MEDICAL ACUPUNCTURE: A WESTERN SCIENTIFIC APPROACH
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Acupuncture and the peripheral nervous system

C. Chan Gunn

INTRODUCTION

Western research into acupuncture has focused on the neurochemical basis of acupuncture analgesia and the CNS. In doing so, it has ignored the peripheral nervous system (PNS), and overlooked some important clues to acupuncture's effectiveness.

This paper reviews the relationship of acupuncture to the PNS, and proposes a model based on radiculopathy (which is peripheral neuropathy occurring at the nerve root). This model helps clarify many of the mysteries surrounding acupuncture and how it works in so many different conditions, including chronic pain. The model also shows that many traditional Chinese concepts can be reconciled with today's understanding of physiology.

Before describing the proposed radiculopathy model, the term 'acupuncture' will be examined. 'Acupuncture' is a word of Western origin which was coined in the sixteenth century to describe the Chinese use of a needle to promote healing in certain diseases. The Chinese themselves referred to this technique by many different names (e.g. 'needle effect', 'needle skill', or 'needle therapy') all of which indicate the central role of the needle. 'Acupuncture' can be confusing because it is used in medical literature to refer to a number of related, but not necessarily identical, modalities. The span of acupuncture's effectiveness depends on the modality used, combined with the knowledge and skill of the practitioner.

Varieties of acupuncture

It should be emphasized that classical or traditional acupuncture in China is only part of the whole philosophy of TCM (Sivin 1987). Most Western medical doctors practising acupuncture, or medical acupuncturists, have had training in classical acupuncture, but few practise the ancient principles of TCM, even though they continue to use TCM nomenclature and terminology. Medical acupuncturists, for instance, do not use TCM techniques such as pulse diagnosis for examination. They accept, instead, the neurochemical explanation for acupuncture analgesia; consequently, many of them restrict their practice to pain management. Many medical acupuncturists, in effect, use acupuncture as a form of trigger point therapy (Chapman & Gunn 1990); or as a procedure for electric stimulation (Lee & Liao 1990). Some Western researchers have called electrical stimulation with surface electrodes applied over acupuncture points by the term 'acupuncture', but this is incorrect as acupuncture implies needling. It should be termed instead 'transcutaneous electrical nerve stimulation' (TENS).

Acupuncture becomes perplexing when all versions, despite different methodologies and rationales, are claimed to be effective for a wide range of applications—everything from asthma to allergic rhinitis, from addiction to chronic pain. If these claims are true, how can such a simple procedure have such a prolific range of benefits? By what mechanism is needling effective? Western research, which concentrates on pain, has thrown some light on the neurochemical basis of acupuncture analgesia (Han & Terenius 1982), but has not produced a satisfactory explanation for all of acupuncture's applications.

Intramuscular stimulation

In recent years, more and more medical doctors have replaced TCM concepts to practise a contemporary version that is better attuned to neuroanatomic principles. The Multidisciplinary Pain Center, University of Washington School of Medicine, uses and teaches a system of dry needling that relies entirely on neuroanatomy. Examination, diagnosis and treatment, as well as progress of therapy, are all determined according to physical signs of peripheral neuropathy (Gunn 1989a). The system, referred to as 'intramuscular stimulation' (or IMS) to distinguish it from other forms of needling, is now used at many pain centres throughout the world.

IMS and the proposed model have been developed from the writer's conclusions following clinical observations and research carried out over a period of more than 20 years (first at the Workers' Compensation Board of British Columbia and subsequently at the writer's pain clinic). Some salient conclusions that have led to the radiculopathy model proposed in this paper are:

- acupuncture points are nearly always situated close to known neuroanatomic entities, such as muscle motor points or musculotendinous junctions (Gunn et al 1976)
- points that are found to be effective for treatment belong, more often than not, to the same segmental level(s) as presenting symptoms or the injury (Gunn & Milbrandt 1980)
- these points usually coincide with palpable muscle bands (sometimes called 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 (Gunn 1978)
- muscles with tender points are unfailingly shortened from spasm and contracture
- virtually all conditions that respond to needling demonstrate signs of peripheral neuropathy (Gunn 1989b, Gunn & Milbrandt 1978); these signs are not well known, and therefore frequently missed (Gunn & Milbrandt 1978)
- symptoms and signs typically disappear when the tender and tight muscle bands are needled (Gunn & Milbrandt 1980).

IMS practitioners therefore purposely seek out tender and tight muscle bands in affected seg-

ments for needling. Following needling, physical signs of peripheral neuropathy such as muscle spasm, vasoconstriction and tenderness often disappear within seconds or minutes, and it is extremely satisfying to see these signs disappear before one's eyes. Other signs, like trophedema, diminish gradually, maybe taking days or even weeks to disappear. Ultimately, however, all signs vanish following successful treatment. IMS practitioners, with extensive training in anatomy and neurophysiology, thus freed from the limited number of empirical points available in classical acupuncture, can be many times more effective than traditional acupuncturists.

Proposed radiculopathy model

This chapter reviews the specific effects of the needle on the PNS, and offers a model in which it is proposed that:

1. the many and various conditions amenable to needle therapy, including chronic pain, are essentially epiphenomena (or signs and symptoms) of abnormal physiology in the PNS that occur with radiculopathy (Gunn 1989b)
2. these various conditions (including any accompanying pain) improve when normal function is restored
3. the needle is a simple, yet unique tool, able to access the PNS to restore normal function.

In other words, although the needle in 'acupuncture' helps *many* conditions, they are but different facets of a *single* underlying condition—that is, radiculopathy. Needle therapy does not treat individual diseases. Rather, it aims to restore homeostasis to the entire patient. It helps many conditions by a single expedient—restoring normal function to the PNS.

SPONDYLOSIS AND RADICULOPATHY

Radiculopathy and denervation supersensitivity

TCM places great emphasis on Qi (Chi), the 'flow of energy' (Sivin 1987). Its physiological equivalent is probably the flow of nerve impulses in the PNS. When the flow of nerve impulses is blocked, innervated structures are deprived of the trophic factor. This factor (thought to be a combination of axoplasmic flow and electrical input) is normally delivered by the intact nerve. It is needed for the regulation and maintenance of cellular function and integrity. Structures deprived of the trophic factor become highly irritable and develop supersensitivity according to Cannon & Rosenblueth's law of denervation (1949):

When a unit is destroyed in a series of efferent neurons, an increased irritability to chemical agents develops in the isolated structure or structures, the effect being maximal in the part directly denervated.

Not all physicians are familiar with the condition of peripheral neuropathy. It may be defined as a disease that causes disordered function in the peripheral nerve. Although sometimes associated with structural changes, a neuropathic nerve can, deceptively, appear normal. It still conducts nerve impulses, synthesizes and releases transmitted substances, and evokes action potentials and muscle contraction. Muscle cells innervated by the axon, however, become supersensitive and behave as if the muscle had indeed been denervated. They generate spontaneous electrical impulses that can trigger false pain signals or provoke involuntary muscle activity (Culp & Ochoa 1982).

Supersensitivity also affects nerve fibres. These become receptive to chemical transmitters at every point along their length, instead of at their terminals only. Sprouting may occur, and denervated nerves are prone to accept contacts from other types of nerves, including autonomic and sensory nerve fibres. Short circuits are possible between sensory and autonomic (vasomotor) nerves and may contribute to reflex sympathetic dystrophy or causalgic pain.

Cannon & Rosenblueth's original work (1949) was based on total denervation or decentralization for supersensitivity to develop. Accordingly, they named the phenomenon 'denervation supersensitivity'. Today, however, it is known that physical interruption and total denervation are

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, and can cause *disuse* supersensitivity in that organ *and in associated spinal reflexes* (Sharpless 1975).

The importance of disuse supersensitivity cannot be overemphasized. When a nerve malfunctions, the structures it supplies become supersensitive and will behave abnormally. These structures overreact to many forms of input, not only chemical but physical inputs including stretch and pressure. Disuse supersensitivity is basic and universal, yet not at all well known or credited.

Spondylosis and degeneration

It is not unusual for the flow of nerve impulses to be obstructed. Peripheral neuropathy, which is often accompanied by partial denervation, is not exceptional in adults. There are innumerable causes of peripheral nerve damage, such as trauma, inflammation and infection; they may be from metabolic, degenerative, toxic and other conditions. The nerve's response to any agent, however, is always the same: dysfunction of the nerve.

Spondylosis is probably the most common cause of peripheral neuropathy (Gunn 1978). The spinal nerve root, because of its vulnerable position, is notably prone to injury from pressure, stretch, angulation and friction. Because spondylosis follows wear and tear, radiculopathy is typically seen in middle-aged individuals.

Ironically, radiculopathy itself contributes to degenerative conditions (including spondylosis!). Radiculopathy degrades the quality of collagen, causing it to have fewer cross-links: it is therefore more frail than normal collagen (Klein, Dawson & Heiple 1977). The amount of collagen in soft and skeletal tissues is also reduced. Because collagen lends strength to ligament, tendon, cartilage and bone, neuropathy can expedite degeneration in weight-bearing and activity-stressed parts of the body—which include the spine and joints.

EFFECTS OF RADICULOPATHY

This section reviews some of the repercussions of radiculopathy on the PNS. The effects of radiculopathy vary according to the type (sensory, motor, autonomic or mixed) and distribution of nerve fibres involved. All denervated structures can develop supersensitivity (including skeletal muscle, smooth muscle, spinal neurons, sympathetic ganglia, adrenal glands, sweat glands and brain cells).

Contracture and concurrent muscle shortening

Contracture, commonly referred to as 'spasm', is the evoked shortening of a muscle fibre in the absence of action potentials. It cannot be satisfactorily explained without reference to denervation supersensitivity.

Of the structures that develop supersensitivity, the most critical is striated muscle. Neuropathy can cause muscle contracture, with concurrent muscle shortening. These constant companions of musculoskeletal pain can be palpated as ropy bands in muscle (Fig. 9.1). Although shortened muscles are no longer

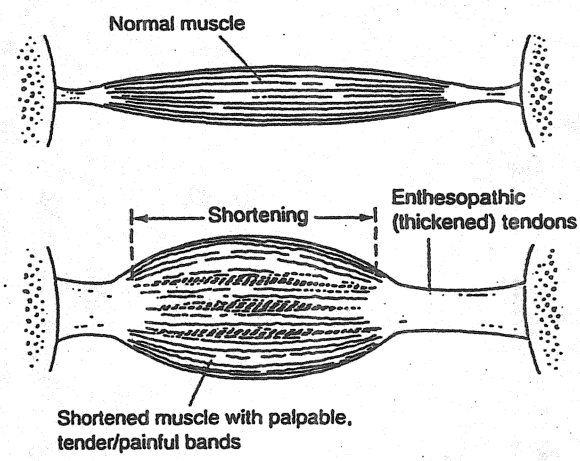

Figure 9.1 Neuropathy can cause muscle contracture, with concurrent muscle-shortening. (From Gunn C C 1996 The Gunn approach to the treatment of chronic pain. Churchill Livingstone, Edinburgh.)

believed to cause pain and tenderness by compressing normal nociceptors (Mense 1993), pain and tenderness may result when nociceptors are supersensitive. Thus, muscle bands, although usually pain free, can become focally tender and painful as trigger points.

When trigger points are numerous and widespread in the body, the condition has been called 'fibrositis', 'fibromyositis', or 'fibromyalgia'. This common condition causes much grief and distress because it is frequently misunderstood and therefore incorrectly treated.

Muscle shortening can cause further pain through mechanical pull. Such syndromes are discussed on pp 143–145.

Contracture is not maintained by volitional contraction, and cannot be ended by voluntary relaxation. When examined in the electromyograph (EMG), it is silent, as in a completely relaxed muscle; there are no motor units. The only findings are miniature endplate potentials (mepps) caused by the release of small packages or quanta of acetylcholine (ACh). This model postulates that these tiny potentials, although incapable of initiating contraction in normal muscle (which is sensitive to ACh only at the endplate region), can indeed initiate contraction in a supersensitive muscle that reacts to ACh along the entire surface of the fibre membrane. ACh slowly depolarizes the muscle membrane, and this induces electromechanical coupling.

Cannon described four types of increased sensitivity:

1. superduration of response, where the amplitude of responses is unchanged, but their course is prolonged
2. hyperexcitability, where the threshold for the stimulating agent is lower than normal
3. increased susceptibility, where lessened stimuli that do not have to exceed a threshold produce responses of normal amplitude and
4. superreactivity, where the ability of the tissue to respond is augmented. Contracture may thus represent muscle shortening of superduration, launched by mepps, in a superreactive and hyperexcitable muscle.

Trophedema, or neurogenic oedema, is a frequent companion of underlying muscle contracture. It may result from increased capillary permeability and impaired lymphatic drainage. Trophedema is easily confirmed by the 'peau d'orange' effect, or the matchstick test: trophedema cannot be indented by digital pressure, but when a blunt instrument is used, like the end of a matchstick, the indentation produced is clear cut and persists for many minutes (Gunn & Milbrandt 1978).

Radiculopathy and segmental autonomic reflexes

The actions of the sympathetic and parasympathetic systems are generally mutually antagonistic. The sympathetic system helps maintain a constant internal body environment, or homeostasis. It commands reactions that protect the individual, such as increase of blood sugar levels, temperature regulation, and regulation of vasomotor tone. The parasympathetic system lacks the unitary character of the sympathetic, and its activity increases in periods of rest and tranquillity. The TCM term 'rebalancing the Yin and Yang' (Yin and Yang representing opposing forces) probably parallels restoration of the balance between the two autonomic systems.

Sympathetic fibres in spinal nerves innervate the blood vessels of skin and muscle, pilomotor muscles and sweat glands. In emergency situations, there is a generalized sympathetic discharge and fibres that are normally silent at rest are activated: sweat glands, pilomotor fibres, adrenal medulla and vasodilator fibres to muscles. In radiculopathy, comparable reactions occur in the affected segment, *which indeed behaves as if it were in a state of emergency*. Vasoconstriction gives radiculopathy its cardinal feature—affected parts are discernibly colder, as may be shown by thermography. The pilomotor reflex is alerted, which may be manifested as 'goose bumps' in the involved dermatome; sudomotor activity may be profuse too.

Sympathetic fibres in visceral nerves innervate the intestine, intestinal blood vessels, heart, kidney, spleen and other organs (Fig. 9.2). As

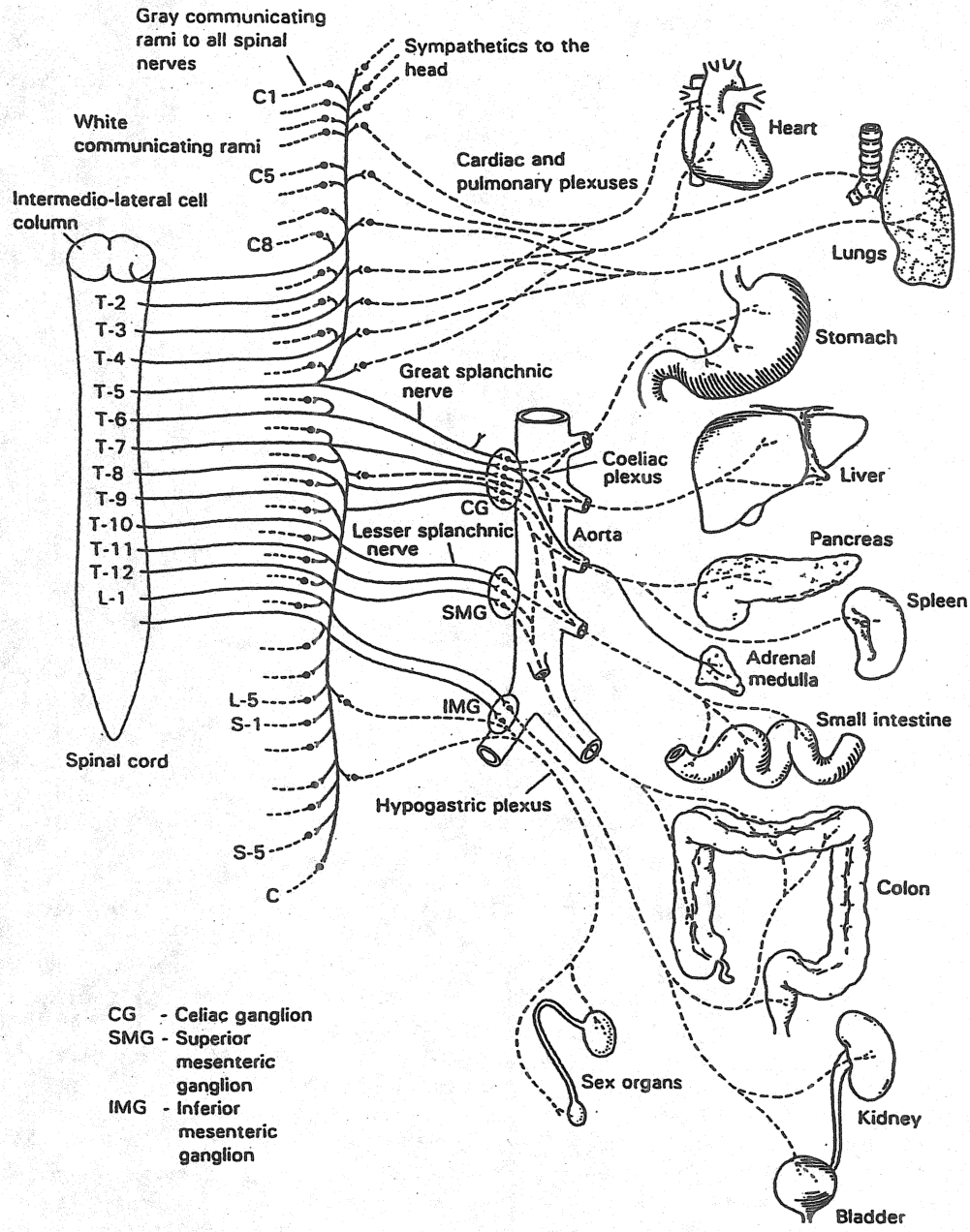

Figure 9.2 Sympathetic division of the autonomic system. (From deGroot J, Chusid G 1991 Correlative neuroanatomy, 21st edn. Appleton & Lange, reproduced with kind permission.)

with the somatic system, afferent impulses from the viscera connect with motor efferent neurons of the autonomic system in the spinal cord and brainstem. Fibres to the different visceral effectors are independent and discrete, and are carried out in reflex fashion. (Early TCM workers

indoubtedly noticed the association between the autonomic system and viscera—thus naming meridians after them.)

Although modulation of autonomic reflexes is carried out in the CNS, supersensitive segmental autonomic reflexes can be influenced and restored to normal by releasing muscle contractures in involved segments. For example, epiphenomena (or manifestations) of radiculopathy, such as tension headache, cluster headache, even migraine and allergic rhinitis, improve when supersensitive sympathetic nerve fibres are restored to normal (C1–3, Fig. 9.2).

Upper gastrointestinal complaints are common, but symptoms like heartburn, gastroesophageal reflux, non-ulcer dyspepsia and peptic ulcer disease are often difficult to differentiate from those of the irritable bowel syndrome (abdominal pain, abdominal distention, relief of pain with defaecation, frequent stools with pain onset, loose stools with pain onset, mucus passage and the sensation of incomplete evacuation or tenesmus). The two groups of symptoms may indicate, respectively, dysfunction in the greater and the lesser splanchnic nerves (Fig. 9.2).

Upper gastrointestinal complaints are usually associated with mid-dorsal back pain and signs of spondylotic radiculopathy (such as tenderness and trophedema) in the mid-dorsal back (T2–5). The irritable bowel syndrome is generally associated with the lower dorsal back (T5–L1), but it is not uncommon for a patient to suffer from both groups. Dorsal spondylosis commonly remains silent until symptoms are precipitated by emotional stress or physical strain (lengthy air travel and carrying heavy baggage, for instance).

There is a tendency to overinvestigate these symptoms because they can suggest something benign or something serious. Since these symptoms respond quickly to the release of paraspinal muscle contractures in affected segments, however, it is feasible and probably preferable to try IMS first.

Parasympathetic fibres travelling in the vagus nerve are abundant in the thorax and abdomen; they slow the heart, enhance digestion and produce bronchial constriction. Problems of bronchial constriction and secretion may be relieved with treatment to the cervical and upper dorsal spine.

Radiculopathy and chronic pain

Chronic pain can be the outcome of any (or a combination of) the following: (1) continuous stimulation of Aδ and C fibres from ongoing nociception (such as an unhealed fracture), or from ongoing inflammation (rheumatoid arthritis, for instance); (2) psychogenic factors (which are outside the present discussion), and (3) functional disturbances in the nervous system, when there may be supersensitivity in the pain sensory system, but no actual excitation of nociceptors from extrinsic sources.

Radiculopathic (and neuropathic) pain belongs to category (3); it typically occurs in the absence of ongoing tissue injury, nociception or inflammation. It is secondary to a functional disturbance in the nervous system (radiculopathy), and is always, therefore, accompanied by signs of neuropathy (Thomas 1984), which resolve after successful treatment. When radiculopathic pain involves primarily the musculoskeletal system, it is commonly called myofascial pain.

Radiculopathic pain in this model is deemed to be the *sensory* expression of the mixed manifestations (sensory, motor, autonomic and mixed) that can occur with radiculopathy, and pain is not a feature unless nociceptive fibres are involved. Other features of neuropathic pain (Fields 1987) include: (1) delay in onset after precipitating injury (supersensitivity takes at least 5 days to develop); (2) unpleasant sensations such as dysaesthesiae, or deep, aching pain; (3) pain felt in a region of sensory deficit; and (4) paroxysmal, brief, shooting or stabbing pain. Mild stimuli can be very painful (allodynia). Significantly, additional pain may be produced mechanically by muscle shortening.

The shortened muscle syndrome

Physical force generated by a shortened muscle can give rise to many painful conditions (Gunn 1990), as in the following examples which are *motor* manifestations of neuropathy:

• Shortening gives rise to tension in tendons and their attachments—when protracted, tension can cause such syndromes as epicondylitis, tendinitis, tenosynovitis, or chondromalacia patellae (Box 9.1, and Fig. 9.3). Because these syndromes appear dissimilar and occur at different anatomical sites, they are not currently recognized as having the same aetiology.

• When muscles acting on a joint shorten, they limit the joint's range. An example is acute torticollis, which results from shortening of the splenius capitis and cervicis muscles; an extreme

Box 9.1 Common myofascial pain syndromes caused by the shortened muscle syndrome

Muscles shorten on neuropathy and can compress muscle nociceptors to generate primary pain in muscle. Shortened muscles can also cause secondary pain by mechanically overloading tendons and the joints they activate; this increases wear and tear and can eventually lead to degenerative changes in these structures. Musculoskeletal pain syndromes are, therefore, of great diversity. In radiculopathy, muscles of both primary rami are involved, and symptoms can appear in peripheral as well as in paraspinal muscles of the same segment (all of which should always be examined). When paraspinal muscles shorten, they can press upon nerve roots and perpetuate radiculopathic pain. It is also important to note that radiculopathy can involve the autonomic nervous system (see Fig. 9.2). Some common syndromes are:

Syndrome	Shortened muscle
Achilles tendinitis	Gastrocnemii, soleus
Bicipital tendinitis	Biceps brachii
Bursitis, prepatellar	Quadriceps femoris
Capsulitis, frozen	All muscles acting on the frozen shoulder: deltoid, trapezius, levator scapulae, rhomboidei, pectoralis major, supra- and infraspinati, teres major and minor, subscapularis
Carpal tunnel syndrome	The median nerve can be entrapped by the pronator teres, and the tendinous arch connecting the humero-ulnar and radial heads of the flexor digitorum superficialis (the sublimis bridge). Trophedema can compromise the nerve in the forearm and carpal tunnel
Cervical fibrositis	Cervical paraspinal muscles
Chondromalacia patellae	Quadriceps femoris
De Quervain's tenosynovitis	Abductor pollicis longus, extensor pollicis brevis
Facet syndrome	Muscles acting across the facet joint, e.g. rotatores, multifidi, semispinalis
Fibrositis, fibromyalgia, (diffuse myofascial pain syndrome)	Multisegmental radiculopathy
Hallux valgus	Extensor hallucis longus and brevis
Headaches, frontal	Upper trapezius, semispinalis capitis, occipitofrontalis
Headaches, temporal	Temporalis, trapezius
Headaches, vertex	Splenius capitis and cervicis, upper trapezius, semispinalis capitis, occipitofrontalis
Headaches, occipital	Suboccipital muscles
Infrapatellar tendinitis	Quadriceps femoris
Intervertebral disc	Muscles acting across the disc space, e.g. rotatores, multifidi, semispinalis
Juvenile kyphosis and scoliosis	Unbalanced paraspinal scoliosis muscles (e.g. iliocostalis thoracis and lumborum)
'Low back sprain'	Paraspinal muscles: e.g. iliocostalis lumborum and thoracis, multifidi (see also 'Intervertebral disc')
Plantar fasciitis	Flexor digitorum brevis, lumbricals
Piriformis syndrome	Piriformis muscle
Rotator cuff syndrome	Supra- and infraspinati, teres minor, subscapularis
'Shin splints'	Tibialis anterior
Temporomandibular joint (TMJ)	Masseter, temporalis, pterygoids
Tennis elbow	Brachioradialis, extensor carpi ulnaris, extensor carpi radialis brevis and longus, extensor digitorum, anconeus, triceps
Torticollis (acute)	Splenius capitis and cervicis

Reproduced with permission from Gunn C C 1989a

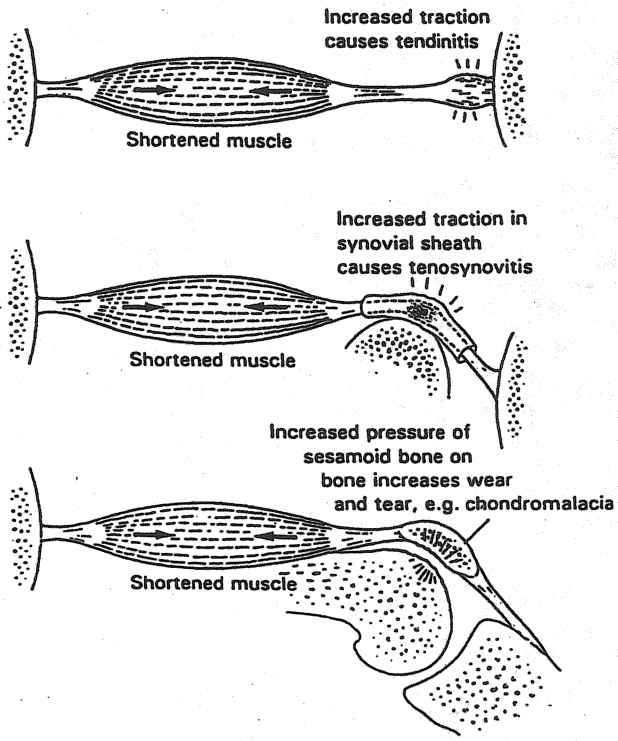

Figure 9.3 Shortening creates tension in tendons and their attachments and can cause such syndromes as epicondylitis, tendinitis, tenosynovitis, or chondromalacia patellae. (From Gunn C C 1996 The Gunn approach to the treatment of chronic pain. Churchill Livingstone, Edinburgh.)

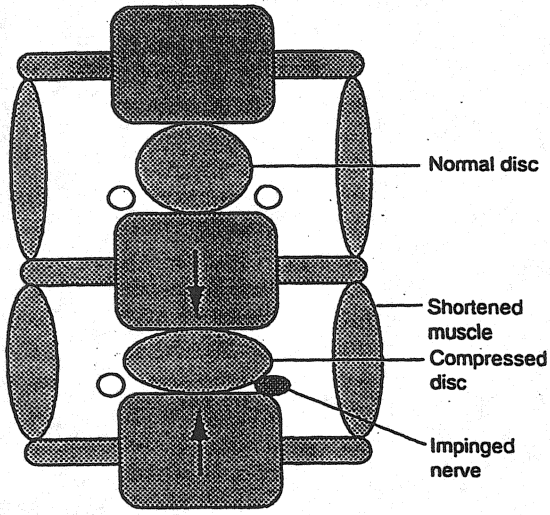

Figure 9.4 Shortened paraspinal muscles across an intervertebral disc space can compress the disc. (From Gunn C C 1996 The Gunn approach to the treatment of chronic pain. Churchill Livingstone, Edinburgh.)

example is the frozen shoulder, in which all muscles acting on the joint have shortened.

- Muscle shortening from contracture can upset joint alignment—hallux vulgus, for example, is due to shortening of the extensor hallucis longus muscle; the bunion is a secondary development.
- Increased pressure on the articular surfaces of a joint can cause arthralgia—as in medial knee joint pain. This pressure can lead also to a torn meniscus.
- Chronic restriction of joint range, misalignment and increased pressure on articular surfaces can eventually lead to degenerative arthritis or osteoarthritis.
- Pressure on a nerve can produce an entrapment syndrome—shortening in the pronator teres or pronator quadratus, for example, can give rise to symptoms of a carpal tunnel syndrome.
- The most critical of all the muscles that can shorten and press on, or pull upon, supersensitive structures to cause pain, are the paraspinal muscles that act across an intervertebral disc space. They draw adjacent vertebrae together, compress the disc, and narrow the intervertebral foraminae. The nerve root can be compressed by a bulging disc; or it can be irritated after it emerges from the intervertebral foramen (Fig. 9.4). A vicious circle can thus arise: pressure on a nerve root causes radiculopathy; radiculopathy leads to shortening in muscles, including paraspinal muscles, and shortening in paraspinal muscles further compresses the nerve root (Gunn 1989a).

The key to treating all radiculopathic conditions is releasing the shortened paraspinal muscles that pull adjacent vertebrae together and cause pressure on the disc and nerve root. *And here is where the acupuncture needle plays its unsurpassed role.*

CENTRAL ROLE OF THE NEEDLE

Acupuncture owes its full capabilities to the needle. The needle is the most effective instru-

ment devised for stimulating the PNS through muscle receptors. (At least 40% of nerve fibres innervating a muscle subserve sensory rather than motor end organs.) A primary object of treatment is to release muscle shortening, and the needle does this more swiftly and precisely than any other physical therapy, including TENS or shallow percutaneous procedures (in which a needle is used to pierce skin to overcome skin resistance).

When the needle is inserted, it is deftly tapped through the skin to avoid alerting Aδ nociceptive fibres located close to the surface. The needle is then eased through subcutaneous tissue and into muscle. The fine, pointed needle (unlike the cutting edge of a hollow needle used for injecting medications) pushes tissues aside and produces minimal tissue injury. Under normal circumstances, when there is no muscle shortening, the patient feels practically no sensation or pain. (C fibres sense pain only when there is cellular damage followed by the release of inflammatory, algogenic substances such as histamine, prostaglandin or bradykinin.)

Acupuncture and the current of injury

When the needle pierces muscle, it disrupts the cell membrane of individual muscle fibres, mechanically discharging a brief outburst of injury potentials referred to as 'insertional activity'. Less insertional activity occurs where muscle tissue has been replaced by fibrosis or necrosis, or where there is trophedema. Insertional activity is greater where muscle cell membrane has become hyperirritable.

Needle injury also generates long-lasting currents that are involved in repair and regeneration. The current of injury, first described by Galvani in 1797, has been shown (using a vibrating probe that can measure steady extracellular currents as small as 0.1 $\mu A/cm^2$) to generate up to 500 $\mu A/cm^2$ in a freshly amputated fingertip (Jaffe 1985). Unlike externally applied, short-lived forms of stimulation like massage or heat, the current of injury can provide stimulation for several days until the miniature wounds heal. Stimulation by using the body's response to injury is an important resource, as desensitization of supersensitivity can take many days (Lomo 1976, Thesleff & Sellin 1980).

The needle's role in healing

Needle therapy has another unique advantage that other physical modalities do not: it causes local bleeding. Bleeding promotes healing by delivering numerous growth factors, including platelet-derived growth factor (PDGF) (Ross & Vogel 1978). PDGF attracts cells, induces DNA synthesis and stimulates collagen and protein formation; it is, in fact, the principle mitogen responsible for cell proliferation. Body cells are normally exposed only to a filtrate of plasma (interstitial fluid); they do not normally come directly in contact with the platelet factor, except in the presence of injury, haemorrhage and blood coagulation.

Needle-grasp, De Qi and muscle proprioceptors

When the needle penetrates a shortened muscle, it can provoke the muscle to fasciculate and release quickly—in seconds or minutes. A shortened muscle that is not quickly released, however, will invariably grasp the needle. This needle-grasp can be perceived by the physician when an attempt is made to withdraw the needle. Leaving the grasped needle in situ for a further period (typically 10 to 30 minutes) generally leads to objective release of a persistent contracture. Failure of a correctly placed needle to induce needle-grasp signifies that spasm is not present and therefore not the cause of pain—in which case, the condition will not respond to this type of treatment.

When there are several muscles, each with many muscle bands or fasciculi requiring treatment, it may be necessary to hasten contracture release by augmenting the intensity of stimulation. The traditional method is to twirl the grasped needle—a motion that specifically stimulates proprioceptors. All forms of stimuli have their specific receptors: massage excites

tactile and pressure receptors; heat and cold activate thermal receptors; traction, exercise or manipulation stimulate muscle proprioceptors, and so on. As an alternative to twirling the needle, heat (moxibustion) or electrical stimulation is sometimes used.

How does twirling the needle work? When a muscle is in spasm, muscle fibres cling to the needle, and twisting causes these fibres to wind around its shaft. This coiling of muscle fibres shortens their length, converting the twisting force into a linear force. Unlike traction or manipulation, this stimulation is very precise and intense because the needle is precisely placed in a taut muscle band.

The needle-twirling manoeuvre vigorously stimulates muscle proprioceptors and gives rise to a peculiar, subjective sensation known in TCM as 'De Qi' (formerly written as Teh Chi) phenomenon. This distinctive sensation is an extreme version of the muscle ache felt in myofascial pain. Patients have variously described the sensation as 'cramping', or 'grabbing', or a 'dull, heavy ache'. De Qi is outside any normal experience of pain, and must be experienced in person in order to fully comprehend the unmistakable quality of myofascial pain. The muscle's grasp on the needle and the sensation the patient feels are both intensified as the needle is twirled to increase stimulation—until some moments later the shortened muscle is released with coincident disappearance of pain.

Twirling the grasped needle elicits the stretch or myotatic reflex (seen clinically in the knee-jerk). The reflex is activated by the muscle stretch and causes a contraction in that same muscle. Twirling the grasped needle is like stretching the muscle: it stretches muscle spindles, causing group-Ia fibres from the annulospiral endings to monosynaptically excite skeletomotor neurons that supply homonymous and synergist muscles. The same afferent volley disynaptically inhibits skeletomotor neurons that supply antagonist muscles.

Group-Ia and group-Ib fibres work together in close association; whereas the muscle spindle signals the velocity of muscle stretch and muscle length, the Golgi tendon organ (GTO) signals the velocity of muscle tension development as well as steady tension. Group-Ib fibres from the GTO make disynaptic inhibitory connections with both homonymous and synergist skeletomotor neurons.

By stipulating the needle-grasp and the De Qi phenomenon as requirements for diagnosis and treatment, TCM has perceptively recognized the central role of muscle proprioceptors in chronic neuropathic pain. Inserting a needle into normal muscle does not produce needle grasp or De Qi. Aδ and C fibres, carriers of injury signals, are not primarily involved in chronic neuropathic pain; their incitement produces nociception, which elicits a different reflex—the flexion or withdrawal reflex.

The important observation is this: when a shortened muscle is released, all associated epiphenomena of peripheral neuropathy (including pain, tenderness and vasoconstriction) vanish from the treated area, and sometimes from the entire segment. Simultaneous resolution of the different epiphenomena by reflex stimulation may be explained by the overlap of neuronal circuits in the periphery (where two reflexes may share the same afferent receptor population), and in the spinal cord (where the same interneuronal circuit and/or motor neuron may serve more than one reflex; Fig. 9.5).

It is important to note too that the end product of any single spinal reflex, such as a muscle contraction, will itself initiate other reflexes.

CHALLENGES OF DIAGNOSIS AND TREATMENT

Clinical diagnosis

Diagnosing pain and dysfunction caused by radiculopathy can be difficult. A history gives little assistance. Pain often arises spontaneously, with no history of trauma; or else the degree of reported pain far exceeds that consistent with the injury. Laboratory and radiologic findings are generally not helpful either. Thermography can reveal decreased skin temperature in affected dermatomes but does not itself indicate pain or identify individual painful muscles.

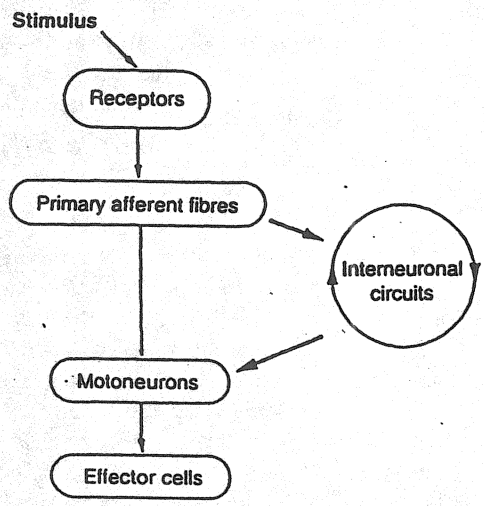

Figure 9.5 Information flow in the nervous system. Receptors transmit information to the CNS via primary afferent fibres, which synapse on to either motoneurons or interneurons. The latter may activate other interneurons, either in the cord or in the brain. Following complex patterns of interactions among these cells, information is fed to motoneurons and effector cells.

Signs of neuropathy are subtle, and differ from those of outright denervation (such as loss of sensation and reflexes). Radiculopathies are difficult to document with routine nerve conduction studies, which measure only the few fastest-conducting and largest fibres and take no account of the majority of smaller fibres. In focal neuropathy, nerve conduction velocities remain within the wide range of normal values, but F wave latency can be prolonged. Electromyography is not specific either.

In view of these considerations, diagnosis depends almost entirely on the examiner's clinical experience and acumen. A careful inspection for signs of motor, sensory, trophic, or autonomic dysfunction in the skin and affected muscles is necessary. Because changes in these conditions are primarily in muscle, even when symptoms appear to be in joints or tendons, signs in the muscles are the most consistent and relevant: increased muscle tone; tenderness over motor points; taut and tender, palpable contracture bands; and associated restricted joint range.

It is important to remember that, in radiculopathy, signs are generally present in the territories of both the posterior primary division and the anterior primary division of the affected nerve root or the formed nerve. Consequently, the symptoms are projected on to the dermatomal, myotomal and sclerotomal target structures supplied by the affected neural structure. Knowledge of the segmental nerve supply to muscles and bones is essential for diagnostic treatment. Each constituent muscle must be palpated and its condition noted. The most effective sites of dry needling are at muscle motor points and musculotendinous junctions. The procedure requires detailed knowledge of anatomy, and clinical skill comes only with practice. Moreover, because many paraspinal muscles are compound (e.g. the longissimus) and extend throughout most of the length of the vertebral column, the entire spine must be examined even when symptoms are localized to one region.

The needle as a powerful diagnostic tool

The needle is more than a therapeutic tool: it is a powerful diagnostic tool as well. Indeed, deep contracture can *only* be discovered by probing with a needle. Contracture is invisible to X-rays, CAT scans, or MRI, and contracture in deep muscles is beyond the finger's reach. The fine, flexible needle transmits feedback on the nature and consistency of the tissues it is penetrating. When it penetrates normal muscle the needle meets with little hindrance, when it penetrates a contracture there is firm resistance and the needle is grasped, and when it enters fibrotic tissue, there is a grating sensation (like cutting through a pear). Sometimes the resistance of a fibrotic muscle is so intense (the hardness can be mistaken for bone) that extreme pressure may be required to force the needle in.

Guided by the needle-grasp and the De Qi, an examiner is able to identify the distressed segment quickly, and with greater accuracy than with X-rays, scans or MRIs. Indeed, radiological findings may mislead by showing older, non-active lesions.

Treatment considerations

When irritation to a nerve is minor, neuropathy can be a transient condition, and releasing shortened muscles may be all that is necessary to restore function while the nerve heals. When shortened muscles are released, pain and joint range improve. Treating the several most painful shortened bands in the muscle is usually followed by relaxation of the entire muscle.

In recurrent or chronic pain, fibrosis generally becomes a feature of the contractures, and response to treatment is then much less dramatic and less effective. The extent of fibrosis is not necessarily correlated with chronological age; scarring occurs after injury or surgery, and many older individuals have less wear and tear than younger ones who have subjected their musculature to repeated physical stress. Treatment of extensive fibrotic contractures necessitates more frequent and extensive needling, and release of the contracture is often limited to the individual muscle band treated. To relieve pain in such a muscle, therefore, *all* tender bands require treatment. In chronic myofascial conditions, the needle can be used to disperse fibrotic tissue entrapping a nerve.

For long-lasting pain relief and restoration of function, it is essential to release shortened paraspinal muscles that are compressing a disc and irritating the nerve root. Surgical intervention is rarely necessary, as the needle can reach almost all shortened muscles.

The efficacy of IMS therapy for chronic low back pain was demonstrated by a randomized clinical trial involving a large group of patients in the British Columbia Workers Compensation Board (Gunn & Milbrandt 1980). At their 7-month follow-up, the treated group was clearly and significantly better than the control group. It is worth noting, however, as examination skill improves, that any physical change in the patient condition becomes self-evident and unmistakable.

DISCUSSION

Many Western researchers are unaware of neuropathic pain. They generally assume chronic pain to be ongoing signals of tissue damage (nociception or inflammation) conveyed to the CNS via a healthy nervous system. As a consequence, they are preoccupied with analgesia and the suppression of nociception. When endogenous opioids were discovered, these researchers assumed that acupuncture worked as a neuromodulating technique, activating multiple analgesia systems in the spinal cord and brain, and stimulating the endogenous pain suppression system to release neurotransmitters and endogenous opioids. However, neurochemicals are most likely to be released under stressful conditions (including drug and smoking withdrawal), which do not even necessarily produce pain. Their role may be to modulate the various homeostatic mechanisms and act as an endocrine–endorphin stress system that complements the neuronal regulatory system.

In fact, acupuncture's suppression of nociception is limited; acupuncture cannot be relied on to block the perception of a noxious input, and even in China it is not a popular choice for surgery.

CONCLUSION

Classical acupuncture is a clever TCM technique, and it is amazing that early workers, centuries ago, appeared to have comprehended so many fundamental principles of health and disease—principles that are often overlooked in today's technological age. These workers, with extraordinary insight, seemed to understand the nature of the trophic factor, the crucial flow of nerve impulses in the nervous system (Qi or Chi), and the need for balance in the parasympathetic and sympathetic autonomic systems (Yin and Yang). They described the critical role of proprioceptors (De Qi), and identified strategic loci (acupuncture points) where these could be accessed.

While many of its ancient philosophic concepts can be reconciled with modern physiology, classical acupuncture does have its limitations. With today's advanced scientific knowledge, however, we can build upon that classical knowledge. In intramuscular stimulation, diagnosis and treatment are correlated with physical

signs of peripheral neuropathy, and the medical practitioner, thanks to extensive training in anatomy and neurophysiology, is able to treat any accessible part of the body without constraint by the limited number of traditional points prescribed in classical acupuncture.

The needle is effective in treating many diseases that are resistant to Western methods of treatment by accessing the PNS and reversing peripheral nerve dysfunction. The puzzle of how acupuncture works in so many different conditions is understood when these conditions are seen as being related to radiculopathy.

Because intramuscular stimulation is so effective, it should be taught in all medical schools. Knowledge of IMS can provide an excellent bridge between Eastern and Western medicine. Indeed, not only does IMS bridge the gap between them, it transcends the limitations of both.

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