Acupuncture and pain: A review of the literature

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In the United States today, as many as one third of the population suffers from chronic pain conditions. These syndromes cost an estimated $80 billion and are a major source of burden to the healthcare system as well as to the suffering patients. According to a study by Harvard Medical School in 1997, visits to alternative medicine providers had reached 629 million, mostly for these pain conditions.

The action of acupuncture as an analgesic, although widely accepted, remains somewhat of an enigma. In reviewing the literature it became evident that many investigators have had conflicting data; however, with regard to acupuncture in pain management, quite a few results were found to be positive.

Many now believe that acupuncture should be considered a valuable asset in the specialty of pain, and that it can be of value in comprehensive pain clinics as well as physical therapy practice. Acupuncture is certainly not a cure-all; however, researchers and experienced clinicians both attest to its benefits.

This article is a review of the literature with regard to acupuncture as a modality for pain management.

Key words: **Acupuncture, alternative medicine, chronic pain, complementary medicine, pain management.**

In the United States today, as many as one third of the population suffers from chronic pain conditions, and the annual cost of chronic pain is estimated to be at least $80 billion.[1] The cost includes millions of lost workdays, costs of the necessary healthcare, and the consequences of pain in terms of compensation and litigation.

Headaches are still the number one chronic pain problem in the United States, with back pain a close second.[2,3] Back pain contributes greatly to the tremendous healthcare costs, partly because it renders otherwise healthy individuals to lose time from work. Statistics reveal that about 10% of patients with acute low back pain do not improve after 4 to 6 weeks and progress into chronic pain syndromes.[4]

This discussion will review the basics of Western medicine theories and treatment modalities of pain, followed by an in-depth look at acupuncture. The discussion will touch upon the theory of acupuncture with a concise review of the investigations that have been undertaken to provide scientific data for its effectiveness in pain management.

Mechanisms of pain

Pain is a sensory and emotional experience associated with actual tissue damage or described in terms of such damage.[5] In the classic descriptions of pain, tissue-damaging or tissue-threatening stimuli send neurophysiologic messages directly from the peripheral receptors to the sensory cortex via specific pathways in the peripheral and central nervous systems; the greater the stimulation of the peripheral receptor, the more severe the pain.[1] More recent research indicates that this simple concept of pain is rather rudimentary especially with regard to chronic pain.[6] Pain impulses from the periphery are transmitted by A-delta (A-δ) fibers and C fibers.[1] A-δ nerves are small and myelinated and transmit fast-sharp, pricking sensations. C polymodal fibers also are small but unmyelinated; these fibers transmit fast-dull, achy and diffuse pain, and thermal and chemical impulses.[1] The A-δ fibers increase their firing rate with increased stimulus intensity but demonstrate lessening activity with repeated stimulation.[7] In contrast, the C fibers have larger receptive fields and have input that does not fatigue or extinguish with repeated stimulation.[7] When information from these pain pathways synapse in the dorsal horn of the spinal cord, they are modified, dampened, or augmented. Peptides such as substance P, somatostatin, cholecystokinin, enkephalins, glutamate, aspartate, and vasoactive intestinal polypeptide act as neurotransmitters.[1] The release of these transmitters continues propagation of the neural response. Repetitive stimulation of the dorsal horn neurons involved in the pain response causes the frequency of discharge to increase.[1] This phenomenon is termed sensitization or "wind-up."[3] This manifests as a pain syndrome whereby less peripheral stimulation is required to activate a pain response. Thus, stimuli that are normally not painful cause the patient to have pain, and the pain lingers even after the stimulus has been discontinued.[3]

There are 2 classifications of pain: acute and chronic, now termed inflammatory and neuropathic respectively.[1] The newer nomenclature for these 2

types of pain places an emphasis on the fact that chronic pain is more involved because it produces significant changes in the central nervous system (CNS). These changes include the induction of A-alpha (A-α) fibers and A-beta (A-β) fibers to transmit nociceptive input, the use of neurotransmitters that vary from those involved in acute pain response, an increase in receptive fields, remodeling in the CNS, and the sensitization of the CNS by constant input from noxious stimuli.[1] Chronic pain is influenced by the intensity of the stimulus, the interaction between the stimulus and the afferent modulating systems within the CNS, and most importantly, by a variety of behavioral and learned strategies that intensify or suppress the resulting neurophysiologic event.[1]

There are several existing modalities for treatment of pain in the traditional Western medicine practice of pain management. Pain as a specialty has grown and continues to draw the attention of the medical community.

Western medicine treatment regimens

The goals for treating acute pain versus chronic pain are vastly different. In acute (inflammatory) pain, the aim is to eliminate pain and return the patient to a premorbid functional level. In chronic (neuropathic) pain, the goals are to achieve a maximum reduction in pain, assist the patient in coping with residual pain, and finally, increase the patient's ability to function.[8]

• *Medications.* Nonsteroidal anti-inflammatory drugs and acetaminophen are the most useful analgesics used for chronic pain. The narcotic analgesics have traditionally been used for acute pain or for malignant pain because of their short duration of action. The potential for tolerance and physical dependence have impelled practitioners to use these agents rather cautiously in chronic pain scenarios. Fortunately, as pain medicine has developed and research has been reported, data show that selected patients can use opioids responsibly on a long-term basis and that physicians' attitudes about such use are changing.[9]

Anticonvulsants, antidepressants, and sedative-hypnotic agents also are used in conjunction with nonsteroidal anti-inflammatory drugs and narcotics. For example, the use of the tricyclic antidepressant, Amitriptyline, is widely used in treating human immunodeficiency virus (HIV) related neuropathies, and it has been shown to be an effective adjunct.[10] Most of these drugs have substantial side effects, which can vastly alter a patient's lifestyle.

• *Nerve blocks.* Myofacial trigger point injections, sympathetic nerve blocks, stellate ganglion blocks, lumbar sympathetic blocks, celiac plexus, hypogastric plexus, and ganglion impar (denervation of the lower pelvic structures and perineum) blocks have all been used in attempts to alleviate acute as well as chronic pain with varying degrees of success.[11,12] Epidural steroid injections have been used for some time for chronic back pain; however, controversy rages with regard to this widely used therapy, and specific guidelines and indications are awaited.[13] Obviously, as with many invasive treatment modalities, all of these procedures are plagued with numerous side effects.

• *Neurosurgical techniques.* Surgery has been performed on almost every conceivable part of the nervous system in an attempt to control pain.[14] These procedures often provide the patient with good relief; however, pain often returns over time. Therefore these procedures are reserved for the terminally ill cancer patient with pain. Percutaneous cordotomy interrupts the lateral spinothalamic tract of the spinal cord and again provides a high degree of pain relief only within the first year of treatment.[15]

Traditional Chinese medicine and acupuncture

In contrast to Western medicine, pain is not looked upon as a symptom but as a disease in and of itself. The patient is examined holistically, and a diagnosis is made based on many variables. The science of acupuncture is an important component of traditional Chinese medicine (TCM) used in prevention and treatment of disease. According to TCM, the body consists of meridians and collaterals, which are pathways in which the *qi*, energy of life (pronounced "chi") and blood circulate. These pathways correspond to the various body organ systems named the *Zang-Fu* organs. These organs are similar to those of Western medicine, such as the heart, lung, etc, but are not viewed in the same manner. The meridians and collaterals are believed to pertain to the organ systems interiorly and extend over the body exteriorly forming a network that links the tissues and organs into an organic whole. There are 12 regular meridians, 8 extra meridians, 15 collateral meridians, and 12 divergent meridians. The functions of these meridians are to transport *qi* and blood, regulate yin and yang (the balance of the body), resist pathogens, and reflect signs and symptoms such as pain.[16] They also transmit needling sensation, thereby regulating deficiencies or excesses, which in TCM are believed to be the main cause of disease and pain. Acupuncture treatment is thus often aimed at regulating the flow of *qi* in the meridians and collaterals by dissipating excess and tonifying deficiency, as well as balancing the yin and yang of the body.

According to Chinese medicine, pain is defined as obstruction in the circulation of *qi* and blood in the

channels. This obstruction of energy can be caused by many factors, either environmental or arising from within the organism's body. In TCM, cold, heat, dampness, and wind are all causative environmental agents that can contribute to pain syndromes. Inactivity, poor diet, excessive alcohol and drug intake, as well as overactivity, emotional issues, and trauma are all considered causative agents that, over time, can produce weakness of the body's energy. This weakened state then predisposes the patient to disease and pain.

Treatment modalities are aimed at recognizing the causative agents and directing treatment to relieve them, as well as palliating symptoms such as pain. Once a diagnosis has been made, the treatment can include acupuncture, herbal medicine, moxibustion (the burning of a special Chinese herb on acupuncture points), and/or cupping, a suctioning method similar to massage. Acupuncture is a relatively noninvasive procedure, whereby the practitioner inserts stainless steel, sterile needles into certain designated points on the body. There are generally 361 acupuncture points distributed over the anterior and posterior aspects of the body and limbs and on the head and face. These points are spread over the meridians and pathways and are used to regulate the *qi* and blood of the meridians. There also are many auricular points representing various organs, as well as the limbs, trunk, head, etc.

In the case of pain, the treatment usually consists of needling the points on the meridian where the obstruction of *qi* has occurred, as well as some distal points on meridians that are related to the ailing meridian in a direct fashion. Auricular points also have been used with some degree of success.

Review of the literature

Visits to complementary medicine providers, such as chiropractors, acupuncturists, homeopathists, and other more esoteric therapists now exceed patient visits to traditionally trained primary care physicians.[17] According to a study by Harvard Medical School in 1997, visits to alternative medicine providers had reached 629 million, an increase of 47% since 1990.[17] Many of these treatments are paid for out-of-pocket; however, 67% of health maintenance organizations are willing to pay for at least 1 kind of complementary treatment. Chiropractic care and now acupuncture are the most common therapies.[17] The properties of acupuncture and its validity as a modality for the treatment of pain have long been examined in hopes of finding supportive scientific data. This article is a review of some of these pain studies conducted since 1975.

Research strategy

The National Institute of Health's Medline was searched for studies conducted on acupuncture since 1975 in the United States as well as in other nations. These articles were further explored for their relevance to pain management. All related research studies were carefully examined with regard to their methodology and significance. Those investigations that demonstrated strong methodology with a solid scientific basis were chosen. The studies used human as well as animal subjects and were based on the scientific method.

Neck and back pain

US Agency for Healthcare Research and Quality (formerly the US Agency for Health Care Policy and Research) and the National Center for Complementary and Alternative Medicine have awarded grants totaling $1 million grant to investigators studying acupuncture as a treatment modality for chronic low back pain.[18] This is due to many previous studies that have hinted at the effectiveness of acupuncture in this arena.

In a study of clinical response to acupuncture therapy and back pain, Shifman[19] classified 328 patients into 13 categories of varying back pain. He found that in general for each problem disorder, such as lumbar pain with or without radiation, the average positive response ranged from 60% to 65% after 3 weeks of acupuncture treatments. Laitinen[20] demonstrated that in 50 patients suffering from chronic sacrolumbalgia and ischialgia, treatments with acupuncture at a mean of 5 treatments was effective in more than half the group. Pain relief was noted to be complete or moderate in 58% of the cases, after 2 months about 60% still had relief, and after 6 months he found that 30% remained moderately to completely pain free.

In a 1983 study, Petrie, and Langley[21] ascertained that acupuncture was indeed superior to placebo in relief of pain in patients with chronic cervical discomfort ($P < .01$).

The effects of acupuncture on sciatic pain also have been studied by several investigators. Fischer et al[22] used electroacupuncture on 26 sciatica patients in a large multidisease study. They found that 65% of their patients had some relief. Forty-two percent of these patients were rendered symptom free without medication, but 35% felt only a slight improvement to no improvement at all.

In a randomized controlled study, Coan et al[23] examined 30 neck-pain patients' response to acupuncture. After 12 weeks, they found that 80% of the treated group felt improved, with a mean 40% reduction in pain score, 54% reduction of pain pills, and

32% less limitation of activity. The control group had a mean 2% worsening of the pain score, 10% reduction of pain pills, and 12% less limitation of activity.

Petrie and Hazleman[24] also investigated the effects of acupuncture on neck pain. They performed a randomized trial of acupuncture versus placebo transcutaneous nerve stimulation. A single-blind, non-crossover design was used and incorporated several outcome measures. These scientists found no significant difference between acupuncture and a strong placebo. In 1987, a year after the above study, Pen et al[25] studied 37 patients with chronic neck and shoulder pain. All their patients had been unresponsive to conventional and placebo treatments for their pain. More than half (64.9%) of their patients obtained significant long-term improvement, which they thought was a subsequence of increase in regional microcirculation by peripheral sympathetic blockade from electroacupuncture.[25]

Conflicting data such as those seen in the above studies are not uncommon, and the effectiveness of acupuncture on chronic neck and back pain remains somewhat controversial. The multifacility study, aforementioned, being funded by the US Agency for Healthcare Research and Quality and the National Center for Complementary and Alternative Medicine will be conducted over a 3-year period at the Northwest Institute of Acupuncture and Oriental Medicine, University of California, San Francisco, Calif, and Washington University, St Louis, Mo.[18] This study will investigate issues such as whether acupuncture is effective for lower back pain, whether acupuncture is more effective when needles are inserted into acupuncture points compared with non-acupuncture points, and whether acupuncture is more effective than standardized medical care.[18]

Dental pain

The efficacy of acupuncture for treatment of dental pain has long been respected by many Oriental medicine practitioners, and is often used in the management of dental patients in China. It also is one of the most commonly studied treatment modalities for such pain. In a study conducted in 1975, Chapman et al[26] compared responses to electrical stimulation of the tooth pulp in both baseline and test sessions for subjects receiving acupuncture, 33% nitrous oxide, or control conditions. A signal-detection analysis across all sessions showed that both treatment groups (those given acupuncture and those given 33% nitrous oxide) demonstrated reduced sensitivity to stimulation. The study also showed an increase in bias against reporting strong stimuli as painful. The authors concluded that acupuncture was as effective as nitrous oxide for reducing dental pain.

The effect of acupuncture on the pain perception threshold of human teeth was investigated by Bakke.[27] He found that compared with the control group's threshold for pain at 8.44 μA, the acupuncture group's threshold for pain was accompanied by a small increase, most pronounced after 45 minutes of acupuncture, to 1.51 μA ($P < .0005$). Although this was a significant finding, the author observed that the resulting hypalgesia was insufficient to justify acupuncture as a sole means of pain control in conservative dentistry.[27]

A similar study demonstrated a 187% increase in dental pain threshold over a 20-minute period of acupunctural stimulation.[28] However, subjects in this analysis were able to perceive some of the stimuli presented below threshold level following acupuncture. This rendered the threshold concept inadequate as a description of the phenomenon.[28] The authors attempted to discuss other possible explanations, with most needing further investigation.

Ha and Tan[29] replicated the above studies on monkeys and observed that needling and applying pressure to acupuncture points indeed raises the pain threshold of tooth pulp. Some acupuncture points were observed to be more effective than others, causing a significant rise in threshold.[29]

Chapman et al[30] were further interested in examining the comparative effects of acupuncture in Japan versus the United States on dental pain perception. They compared 20 Japanese to 20 American patients in 2 functionally identical laboratories: one in Yonago, Japan, and the other at the Washington University, St Louis, Mo. Each subject underwent a control and an acupuncture session. Sensory decision theory analysis demonstrated a significant reduction in perceptual capability and an increased bias against reporting stimuli as painful following acupuncture.[30] They found no significant differences between groups in alteration of perceptual capability, bias, or pain threshold. This they concluded was evidence that the cultural and racial differences studied did not influence responses to acupuncture in a laboratory setting.[30] This analysis was interesting as it examined the cultural issues associated with pain perception and acupuncture.

Musculoskeletal and arthritic pain

Many patients suffer from arthritis and arthritic pain in the United States. As the number of elderly grows so does the number of patients with osteoarthritis and pain associated with it. In a double-blind study, Gaw et al[31] examined the efficacy of acupuncture on osteoarthritic pain. Forty patients were assigned randomly to an experimental and a control group. The

experimental group received treatment at standard acupuncture points, and the control group received treatment at placebo points. Analysis before and after treatment showed a significant ($P < .05$) improvement in tenderness and subjective report of pain in both groups.[31] Comparison of responses to treatment between the 2 groups showed no significance ($P > .05$). Thus both experimental and control groups showed a reduction in pain after the treatments. The authors concluded that their results may have reflected various attitudinal and social factors, as well as the natural course of the illness.

In a more recent study, Berman et al[32] performed a randomized trial of acupuncture as an adjunctive therapy in osteoarthritis of the knee. Seventy-three patients with symptomatic osteoarthritis of the knee were randomly assigned to treatment (acupuncture) or standard care (control). Patients self-scored Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Lequesne indices at baseline and at 4, 8, and 12 weeks.[32] Patients randomized to acupuncture improved on both WOMAC and Lequesne indices compared to the control group. The authors concluded that their data suggest that acupuncture is an effective and safe adjunct therapy to conventional care for patients with osteoarthritis of the knee.

Acupuncture also is widely used in musculoskeletal pain, trauma pain, and sports injuries. In fact, several professional sports teams now have a staff acupuncturist that deals solely with injury-induced athletic pain.

Acupuncture therapy for patients suffering from tennis elbow has shown itself to be an excellent alternative to steroid injections.[33] In a study by Brattberg,[33] 21 out of 34 patients who were treated with acupuncture became much better—completely free of pain. Many of them had been given previous steroid injections without improvement. The author concluded that acupuncture is well worth trying as therapy for this disabling complaint.[33]

Unlike Brattberg,[33] Godfrey and Morgan[34] found no significant difference in the improvement of musculoskeletal pain between a group that received sham acupuncture versus true acupuncture. In a similar study, acupuncture was offered to Nigerian patients with disorders of the musculoskeletal system.[35] These patients had received conventional physiotherapy with limited success. The authors found that response to acupuncture was excellent in the more acute conditions of low back pain and frozen shoulder. The more chronic conditions required many more treatments and the improvement recorded was significant, though not complete.[35] It was concluded that acupuncture has a valuable role to play in a physiotherapy department. Indeed, in recent years, many private and government-subsidized hospitals (such as Walter Reed Army Medical Center, Washington, DC), have incorporated acupuncture into their physical therapy departments.

Chronic pain syndromes

Given the prevalence of pain syndromes and the vast cost of healthcare delivery for chronic pain, the advantage of using acupuncture over other expensive treatment modalities is obvious. Its use in conjunction with medications to reduce dosages and allay side effects is an important value. As a result, many studies have been conducted to examine the benefits of acupuncture in this arena.

Lewis et al[36] conducted an investigation of chronic pain patients receiving acupuncture. They found that all of their patients had considerable experience with traditional medical care for their problems.[36] More than one third indicated that they sought acupuncture as a "last resort."[36] An initial psychological profile was performed and was within normal range for all of their patients. Upon completing 6 or more treatments, 74% said they had been helped. Of those followed for 3 months, 54% had been improved, and 24% contacted 1 year later were still improved. They found that a subgroup of patients who received only temporary improvement had significantly different scores on psychological scales. They deduced that the results in this group may have been because of a placebo effect. They also discovered that a significant portion of those who dropped out of treatment did so because they had achieved the desired benefits.

In an interesting study, Lee et al[37] found that in performing acupuncture for 261 chronic pain patients, on classic acupuncture points and other nonacupuncture points, 17% reported a 50% reduction in pain. Most of their patients (65%) had little to no relief, but 18% had a 75% reduction in their pain. The majority of patients in the latter group had received acupuncture in the proper points, again increasing the validity of acupuncture points versus sham points.

An opposite finding occurred in an evaluation of 10 sickle cell anemia patients during 16 pain crises.[38] The patients in this study served as their own control, in that both patient and examiner were unaware of whether an acupuncture, meridian loci needling, or a sham site was treated. The results demonstrated that pain relief was obtained in 15 out of the 16 crises (94%) episodes regardless of meridian loci needling or sham needling, and that needling, whether at either site, can be useful for alleviating pain in sickle cell crises and potentially other pain syndromes.[38]

Yamauchi[39] performed acupuncture on 72 chronic pain patients over a 1-year period. At the completion of treatment, 26% showed marked improvement, and 27% reported improvement. Long-term results were assessed at a mean of 4 months after the final treatment, with 15% reporting marked improvement and 27% continuing to assert improvement.[39]

Based on their examination, Spoerel et al[40] discovered that in 38 of their chronic migraine patients, 81% reported betterment. Sixty-one percent of their other 99 chronic pain patients also noted an improvement, with 69 patients still reporting a worthwhile degree of relief over the observation period of 2 months.[40] Thirty-nine percent of all their patients combined (n = 200) had little to no relief. The authors concluded that since a majority of their patients felt better after acupuncture treatments, that acupuncture could, in fact, be viewed as a useful therapeutic modality in the management of pain.[40]

Chen and Hwang[41] had a similar view after conducting their study, where more than 50% of their patients had better control of their pain after acupuncture treatments. They found that there was little difference between males and females in their response, however, they concluded that younger patients, who had not had surgery for their problem, did better. Upon completion of their survey, they too felt that acupuncture may be a valuable extension of a conventional pain clinic.[41]

Since transcutaneous electrical nerve stimulation (TENS) and electroacupuncture are so similar, the effectiveness of one over the other also has been examined extensively in treatment of chronic pain syndromes. In a randomized, double blind, noncrossover study, 33 patients with chronic pain were evaluated using both methods.[42] Both TENS and electroacupuncture were equally effective in producing analgesia of similar degree and trend over time.[42]

A similar study also had the same results demonstrating that TENS and electroacupuncture were both effective in 75% of their patients using the visual analogue scale.[43] They found it encouraging that their patients reported an increase in social activity and a decrease in analgesic drug intake by more than 50%. They too found no discernable differences between the 2 treatment modalities.[43] However, in a later study, it was demonstrated that only patients receiving auricular electroacupuncture had an increase in their pain threshold versus those with TENS.[44]

This variability in results could be because of the difference in auricular acupuncture versus acupuncture performed on the limbs and body, although TENS applied to any of the 3 sets of acupuncture points has shown to be equally effective.[45] Further investigation would be of much value in this arena.

Another similarity is seen in trigger points and acupuncture points. In myofascial and visceral pain, trigger points often lie within the areas of referred pain, but many are located at a distance from them.[46] Intense stimulation of trigger points frequently produces prolonged relief of pain.[46] These properties of trigger points resemble acupuncture points used in pain relief, indeed a 71% correspondence was found by Melzack et al.[46]

The psychology of chronic pain and its effect on responsiveness to acupuncture are an interesting topic. Responders to acupuncture, defined as 50% or more reduction in pain estimate for greater than 2 weeks, seem to be patients who are less depressed, less passive, have shorter duration of their pain, endorse less frequent exposure to stressors, and have less serious non–pain-related illnesses.[47] This is supportive of the importance of considering psychological variables in evaluating patients for pain treatment strategies and suggests inclusion of such variables in investigating response to other modalities of treatment for chronic pain, such as acupuncture.[47] Levine et al[48] also had similar findings in their study. They concluded that the high score on psychometric indicators of anxiety and depression is positively a significant predictor of successful acupuncture analgesia.[48]

More recent studies demonstrate that acupuncture can indeed provide symptomatic relief in many pain syndromes including angina pectoris, osteoarthritis, sympathetic reflex dystrophy, facial pain, tension headache, and fibromyalgia.[22,49] These studies have the advantage of being published in respected, peer reviewed journals; however, even these recent trials do not provide the final answer as to the mechanisms of analgesic effectiveness of acupuncture.[49]

Theories on effectiveness of acupuncture

That acupuncture causes the release of neuroendorphins and other chemical mediators has long been suspected. Many studies have hinted at this supposition, by using varying methods to describe the neurohormonal effects that occur when acupuncture is performed. An early study examined the effects of acupuncture analgesia using the change in halothane minimal alveolar concentration (MAC) in human volunteers.[50] Halothane MAC was reduced by 86.2% (±11.1%) in those treated with electroacupuncture versus the control group. After administration of naloxone (a morphine antagonist), to the electroacupuncture group, the level of MAC was raised to the same level as the control group.[50] The authors of

this study concluded that the changes in halothane MAC under acupuncture stimulation are caused by the release of an endogenous analgesic substance in the brain.[50]

The action of acupuncture on analgesia in rabbits was studied shortly after the above investigation. The authors found that the brain and serum extracts of acupunctured rabbits when injected into non-acupunctured rabbits, produced a marked analgesic effect on the recipient.[51] This effect was then counteracted by naloxone, again suggesting that release of endogenous substances with morphine-like biological properties, such as endorphins, is increased by acupuncture stimulation. A similar study on rabbits proved not to have any analgesic outcomes after acupuncture manipulation,[52] and in another investigation, naloxone was not effective in reversing acupuncture-mediated analgesia.[53] However, an overwhelming number of studies conducted have demonstrated that whether analgesia is produced by morphine, acupuncture or electrical stimulation of an appropriate brain region, analgesia can be blocked by naloxone.[50-62]

This would indicate that acupuncture causes the release of endorphin substances. β-endorphins and adrenocorticotropin-like immunoreactivity (ACTH) are believed to be released upon electroacupuncture stimulation.[63] Since ACTH induces the release of cortisol from the adrenal glands, blood cortisol levels have been used to establish a relationship between acupuncture and endorphin release. Indeed, blood cortisol levels have been shown to be significantly increased after 30 minutes of electroacupuncture in horses.[63]

As suspected, β-endorphins have been found to be mediators of acupuncture's analgesic effects in both humans and animal experiments.[64-68]

Acupuncture has also been shown to reduce norepinephrine levels in perfusates of certain brain areas as well as in blood circulation, accompanied with a rise of pain threshold and other physiologic changes associated with norepinephrine.[69] By using these physiological indices, such as palm temperature, finger plethysmogram, and pain tolerance threshold, it has been shown that norepinephrine neurons of the ascending dorsal fasciculus have some antagonizing effect on acupuncture, and that acupuncture inhibits sympathetic activities.[69]

Methionine- and leucine-enkephalins have been implicated in their release because of acupuncture treatment as well.[56,58,70,71] Many other chemical mediators and receptors also have been found to modulate acupuncture analgesia such as substance P, serotonin, and 5-HT[72] and gamma-aminobutyric acid (GABA).[73]

The various sites in the CNS where acupuncture exerts its effects have also been under scrutiny. In a study by Liu et al,[74] it was demonstrated that raphespinal neurons of the nucleus raphe magnus was such a site. Electroacupuncture was shown to activate nucleus raphe magnus, a supraspinal area mediating a negative feedback circuit, modulating pain, thus inducing analgesia via descending inhibition.[74]

The effect of the central gray matter on pain sensitivity also has been investigated with regard to various analgesic techniques including acupuncture analgesia.[75] It has been demonstrated that baseline pain thresholds after surgical operation were significantly greater in central gray-lesioned rats than in controls, demonstrating that antinociceptive effect of acupuncture is also mediated by central gray matter.[75]

It is clear that acupunctural analgesia is induced through highly specific nervous and chemical mechanisms, and that the substances produced (β endorphins, enkephalins, substance P, serotonin, etc) can distinguish specific body regions, even those located on one side of the body from the other.[76-78]

Probably some of the most useful pain studies involving acupuncture have been the pain threshold studies. It has been shown time and again in many studies that the pain threshold is increased upon acupuncture stimulation.[79-87] Most recently, functional magnetic resonance imaging has also been employed to examine acupuncture analgesia. Researchers at the University of Medicine and Dentistry of New Jersey, Newark, NJ, found markedly decreased brain activity in 75% of volunteers who were exposed to pain and also given acupuncture.[88] The decrease in activity was not consistent in the areas of the brain of the various volunteers, indicating the well-documented fact that pain is a highly individualized sensation.[88]

Discussion

Acupuncture remains one of the "alternative" medicine disciplines. Although named as such there is mounting evidence of its effectiveness. Most recent randomized, controlled, clinical studies are indicating that there is definitely room for acupuncture as an analgesic modality. It has been shown to be effective in malignant pain problems,[89-91] osteoarthritis,[92] fibromyalgia,[93] pediatric pain problems,[94] headaches[95] and even phantom limb pain.[96] A 1997 National Institute of Health consensus panel recommended acupuncture as an effective tool for the treatment of various health problems.[97] Of those listed, chronic pain, migraines, and fibromyalgia were some of the pain syndromes highlighted. In a recent study at the Massachusetts General Hospital, Boston, Mass, it was found that acupuncture changes pain threshold, and it has been used in dental procedures as

well as superficial operations, such as thyroidectomy.[98] It also has been employed in more complex surgical procedures, providing stable heart rate and blood pressure recordings that are yet inexplicable.[98]

While acupuncture is certainly no panacea, researchers and experienced clinicians both attest to its value,[99] and as one researcher at the University of Michigan, Ann Arbor, Mich, said it would behoove healthcare practitioners who deal with pain management to add [acupuncture] to their armamentarium of therapies.[100]

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