

REVIEW ARTICLE

Neurobiological Mechanisms of Acupuncture for Some Common Illnesses: A Clinician's Perspective



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Abstract

This paper presents some previously proposed neurobiological mechanisms on how acupuncture may work in some clinical applications from a clinician's perspective. For the treatment of musculoskeletal conditions, the proposed mechanisms included micro-injury, increased local blood flow, facilitated healing, and analgesia. Acupuncture may trigger a somatic autonomic reflex, thereby affecting the gastric and cardiovascular functions. Acupuncture may also change the levels of neurotransmitters such as serotonin and dopamine, thereby affecting the emotional state and craving. This mechanism may form the basis for the treatment of smoking cessation. By affecting other pain-modulating neurotransmitters such as met-enkephalin and substance P along the nociceptive pathway, acupuncture may relieve headache. Acupuncture may affect the hypothalamus pituitary axis and reduce the release of the luteinizing hormone in the treatment of polycystic ovary syndrome. In addition, two other approaches to the acupuncture mechanism, the fascia connective tissue network and the primo vascular system, are briefly reviewed. Finally, the idea of true versus sham acupuncture points, which are commonly used in clinical trials, is examined because the difference between true and sham points does not exist in the neurobiological model.

1. Introduction

Acupuncture is a modality of medicine involving insertion of needles at certain locations of the body to achieve

therapeutic effects. Believed to be originated in China thousands of years ago, it is remarkable that acupuncture is still widely practiced [1–3]. Clinical evidence supports the efficacy of acupuncture treatment in many applications. At

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present, acupuncture is not only practiced by practitioners from the school of traditional Chinese medicine (TCM), but is also practiced or recommended by clinicians of mainstream Western medicine especially for the treatment of musculoskeletal conditions such as back pain. This use of acupuncture in mainstream medicine is certainly an encouraging trend in the promotion and advancement of acupuncture. Although the traditional concepts of qi, meridians, and yin–yang are appealing to many, they are foreign and archaic to many clinicians and patients of Western medicine. To promote acupuncture and incorporate it into mainstream medicine, it would be helpful to describe the mechanism of acupuncture to clinicians and patients alike of mainstream medicine using contemporary concepts of neurobiology.

To formulate the mechanisms of acupuncture based on concepts of contemporary science and medicine, it is useful to first think of the essence of acupuncture simply as the process of inserting acupuncture needles at certain locations of the body to achieve certain therapeutic effects, disassociating it from the ideas of qi and meridians. This is shown in Fig. 1A, where the input is the insertion of the acupuncture needles and the output is the therapeutic effect. This phenomenon is what ancient practitioners discovered thousands of years ago. Based on the contemporary knowledge at that time, the ancient practitioners

associated this phenomenon with the ideas of qi and meridians, in an attempt to explain how acupuncture works. This is shown in Fig. 1B. Instead of using the ideas of qi and meridians, one may also use concepts of contemporary science and medicine to explain this phenomenon. This is shown in Fig. 1C. This paper is based on this approach. Much progress has been made in the past few decades toward this approach.

This paper presents the perspective of a clinician practicing Western mainstream medicine using an approach to acupuncture, in which the classical concepts of TCM are foregone and only contemporary scientific concepts are embraced. This approach is known as Western medical acupuncture [4,5]. An important difference between the TCM and the Western medical approach is the diagnosis process. In TCM, the diagnosis is achieved using the principles of syndrome differentiation, which could be in accordance with the state of the zàng–fǔ organs or qi, or in accordance with the doctrine of meridians [6]. This diagnostic process has no equivalence in Western mainstream medicine. In the Western medical approach, one adheres to the usual diagnosis process of mainstream medicine.

In this paper, some neurobiological mechanisms of acupuncture treatment for some common illnesses from a clinician's perspective are presented. The evidence of efficacy for these applications is indicated. In addition, the implication of this approach on the idea of sham acupuncture points commonly used in clinical trials is briefly discussed. Two other scientific approaches to the study of acupuncture mechanisms—the fascia network and primo vascular system—are also discussed. As will be seen eventually, the historical concepts of qi, meridians, and yin–yang might be accounted for loosely, though not exactly, in terms of concepts of contemporary science.

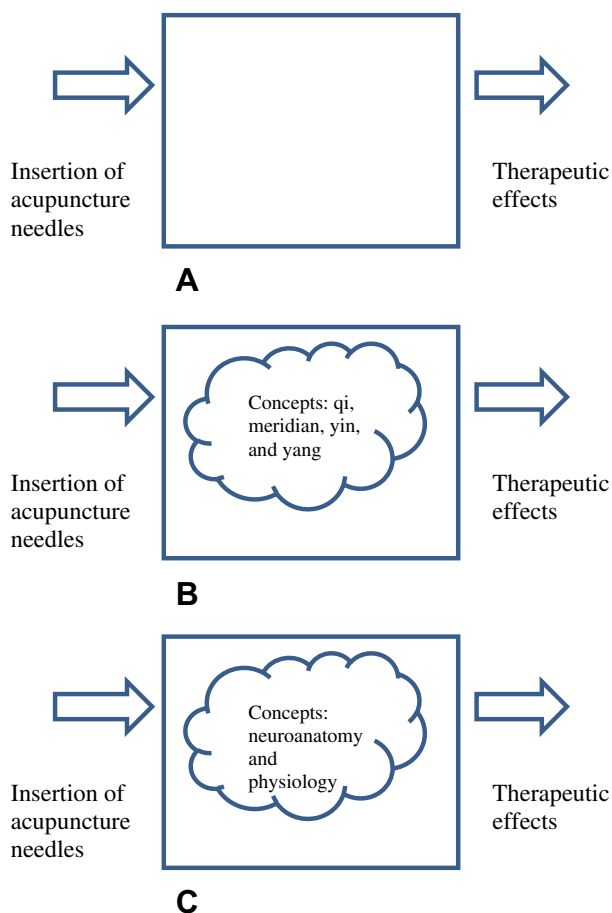


Figure 1 (A) The phenomenon of acupuncture. (B) The phenomenon of acupuncture with concepts of traditional Chinese medicine. (C) The phenomenon of acupuncture with concepts of contemporary science and medicine.

2. Acupuncture mechanism

A pioneer discovery in modern acupuncture research is that acupuncture stimulates the secretion of the endogenous opioid endorphin [7]. At first sight this may appear to be of limited clinical relevance, as only a limited number of common clinical applications involve analgesia. The significance of this discovery is that it establishes the neural model of acupuncture mechanism. If acupuncture stimulation generates a nerve signal to the brain resulting in the secretion of endorphin, it may also result in the activation of other neural pathways as well as the secretion of other neurotransmitters.

Much work has been done on the neural mechanism of acupuncture since then [8–15]. However, there is no unified theory of acupuncture mechanism, but rather only various models and hypotheses for different clinical applications are available. In the following discussions, the mechanism of acupuncture is considered separately for local effects, somato-autonomic reflex, and systemic effects through neurotransmitters. In Table 1 [16,17] [4] [15] [8,18] [19] [20–23] [24,25] [26,27] [28] [29,30] [31] [32] [33–35] [36,37], a list of some acupuncture clinical applications of interest, their proposed mechanism, and evidence for efficacy is presented. A key to the acupuncture points mentioned in the applications is given in Table 2.

Table 1 Proposed mechanisms of acupuncture action and evidence for efficacy for some common applications.

Condition	Commonly used acupuncture points	Reason for choice of acupuncture points	Proposed mechanisms of action	Evidence for efficacy	Comment
Low back pain	Ashi points	Location of affected muscles [16,17]	(1) Microinjury, facilitated healing [4], axon reflexes [15]. (2) Acupuncture analgesia: acupuncture stimulation interrupts pain pathway [8,18]. (3) Intramuscular stimulation releases muscle shortening [19].	Positive [20–23]	Most popular application of acupuncture. Mechanism reasonably well understood. Neural mechanism is consistent with observation that nontraditional acupuncture points are also effective.
Nausea, vomiting	PC6, ST36	PC6 sends strong afferent input to area of interest in the brain [24,25]	(1) Stimulation at PC6 results in neural response at the insula, hypothalamus, cerebellum, which are responsible for autonomic regulation of vestibular function [24,25]. (2) Somato-parasympathetic reflex: improved gastric emptying through increased vagal activity [26,27].	Strong [21–23]	Acupuncture application with the most convincing evidence. Not a common application in acupuncture practice. Mechanism not well established.
Headache	No obvious consensus points	—	Inhibits pain processing, inhibits trigeminal nucleus caudalis and dorsal horn neurons, affects levels of pain-modulating neurotransmitters such as substance P, met-enkephalin [28].	Equivocal [21–23]	Mechanism not well established.
Smoking cessation	Shen Men, Tim Mee, GV20	Unknown	(1) Affects the reward cascade by increasing the level of serotonin in the limbic system thereby reducing the craving [29,30]. (2) Increases the level of dopamine thereby suppressing the reinforcing effects of the drug [31].	Equivocal [21–23]	Mechanism not well established.

(continued on next page)

Table 1 (continued)

Condition	Commonly used acupuncture points	Reason for choice of acupuncture points	Proposed mechanisms of action	Evidence for efficacy	Comment
Facial nerve palsy	Correspond to locations of branches of facial nerve [16]	Indirect stimulation of nerve	Improves local blood flow, indirect stimulation of affected nerve [32,16].	Equivocal [32]	Mechanism not well established.
Gastritis	ST36	Unknown	Somato-parasympathetic reflex: improved gastric emptying through increased vagal activity [26,27].	Lacking	Mechanism reasonably established in animal studies, but lacks clinical data to establish its efficacy.
Hypertension	PC6, ST36	PC6 sends strong afferent input to cardiovascular sympathetic neurons in the medulla [33,34]	Somato-sympathetic reflex resulting in inhibition of cardiovascular sympathetic neurons. The neural pathway involves the arcuate nucleus of the hypothalamus, ventrolateral periaqueductal gray in the midbrain, rostral ventrolateral medulla [33–35].	Lacking	Mechanism reasonably established in animal studies, but lacks clinical data to establish its efficacy.
Polycystic ovary syndrome	SP6	Unknown	(1) Acupuncture stimulation eventually affects the hypothalamus–pituitary axis, resulting in decreased release of luteinizing hormone. (2) Decreases sympathetic activities of the ovaries and release of androgens [36,37].	Lacking	A well-studied case of neuroendocrine effect of acupuncture.

Table 2 Key to acupuncture points mentioned.

Acupuncture point	Associated meridian	Location
Ashi	None	A functional point at wherever the pain is, without a predefined location
PC5	Pericardium	Three thumb widths proximal to anterior crease of the wrist, on the ulnar side of the tendon of flexor carpi radialis
PC6	Pericardium	Two thumb widths proximal to anterior crease of the wrist, on the ulnar side of the tendon of flexor carpi radialis
Shen Men	None	An ear point in the posterior aspect of the triangular fossa
Tim Mee	None	An extra-meridian point also known as smoking cessation point, in the wrist, in the proximal aspect of the anatomical snuffbox
GV20	Governing vessel	Parietal region, on the midsagittal line, on the top of the head
ST36	Stomach	Three thumb widths distal to the inferior border of the patella, one finger width lateral to the tibial tuberosity, in a muscle groove
SP6	Spleen	Three thumb widths superior to medial malleolus, posterior to the tibia

2.1. Local effects

2.1.1. Local segmental effect for musculoskeletal pain

This pertains to acupuncture mechanism of action in the treatment of musculoskeletal conditions, which is by far the most common application.

The essence of acupuncture mechanism in this application is microinjury, increased local blood flow, facilitated healing, and analgesia. Acupuncture needle stimulates the nerves in the local tissues. This causes the release of neuropeptides resulting in vasodilation and increased circulation locally [4,38]. This phenomenon is known as axon reflex, and is essentially a response to peripheral tissue injury [15]. The hyperemia seen at the site of the needle insertion is a consequence of axon reflex. Acupuncture may have an analgesic effect through the release of the neurotransmitter enkephalin, which inhibits the nociceptive pathway [4,18], or through the release of local endorphin [38]. It may also have an analgesic effect by inducing hyperstimulation [8].

There is another model of acupuncture mechanism on musculoskeletal pain conditions proposed by Gunn [19]. Interestingly, Gunn refers to the process not as acupuncture but as intramuscular stimulation, which is a more descriptive and perhaps a better term. In the Gunn model, the two essential elements of myofascial pain are muscle shortening and neuropathy. The goal of intramuscular stimulation treatment is to release muscle shortening and promote healing.

Acupuncture may also be considered a variant of cortisone injection to myofascial trigger points, except that acupuncture needles without medicine are used rather than hypodermic needles with cortisone. This has been referred to as dry needling [39].

2.1.2. Other local effects

Acupuncture has been used in the treatment of dysfunctional nerve such as facial nerve palsy with equivocal evidence for effectiveness [32]. The most commonly used acupuncture points are those corresponding to the anatomic locations of various branches of the diseased nerve [16]. This suggests that acupuncture stimulation might have a local effect on restoring the diseased nerve,

possibly by improving the local blood flow and accelerating the metabolism [32,16].

2.1.3. Clinical relevance of mechanisms

To be useful, a scientific theory has to make predictions that agree with observations. A clinical implication of the aforementioned mechanisms is that the acupuncture points used in the treatment should be local, not distal. In particular, for the treatment of a musculoskeletal condition, a natural location for the acupuncture point would be the area where the pain is. This is in good agreement with clinical observations. The most commonly used acupuncture point for the treatment of musculoskeletal pain is the Ashi point [16], which is simply a functional point where the pain is. Another significant clinical implication of the aforementioned mechanisms pertains to the idea of sham versus true acupuncture points commonly used in the design of acupuncture clinical trials. Predefined true acupuncture points do not exist in our models. This issue will be addressed in more detail later in this paper.

2.2. Somato-autonomic reflex

Acupuncture likely has an effect on homeostasis by the somatic autonomic reflex [40]. This homeostasis involving the sympathetic and parasympathetic branches of the autonomic nervous system is frequently considered as the scientific basis for the concept of the balance between yin and yang in TCM. The neural pathways involved in this acupuncture action have been well investigated in animal studies [26,27,33–35].

2.2.1. Somato-autonomic reflex with segmental pathway

In this case the reflex pathway lies completely within the same spinal segment, that is, the innervation of the muscles stimulated by the acupuncture needles, the afferent fibers traveling to the dorsal horn of the spinal cord, and the sympathetic fibers traveling to the target visceral are all in the same spinal segment.

This mechanism has been investigated by Sato and Schmidt [26] and Sato [27]. These studies show that acupuncture stimulation on the abdomen inhibits gastric motility. The studies also show that the effect persists after spinal transection at the cervical level, but disappears after

bilateral severance of the gastric sympathetic nerve. This suggests that the reflex pathway is at the spinal rather than at the brain level.

Another observation that supports this mechanism comes from an analysis of the stated clinical indications of the trunk acupuncture points according to various textbooks and reference books of TCM [17]. It is found that acupuncture points within certain spinal segments in the trunk tend to affect the functioning of the organs that receive autonomic innervation from the same spinal segments.

Although this segmental somato-autonomic reflex provides a well-defined mechanism to explain some acupuncture effects, it appears to be of less importance in terms of the clinical effects. In actual practice, to elicit a systemic or visceral effect (nonmusculoskeletal effect), the preferred acupuncture points are usually on the extremities. Acupuncture stimulation on the extremities apparently elicits a more potent response because the resulting somato-autonomic reflex follows a brain-level pathway.

2.2.2. Somato-autonomic reflex with brain-level pathway

In this case, the input signal first goes to the brain through a somatic nerve and eventually projects to an efferent autonomic nerve. Sato [27] has shown in animal studies that acupuncture stimulation in the extremity facilitates gastric motility through a somato-parasympathetic reflex involving the vagal nerve. In his studies, the response disappeared either after spinal transaction at the cervical level or bilateral severance of the vagal nerves. This is consistent with a mechanism at the brain level involving a somatic parasympathetic reflex through the vagal nerve.

The role of somato-autonomic reflex in the regulation of cardiovascular function has been well studied by Longhurst and his group [33–35]. In this case, the reflex pathway involves an afferent somatic nerve that goes to the brain, projects to various structures in the hypothalamus, the midbrain, and the medulla, and eventually the autonomic efferent nerve.

The acupuncture mechanism responsible for achieving the antiemetic effect, the acupuncture application with the most convincing evidence, is believed to involve a similar somato-autonomic reflex. In this case, the afferent nerve goes to the brain and projects to various structures in the brain and then the cerebellar region responsible for the regulation of vestibular functions, thereby achieving an antiemetic effect [24,25]. The traditional acupuncture point PC6 (located proximal to the wrist crease on the flexor side) is especially efficacious for the antiemetic effect and cardiovascular effect. It has been reported that certain acupuncture points overlying a deep nerve, PC6 included, send strong afferent input to the sympathetic neurons in the medulla [34]. However, it is not understood why other acupuncture points also overlying a deep nerve do not have the same effect, and why PC6 is the most efficacious.

2.2.3. Clinical relevance of mechanisms

Clinically, the somato-autonomic reflex may account for acupuncture's effect on visceral function as in the treatment for gastritis, or more systemically on cardiovascular function as in the treatment of hypertension. Given the wide prevalence of hypertension, if the efficacy of acupuncture treatment on this condition can be

established, it would be a significant step in the promotion of acupuncture practice.

2.3. Distal systemic effect: neurotransmitters in the brain

It has been well established that acupuncture stimulates the secretion of endorphin. Acupuncture may also affect the level of other neurotransmitters such as serotonin and dopamine in the limbic system, which consists of a group of brain structures including the hippocampus, amygdale, and their connections with the hypothalamus as well as various centers related to emotional behavior, drive, and appetite. This may be the basis of acupuncture mechanism on smoke cessation [29–31] and depression. For example, drug addiction is believed to be due a dysfunction in the limbic system and as a result the body perceives that the drug is needed. Scott and Scott [30] hypothesized that acupuncture increases the amount of serotonin in the hypothalamus where the reward cascade begins, thereby changing the reward cascade and reducing the craving to the addicted substance. Yang and co-workers [31] suggested that dopamine is the actual neurotransmitter through which acupuncture suppresses the reinforcing effects of the drug; serotonin is only an intermediate neurotransmitter that regulates the release of dopamine. Acupuncture is a popular treatment modality for smoking cessation and drug addiction. However, the evidence for the efficacy of these acupuncture applications is still inconclusive.

Acupuncture may also affect the level of pain-modulating neurotransmitters at various sites along the nociceptive pathways. The neurotransmitters include substance P and met-enkephalin. The sites include the trigeminal nucleus in the brain and the spinal dorsal horn. This may be the basis of acupuncture treatment for headache [28].

2.4. Neuroendocrine effect

One of the better studied clinical applications of acupuncture involving neuroendocrine effect is the polycystic ovary syndrome (PCOS), a disease of reproductive-age women associated with anovulation and infertility. The endocrine characteristic of PCOS is a hypothalamic pituitary dysfunction associated with elevated levels of the luteinizing hormone (LH) and androgen. It has also been hypothesized that PCOS is associated with increased sympathetic activity and increased beta-endorphin production. Electroacupuncture decreases the sympathetic tone and decreases the release of LH by the pituitary gland [36,37]. In addition, stimulation at same spinal segments as ovaries decreases sympathetic activity at the ovaries and release of androgen.

3. Other approaches to acupuncture mechanism

3.1. Fascia network as an anatomical basis for meridians

The search for the meridians is an active field of study toward the understanding of acupuncture mechanism. It has

been observed independently by various investigators that the connective tissue planes, or fascia planes, form a network in the body that resembles the meridians described in TCM.

Langevin [41] and Langevin and Yandow [42] examined the locations of acupuncture points and meridians in gross anatomical sections of cadaveric arm, and found good correspondence between the locations of acupuncture points and that of intermuscular or intramuscular connective tissue planes. Using a computerized virtual human body, Yuan and his group [43–45] digitally constructed a three-dimensional network of fascial connective tissue areas that resembles the network of meridians and acupuncture points. They hypothesized this network to be a hitherto undiscovered auto-surveillance system in the body that may lead to new biological explanations for the basic mechanism of acupuncture action. Dorsher [46] compared the acupuncture meridians with the myofascial meridians [47], which are defined as anatomic lines that transmit strain and movement throughout the body's myofascia, and found a strong correspondence between the two.

From a clinician's point of view, the meridians by themselves, even if they correspond perfectly to fascia channels, do not explain the clinical effects of acupuncture. Rather, it is the signals within the channels that account for the clinical effects. The nerves within these channels are certainly an important carrier of the signals. It has been suggested that a mechanical signal propagating along these channels may be responsible for some of the therapeutic effects of acupuncture. Essentially, when the inserted acupuncture needle impacts connective tissue in fascia, it causes the needle grasp phenomenon (deqi sensation). This results in a perturbation of mechanical force in muscle, which propagates to neighboring muscles. This mechanical signal evokes response in connective tissue downstream resulting in some adaptive changes in fascia or anti-inflammatory response [41,44]. Other signals, for example the flow of paracrine-signaling molecules, have also been proposed [44].

The neurobiological and fascia network approaches are complementary rather than exclusive. The neurobiological approach describes the nerve signals within the network that mediate the effect of acupuncture stimulation. The fascia network provides an anatomical explanation of the meridians and new understanding of acupuncture mechanisms beyond the nerve signals.

3.2. Primo vascular system as anatomical basis for meridians

Kim [48,49] first reported the observation of a novel microscopic anatomic structure, an extensive duct system distributed throughout the body that may correspond to the meridians. This structure was initially named after Kim as Bonghan duct, and later referred to as the primo vascular system. It has been studied extensively by Soh [50] and recently reviewed by Stefanov and Kim [51]. Observation of the primo vascular system requires special staining. The primo vessels carry a liquid that contains, among other substances, hormones, amino acids, and free nucleotides. The primo vascular system forms a new circulatory system in

the body apart from the usual blood and lymphatic systems. Although it may provide a significant new understanding to the traditional theories of meridians and qi as well as to basic biology, more studies are warranted to establish the presence of this primo vascular system.

4. Neurobiological mechanisms, point specificity, and acupuncture clinical trial design

Many clinical studies on the efficacy of acupuncture have been carried out during the past few decades. Too often they are based on TCM mechanisms and assume that acupuncture is efficacious only on traditional acupuncture points (considered as "true" points) and not on the sham points. This assumption is questionable. In fact, an increasing amount of evidence shows that the sham points are not entirely inert [20,52–55]. Instead of a simple all or none distinction between a traditional acupuncture point and a sham point, neurobiological models and observations suggest the following. For local musculoskeletal action there is no point specificity. For distal action involving the brain there is some point specificity, though not as strict as that specified in the TCM literature.

In the neurobiological model, the lack of point specificity in a local effect for musculoskeletal pain follows theoretically from the fact that there is no special localized structure involved in the mechanism of action. This lack of point specificity is supported by clinical data such as the large-scale German trial for low back pain [20], which shows that there is simply no significant difference between the true and the sham points; both are efficacious. Interestingly and correctly, the TCM literature works do not strictly adhere to the concept of "true" points in the treatment of musculoskeletal conditions. The works embrace the idea of Ashi point, which is simply a functional point wherever the pain is located. A review of the treatment formulas for low back pain given in several TCM acupuncture references shows that the most commonly used point is the Ashi point [16].

Although there seems to be no point specificity in the musculoskeletal action, observations showed that there is some point specificity in systemic action at the brain level. Results of functional magnetic resonance imaging studies showed that stimulation at a traditional acupuncture point produces a distinct response in specific areas of the brain, which is different from the stimulation at other points on the same spinal segment [25,56], and also different from the stimulation at neighboring points on the same meridian. Neurophysiological studies have also demonstrated point specificity. For example, it has been shown that stimulation at certain traditional acupuncture points in the forearm (PC5 and PC6) elicits a cardiovascular response, whereas stimulation at other nearby points does not [24]. This specificity of acupuncture point has been attributed to the presence of a deep nerve; points overlying the deep nerve are effective and others are not [57]. For example, PC6 and ST36, two of the most potent traditional acupuncture points, overlie the median nerve and the deep peroneal nerve, respectively. However, this does not explain why other acupuncture points overlying the same deep nerve are not effective.

In the fascia network approach, one also arrives at the same conclusion that there is no structural difference between a traditional acupuncture point and a sham point, as fascia connective tissue is everywhere in the body. The difference between a traditional acupuncture point and other points is in the intensity of response rather than structural components, a difference in degree rather than all or none. Thus, according to Yuan [45], acupuncture points are actually everywhere in the body.

It is fair to say that the neurobiological basis of acupuncture point specificity is not well understood. It is however an active research area of much interest, and of significance toward the understanding of acupuncture mechanism [58]. In addition, from a clinician's point of view, the assumption that acupuncture is efficacious only on the traditional acupuncture points and not on sham points is probably oversimplified. There appears to be no point specificity in acupuncture action on musculoskeletal conditions, but rather some point specificity on systemic effect involving the brain. The design of acupuncture clinical studies ought to take this into consideration.

5. East meets West: Western interpretation of TCM concepts

The traditional acupuncture mechanisms based on concepts such as meridian, qi, and yin–yang have stood unchanged for thousands of years. For people who prefer alternative therapy over mainstream medicine, historic concepts over contemporary science, traditional acupuncture has its appeal. Besides, for people who prefer mainstream medicine and contemporary science, it is possible to find a modern interpretation of these concepts. The following is a possible set of interpretation based on neurobiological and fascia network models.

5.1. Meridians

Meridians are the major channels in the connective tissue fascia network in the body. Acupuncture stimulation at sites along this network tends to produce stronger response than other sites because of the concentration of connective tissues and nerve endings.

5.2. Acupuncture points

The traditional acupuncture points are the sites where acupuncture stimulation produces a stronger response than neighboring sites due to the higher concentration of connective tissues and nerve endings. These points are discovered through painstaking observation of ancient researchers and clinicians. However, the difference between a traditional acupuncture point and a nonacupuncture point lies on the intensity of response rather than structural components.

5.3. Qi

Qi refers to the signals within the channels that mediate the effects of acupuncture. Although the nerve signal is the

best understood one, other possible signals are the propagation of mechanical force [42,43] and the movement of paracrine-signaling molecules [44].

5.4. Yin–yang

The maintenance of homeostasis through the parasympathetic and sympathetic branches of the autonomic nervous system approximates the concept of yin–yang balance.

6. Conclusion

Acupuncture is considered by many to be the forefront among the various modalities of complementary and alternative medicine in terms of acceptability and evidence of efficacy. In addition, acupuncture does have a sound scientific basis built on the abundant studies carried out over the past few decades. Although the detailed mechanisms are still unclear, there are nevertheless rudimentary neurobiological models that explain how acupuncture achieves its therapeutic effect in many clinical applications. These models will probably be found insufficient or even proved wrong later and be replaced by new ones. Such is the nature of science. It evolves and advances. Likewise the evidence for efficacy of many acupuncture applications will likely change in the future as new clinical data are available. Such is the nature of evidence-based medicine. Following a neurobiological, evidence-based approach, acupuncture need not be viewed as some mystic practice of complementary and alternative medicine. It is in principle and in practice a modality of mainstream medicine.

Disclosure statement

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