculopathy model inherently suggests that a pain syndrome can have a number of diagnoses and an infinite number of variable factors. For example, diffuse low back pain can be caused by radiculopathy of varying degrees in the lumbar areas, resulting in supersensitivity of varying degrees, resulting in structural and postural derangements of varying degrees. The resulting condition, low back pain, is an amalgamation of all these factors and is individual to each patient. This is unlike a localized blocked coronary artery or a left lower lobe pneumonia, which are discrete lesions. Chronic pain is neither black nor white, but an infinite sea of gray that cannot be parceled out so easily.
- The very nature of chronic pain means that acupuncture and related treatments cannot follow strict treatment guidelines that can be used for other conditions such as coronary artery disease or pneumonia. Setting standards for "correct" treatments for various conditions such as low back pain is nearly impossible.
- Sham acupuncture or other needling techniques cannot be used as controls because any type of needling will stimulate the inflammatory reflex and result in a possible therapeutic effect.
- Current pain research focuses on peripheral nociceptors, the CNS, and neurotransmitters, not on the abnormal function of the PNS.
- Many forms of acupuncture exist making the term acupuncture more generic with time. This makes comparative studies extremely difficult and inaccurate. Many forms bear little resemblance to the traditional Chinese teachings and attempt to make acupuncture a "cookbook" of treatment points. This is in direct opposition to the original principles which respected the individuality of each patient.
- Pressure from insurance companies to conform to "care paths," which do not always allow enough time for appropriate treatments and can interrupt the treatment course, can lead to less effective treatment outcomes.

signs such as sensory and autonomic findings, often instantly. Muscle twitch responses can also be observed. This is most likely due to local depolarization of supersensitive muscle as the result of local injury currents that would be too small to cause contraction responses in normal muscle with higher thresholds to Ach.<sup>8,33</sup> This explanation of the normalization of muscle tone is abbreviated, since the maintenance and control of tone is dependent on normal functioning at six levels: (1) the precentral motor cortex, (2) the basal ganglia, (3) the midbrain, (4) the vestibulum, (5) the spine, and (6) the neuromuscular system.<sup>48</sup> With this in mind, central considerations were made under Central Mechanisms.

An important point needs to be made. IMS does not treat individual diseases, but rather restores homeostasis to the entire patient using the needle as a tool to achieve this outcome. The most important outcome is restoring normal neurologic function in the PNS—restoring the normal flow of Qi. The consequence of this will be pain relief. This philosophy is in harmony with the original Chinese writings on health and wellness.

### Research Limitations

Today there are a lot of research "buzzwords," evidence-based medicine, randomized double-blind placebo-con-

trolled trials, etc. One of my colleagues said to me once, "Nobody is more blind than he who is double blind." There may be some truth to that statement considering the research models available. How long these research models will last is of question. One only needs to look at the various research models over the past few centuries to observe that we have a tendency to change our minds as to what is "valid" and how we view it.

Review of the literature shows that two errors have been repeated consistently. The first is the study that produces a positive outcome when no real treatment effect existed. This is due to the failure to control for placebo, unreliable measures, and failure to conduct long-term follow up. The second error is the failure to detect a treatment effect when one has occurred. This is due to poor study techniques: too few treatments, too few subjects, inappropriate or insensitive measurement techniques, and failure to use a homogeneous group of patients, all of which can lead to inaccurately negative results. Although there are many articles written about the use of acupuncture in treating chronic pain, the available literature is unfortunately relatively mixed and disappointing. There is more research in this area than in any other area of acupuncture.

Another major failing in the area of pain research is the omission of Cannon's law. As stated earlier, it is a universal

law, such as gravity, and thus cannot be ignored. Its relevance to chronic pain has been outlined earlier. However, it is almost never mentioned in any scientific paper or medical textbook. This would be akin to aeronautical engineering without the mention of gravity. Perhaps this could be a contributing factor as to why pain research has not yielded significant advances in pain management based upon the statistics mentioned earlier. In addition, the importance of trophic factor or Qi is rarely addressed in the pain literature. The new findings regarding the inflammatory reflex also offers opportunities to further study the effects of needling and modulation of the immune system. These are but a few categories that deserve more attention.

## Research Findings

To compensate for single poorly designed studies, systemic reviews may offer more insight.<sup>1</sup> In 2001, Linde listed three systemic reviews regarding chronic pain inpatients. All three concluded there was limited or inconclusive evidence for the efficacy of acupuncture in treating chronic pain. These studies compared acupuncture to “sham,” standard care, no treatment, and physiologically inert substances.<sup>51</sup> When all of the results were combined, most of the high-quality studies with positive findings pertained to musculoskeletal pain. However many of the high-quality studies also showed negative results. A review of 11 randomized controlled trials has not shown acupuncture to be effective in treating chronic low back pain.<sup>52,53</sup> Chronic neck pain has been studied as a single entity. The most recent review consisted of 13 randomized clinical trials (RCTs); the results were again mixed with 5 positive and 8 negative studies, with the higher quality studies often being negative.<sup>54</sup> Acupuncture and rheumatoid arthritis has been studied. Four systematic reviews have been done recently, unfortunately no specific conclusion can be drawn due to poor study design or an inability to distinguish positive effects from acupuncture and sham.<sup>51</sup> Two recent RCTs for osteoarthritis of the knee and hip showed a 42% improvement in WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) scores over 8 weeks. Unfortunately neither study contained a placebo-control group.<sup>55,56</sup> There has been one systematic review regarding fibromyalgia. Of the seven studies reviewed, only one was of high quality, which suggested that acupuncture was more effective than sham. However the duration of relief was not documented.<sup>57</sup> The literature regarding headache is more extensive and similarly inconclusive.<sup>1</sup> Acupuncture has been shown to be as effective as metoprolol in influencing the frequency and duration, but not severity, of migraines.<sup>58</sup> Six systematic reviews concluded that acupuncture was no more effective than sham or physical therapy.<sup>51</sup> Melchart reviewed 22 RCTs and found, in 14 studies that compared acupuncture to sham, most showed acupuncture to be more effective. However, compared to other treatments such as physical therapy and medications, acupuncture did not fare well.<sup>59</sup> In their review of overall efficacy of acupuncture, Lewith and Machin<sup>60</sup> compared trials of acupuncture and conventional medical treatments, random injections of needles, and pla-

cebo. They concluded that a positive response is given by about 60-70% of chronic pain patients with the use of real acupuncture, 50% for sham, and 30% for placebo. Importantly they found that acupuncture caused fewer side effects than opioid and antiinflammatory medications. Richardson and Vincent<sup>61</sup> found good evidence from controlled studies that acupuncture can provide short-term relief from 50-80%. Long-term follow up was unfortunately lacking.

Although the quantity of literature regarding Western dry needling techniques is sparse, some of it yields more positive results. A meta-analysis comparing “dry” vs. “wet” needling of trigger points found both to be equally effective.<sup>6,7</sup> A few points need to be made regarding these findings. Most of the dry needling in this analysis was done with hypodermic needles. However, acupuncture needles offer unique advantages over hypodermic needles. The acupuncture needle has a blunt tip which does not cause any muscle damage, unlike the cutting tip of the hypodermic needle which could potentially cause damage. This fact, along with the potential side effects of the injectable medications, has provided a rationale by many insurance providers to limit the number of injections in a year. However, when compared to medications and surgery, the side effects of *any* needling technique are insignificant. Hypodermic needles can also cause increased patient discomfort.<sup>36</sup> This is important because past studies have shown that dry hypodermic needling can cause more posttreatment soreness than injection of anesthetic, thus providing a rationale for injection of anesthetic.<sup>8</sup>

In contrast, IMS bypasses these ill effects and can provide a better therapeutic outcome. In a well-designed RCT, IMS showed a significant benefit in Workers' Compensation patients with chronic myofascial low back pain. Fifty-six males who failed conservative treatment were studied. Follow up was done at 12 and 27.3 (average) weeks. Compared to the control group who received physical therapy and remedial exercises, 96% of the patients in the IMS group returned to work (62% to full and 35% to light duty). Treatments were performed once or twice a week. The average number of treatments was 7.9. In the control group, 67% returned to work (15% to full and 52% to light duty) ( $P > 0.005$ ).<sup>62</sup> In a study of 43 chronic whiplash patients, 79% remained significantly better after 2-year follow up.<sup>63</sup> In a study of 50 patients with tennis elbow who failed conservative treatment, 88% had no symptoms after long-term follow up.<sup>11</sup> In all of these studies, IMS was the only treatment modality and no diagnostic testing was necessary. Treatments were often done once or twice a week without any side effects. These findings suggest that IMS could potentially save global costs by avoiding the unnecessary use of treatments such as drugs, therapy, invasive injections, and surgeries, as well as tests such as CTs, MRIs, and discograms.<sup>11,12,25,62,63</sup> These treatments and tests could then be reserved for more appropriate patients who fail IMS treatment, which is usually a minority. In addition, patients can improve faster because treatments can safely be done once or twice a week.

## Neurogenic Inflammation and the Vagus Nerve

A recent relevant and important research finding has been made regarding inflammation. Medical dogma has it that inflammation is a chemically mediated process. This has been widely accepted. However, the chemical mediation works slowly and only works locally. It is dependent on concentration gradients and can take hours to days. Recent studies show that there is a neurogenic pathway that is more important clinically because it works discretely, is extremely localized, and acts as fast as lightning. Recent discoveries revealed that a neural pathway monitors inflammation reflexively.<sup>64</sup> When activated, the neural inflammatory response reacts reflexively and instantly, similar to a knee jerk reaction from stretching of the patellar tendon.

The inflammatory reflex and cholinergic antiinflammatory pathway of the vagus nerve act as follows. Pathogens activate immune cells that release cytokines. These activate sensory fibers that ascend in the vagus nerve and synapse in the nucleus tractus solitarius. Efferent signals in the vagus nerve suppress peripheral cytokine release through macrophage nicotinic receptors and the cholinergic antiinflammatory pathway. This reflex can also induce systemic humoral antiinflammatory responses. This occurs because vagus nerve activity can be relayed to the medullary reticular formations, to the locus ceruleus, and to the hypothalamus, leading to increased release of ACTH from the anterior pituitary.<sup>64</sup> Increased cytokines in tissues also cause pain. This information can be relayed to other brain centers that influence motor output in the vagus nerve. Pain and stress can activate the sympathetic response, which increases adrenaline and noradrenaline, inhibits macrophage activation, and suppresses synthesis of TNF and other cytokines.<sup>65-67</sup>

Tumor necrosis factor is an important inflammatory mediator. It is a cytokine that is produced by activated macrophages in response to pathogens. Locally it mediates the familiar inflammatory response. Systemically it mediates tissue injury by depressing cardiac output, inducing microvascular thrombosis and systemic capillary leakage syndrome. It amplifies and prolongs the inflammatory response by activating the release of other cytokines such as IL-1, IL-18, and HMGB1. The use of monoclonal antibodies against TNF have shown disease remissions in diseases such as rheumatoid arthritis and Crohn's disease.<sup>68</sup>

Identification of a cholinergic antiinflammatory pathway has been a breakthrough.<sup>69</sup> It was discovered that macrophages exposed to Ach from parasympathetic outflow are deactivated. The vagus nerve, because of its extensive course, is a major pathway. It is important not only for its innervation to the internal organs, but also to the blood vessels. It conducts nerve impulses antidromically (toward the CNS) directly into the dorsal horn.<sup>70</sup> Activation of the cholinergic antiinflammatory pathway through direct stimulation of the vagus nerve inhibits the synthesis of TNF in the liver, spleen, and heart and attenuates serum concentrations of TNF during endotoxemia.<sup>69,71</sup> In addition to systemic effects, vagus

nerve stimulation has been shown to suppress local inflammatory responses in a murine arthritis model.<sup>72</sup> Conversely, vagotomy exacerbates TNF response to inflammatory stimuli and sensitizes animals to the lethal effects of endotoxin.

The link between the cholinergic nervous system and the immune system is a nicotinic alpha-bungarotoxin-sensitive macrophage Ach receptor.<sup>69</sup> When macrophages are exposed to nicotine or Ach, the release of TNF, IL-1, and IL-18 in response to endotoxin is inhibited. Interaction between the macrophage cholinergic receptor and its ligand inhibits the synthesis of proinflammatory cytokines (TNF, IL-1, IL-18) but not antiinflammatory cytokines (IL-10).<sup>69</sup> Ach inhibits the expression of TNF protein in macrophages, not the induction of TNF messenger RNA levels, indicating that activation of the cholinergic receptor inhibits cytokine synthesis at a posttranscriptional stage.

Studies applying these principles show promise. Nicotine administration has been shown to reduce the severity of ulcerative colitis.<sup>73</sup> CNI-1493 is a small molecule that has been shown to inhibit macrophage activation and TNF release.<sup>74,75</sup> It has been shown to reduce disease severity in a small trial of severe Crohn's disease and is currently being evaluated in a large phase II trial of Crohn's disease.<sup>76</sup> CNI-1493 has been shown to be a stimulator of the vagus nerve<sup>71,77</sup> and intracerebral applications of small doses of CNI-1493 significantly inhibited peripheral TNF synthesis. The cardiac antiarrhythmic drug amiodarone has been identified as an inhibitor of TNF synthesis in monocytes *in vitro*,<sup>78</sup> but also functions as a potent stimulator of vagus nerve activity.<sup>79</sup> Systemic administration of aspirin, indomethacin, and ibuprofen substantially increases vagus nerve activity.<sup>80</sup> Over 10,000 patients have received implantable vagus nerve stimulators for epilepsy.<sup>81,82</sup> The immunological effects have not been studied but it would be interesting to assess whether TNF synthesis and inflammation could be modulated.

The clinical implications for needling are exciting. It is well known that needle puncture results in a current of injury. In addition, it causes local bleeding. Through these mechanisms, needling can also produce vagal stimulation, activating the neural inflammatory reflex, which, as described earlier, can act locally and systemically. Unlike vagal nerve stimulators or medications, dry needling is safer and its application is much broader throughout the body. It also offers the benefit of stimulating PDGR as well as mechanical release of contracted and fibrotic tissue.

## Sham Acupuncture

Sham acupuncture has been used in the past as a control group, and, according to the gold standard randomized double-blind paradigm, sham would prove to be the perfect control. However the neurogenic inflammation model shows why sham can have some beneficial effects, especially if done "blindly" in symptomatic areas, which is often the case. In the case of acupuncture and related techniques, randomized double-blind placebo-controlled trials are then impossible. This needs to be addressed given the fact that the medical community to some degree holds acupuncture in a less es-

teemed position due to the lack of randomized double-blind placebo-controlled trials. Perhaps with the awareness of this will come more understanding of the limitations inherent in the present research models. In addition, this poses an intriguing research question as to what extent needling can stimulate the inflammatory reflex by activating the vagus nerve through antidromic conduction via the blood vessels.

## Summary

Medicine is at a crossroads. As stated earlier, the definition of health by WHO is described as the balance between self, external agents, and the environment. Western medicine has made great strides in treating pathogens (external agents) and traumatic injuries (environmental). However it has failed miserably in treating the self. Despite all of our recent “advances” in pain management, chronic pain is increasing. Evidence for this is the ever-escalating cost of the chronic pain industry, not only in financial terms, but individual human lives and society as a whole. Chronic pain *remains* the second most common cause of lost wages. The incidence of drug dependence has been increasing steadily over the past 10 years. The incidence of death from NSAIDs equals the incidence of death from AIDS in the United States.<sup>83</sup> And of course, pain not only affects the patients, but their families, businesses, the healthcare system, and society as a whole. It has become a “society disease.”

All the while, the use of “traditional” treatments such as medications, physical therapy, injections, and surgery all continue to increase. What is happening? And why? As Einstein said, “You cannot solve today’s problems using yesterday’s solutions.” In fact, he may be right and what we may need is not another variant physical therapy, injection technique, or surgical procedure, or another ideology based on the present thinking, or another care-path, but a fundamental paradigm shift in understanding. The healthcare system has focused on treating disease, not on improving health. The focus must shift toward improving health—in restoring equilibrium and balance. Perhaps the mantra for Integrative Medicine should be “to restore balance.”

IMS provides a method to restore this balance. IMS does not treat individual diseases, but restores balance to the entire patient using the needle as a tool to achieve this outcome. The singlemost important outcome is restoring normal neurologic function in the PNS and the normal flow of Qi. It does this by combining both Eastern and Western philosophies. Eastern and Western philosophies have crossed paths many times with regard to medicine and in other fields. It appears that systems that employ both ideals, such as IMS, yield the greatest bounty. Perhaps this is an opportunity for us to re-evaluate and expand our model of chronic pain. This new model would use the best of the old and the new in a discriminating way. It would focus on restoring balance and on optimizing health, not on treating disease. This shift could produce safer and more effective treatments. This is an opportunity for Integrative Medicine to play a large and productive role, not only to restore balance in individuals, but in society as a whole.

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