# Acupuncture for the Treatment of Neuromuscular Conditions in Dogs and Cats, with Emphasis on Intervertebral Disc Disease

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## Abbreviations

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|---|---|
| **DRG** | **Dorsal root ganglion** |
| **ECM** | **Extracellular matrix** |
| **Estim** | **Electrical muscle stimulation** |
| **HJ** | **Hwato Jiaji points** |
| **TCVM** | **Traditional Chinese Veterinary Medicine** |
| **WMA** | **Western Medical Acupuncture** |

## Abstract

The effect of acupuncture needling on tissues creates local and remote biochemical and biomechanical changes. All points (both verum and sham) will interact with fascia, causing mechanotransduction in fibroblasts and other cell types. All points neuromodulate and will also modify fluid motion and immune balance via lymphatics. Effects that are more specific to particular points include location and distribution of neuromodulation, degree of immune modulation, muscle or trigger point effects, brain or homeostatic changes, sympathetic and parasympathetic stimulation, remote visceral organ effects, and degree of lymphatic flow modulation. These distinctive effects help to separate the effects of verum and sham acupuncture points and contribute to the diversity of acupuncture effects and complexity of research on acupuncture.

Frequently selected acupuncture points for various conditions, such as intervertebral disk disease, have common and distinguishing physiological characteristics. The coincident choosing of these points could be justified from either a viewpoint of traditional Chinese medical acupuncture or one of Western medical acupuncture (WMA).

## Introduction

In veterinary species, acupuncture studies that contain randomized, controlled clinical trials are lacking for most conditions (1). Despite the deficits in research, there is growing use and appreciation of acupuncture in veterinary medicine, and species-relevant data for the use of acupuncture in dogs is present for spinal cord diseases (2-5).

In contrast to the dearth of clinical trials, acupuncture has a vast database of physiological studies that explore its local, regional, and systemic effects. Both needle-based and location-based associated techniques such as laser and aquapuncture are included (6-8). Deeply reliant on neurophysiology, this acupuncture research helps to inform the clinical practice of acupuncture, but a vast distance can exist between the neurophysiological science and actual practice. Relating these physiological mechanisms to the clinical practice of acupuncture is a moving target, but critical in order to both broaden the understanding of acupuncture mechanisms and to translate them to specific treatment concepts. This is the charge of this scientific review.

All acupuncture points share some physiological effects, whether verum points (described in acupuncture texts) or other points (often referred to as sham) (9). Distinct points, often those frequently described in acupuncture textbooks and associated with specific observed effects, will also contribute unique physiological effects (9). The shared effects include interaction with fascia, mechanotransduction in fibroblasts and other cell types, neuromodulation

toward analgesia, modulation of fluid motion, and axon-reflex–mediated modification of the microvascular environment (10-12). Effects that may be more specific to certain points compared to others include location and distribution of neuromodulatory changes, degree of immune modulation, muscle or trigger point effects, brain or homeostatic changes, sympathetic and parasympathetic effects, remote visceral organ effects, and degree of lymphatic flow modulation (9, 13-16).

## Interaction with Fascia and Mechanotransduction

Implicit in every acupuncture needle placement is the movement and structural manipulation of the cells and extracellular matrix at the tip of the needle (10). This aspect of needling is amplified with needle manipulation and the sensation of *deqi,* which is a sensory sensation at the tip of the needle that coincides with the feeling of "grab" on the needle due to contraction of fascia and fibroblasts (17). When tissue is mechanically altered (tissue deformation), growth factors and a variety of proteins and neurotransmitters are released, leading to changes in pain processing, metabolic processes, inflammation, blood flow, and healing capacity (10).

Mechanotransduction refers to the processes through which cells sense and respond to mechanical stimuli by converting them to biochemical signals that elicit specific cellular responses (18). Cells are adjacent to either other cells or to extracellular matrix (ECM). The ECM is composed of a variety of proteoglycans and elastic and collagen fibers. Many of these compounds, and the collagen itself, are made by local tissue fibroblasts which are physically and functionally tied into the collagen network, fascia, and ECM. In addition to the fibroblasts managing the ECM tension in diverse regions, other cells in each region change in function and genetic expression as the ECM tension changes. Changes in ECM composition and tension/compliance relate to the progression of degenerative conditions, tumor progression or metastasis, and aging in general (19). As a familiar example, consider the increased rigidity seen in cardiac disease in response to increased chamber pressures (18).

Broadly considered, mechanotransduction is integral to the effect of placing an acupuncture needle (20). While the eventual modification of adjacent nerve fibers leading to neuromodulation is indisputable, there are 2 decades of physiological research showing the importance of the collagen and ECM matrix in transmittal of the mechanical signal from an acupuncture needle to the nervous system (7, 10, 21). Fascial structures are ubiquitous throughout the body. Treating acupuncture points at a superficial depth may provide input to microvascular structures or, with deeper needling, may provide input to deeper fascial sheets. These deep myofascial structures perform neuromuscular feedback loops and provide structural support, which can be modified with sufficient penetration of the acupuncture needle (22).

## Neuromodulation: Peripheral, Central, and Corridor Structrures

With tissue mechanotransduction there is also inevitable traction and modulation of the nervous system (20). Neuromodulation alters neurotransmitters at the skin, along axons, in the spinal cord, interneurons, brain, and even in the supportive structures of the glia. These changes can be short-term, immediately improving comfort and function, or they can be long-standing or permanent, utilizing the plasticity of the nervous system to result in structural differences in pain processing and nerve function (23). Neuromodulation is intrinsic to the analgesic actions of physical medicine techniques in general, and particularly to the practice of acupuncture (24).

The most superficial layers of sensation are primarily occupied by pain (A-d and c fibers) and transient receptor potential (TRP) channel modified high-threshold receptors (8). Touch sensation occurs at the transitional layers, while the hypodermal layer carries vibration, pressure, and stretch as well as the origins of the lymphatics, which are the waterways of the body. Sensation has different underpinnings in haired and non-haired (glabrous) skin, and some of these variations help to explain why very distal points are described as having alternate indications. Non-haired regions and distal regions may have different physiologic consequences when compared to points over haired skin. Gentle touch receptors in mammalian skin collaborate with other sensory components to provide the sensory input from an acupuncture needle (25). The depth of needle placement has superficial effects via mechanotransduction. With deeper penetration there is also interaction with different tissues and innervation patterns. (22).

Other neurosensory structures exist that are deep to the skin but outside the spinal cord region. These include muscle spindle organs, golgi tendon organs, and the dorsal root ganglion (DRG). Like cutaneous sensory sensation, golgi tendon and muscle spindle sensory tissues integrate with spinal and central reflex loops as well as convey pain information to the brain (26). These reflex loops contain afferent sensory information and result in reflex modulation of pain, muscle tension, and coordination of muscle and tendon groups to generate kinesthetic activity. Direct effects on motor units are a component of acupuncture

treatment and can be utilized to neuromodulate injured or dysfunctional motor reflexes (27, 28). This commonly targeted benefit of acupuncture is also shared by techniques known as *dry needling,* performed by physical therapists and acupuncturists, when targeting pathologically shortened muscle groups known as *myofascial trigger points* (29, 30). Several named acupuncture points exist over motor units that can contain sensory motor fibers. The sensation of needling these regions is characterized by cramping type pain, and much of this signal is carried via Aα and Aγ nerve fibers. Myofascial trigger points can also occur in motor regions that are not verum acupuncture points but that also benefit from treatment and are identified as *Ah Shi* (painful) points (30).

The DRG cell body cell body is part of the peripheral nerve and manages the receptor populations, microtubular arrays, and ion channel representation in the peripheral nerve. The nerve cell body is integrally involved in the signals ascending from the peripheral tissues to the spinal cord. An important contribution to the analgesia effects of acupuncture is made by purines, released at the peripheral tissue during acupuncture needle stimulation. These neurotransmitters create transcriptional changes at the nerve cell body in the DRG, resulting in modification of the pain signals at the level of the axon distal to the DRG (31).

The dorsal horn of the spinal cord is the receiving zone for afferent impulses ascending from the periphery. Significant diversity of receptors, pain fibers, and neurochemical compounds contribute to the magnitude and type of signal seen at the dorsal horn. At this level, the signal can be transduced to nerve tracts that ascend to the CNS, with vast opportunity for modification here as well (32).

At the dorsal horn, a variety of biochemicals can modify the likelihood that the signal will cross the synapse and create an action potential in the second order nerve. Moment-to-moment modulation occurs through changes in GABA, serotonin, norepinephrine, nuclear factor kappa-b, calcitonin gene-related peptide, substance P, endorphins, and cannabinoids (33). Acupuncture effects emanating from the periphery have been shown to exert at least some modification on each of these compounds in various laboratory studies (14).

In addition to the modifications possible at the first synapse, the topography of the spinal cord provides for interneurons that can inhibit or amplify the incoming afferent signal. Concepts such as *diffuse noxious inhibitory control* are being utilized to assess amplified pain states and to identify therapies such as acupuncture that work to decrease central pain amplification. Pain sensation can be modified by the local neurochemical milieu and also by descending input from the midbrain. Acupuncture has also been shown to aid in the modification of descending inhibitory mechanisms, and this method of testing the nervous system may significantly improve the clinical data available to demonstrate acupuncture efficacy (34).

In the dorsal horn and infusing all structures within the blood-brain barrier (comprised of astrocytes) are glia. Glia invest each synapse and participate in the synaptic activity. The glia act as the structural and inflammatory cells of the nervous system. They are involved in sleep, mood, pain amplification, pain suppression, tolerance, and addiction. Acupuncture has been shown to influence the activity of glia, potentially reversing some of the negative effects of glial stimulators (like opioids) and decreasing the long-term central neuroinflammation resulting from pain and opioid treatments (23).

The somatotropic layout of the spinal cord is integral to the ability of acupuncture to modify deep tissues and organs. Deeper tissues can be modified by interacting with

somatic sites that share the same spinal innervation network. Examples of this in modern medicine include "sea bands" for nausea (over acupuncture point PC6) and electrical stimulation over the tibial nerve (acupuncture point KI3) to improve urinary continence (35). This structural relationship creates a nervous system interaction that explains the peripheral or somatic recognition of visceral pain, such as myocardial infarction pain that is sensed in the left arm in men or the mandible in women. Likewise, the treatment of visceral structures through somatic sites is possible by targeting the nerve structures present in the inner Bladder line fascial plane (36).

Modification of autonomic outflow is most likely to occur near accessible portions of the sympathetic chain and parasympathetic ganglia. Examples of sympathetic proximity include the cervicothoracic junction (the start of the sympathetic chain) and the lumbosacral junction (the sacral sympathetic outflow). Examples of parasympathetic ganglia can be found in the thoracolumbar region (stellate ganglion) and at the thoracic inlet (cranial cervical ganglion). In addition to the modification of autonomic function via the vagal nerve, acupuncture can also influence sympathetic outflow at certain points and parasympathetic outflow at others (11). Spinal reflex loops, in addition to the modification of sympathetic/parasympathetic balance more globally, have been shown to contribute to some of the organ effects seen with acupuncture, such as regulation of cardiac activity (37).

Due to the invasiveness of such studies, determining the central effects of acupuncture has traditionally been limited to the use of laboratory animals. Decades of data show influences on neurotransmitters as previously discussed regarding the spinal cord, especially with regard to endogenous opioids (38). This has not answered the lingering questions about why acupuncture appears so effective for mood and behavior. However, neuroimaging studies have come of age and provided vast amounts of data, although there remains controversy as to how to value and interpret this data. Imaging studies have shown complex activation and deactivation of many areas of the brain. In general, verum acupuncture needling has shown a larger effect than sham needling, and using a deep needling treatment with adequate tissue grab (*deqi*) appears important (39). The periaqueductal grey area and ventrolateral medulla show consistent responses to acupuncture for pain. Signal transduction effects of acupuncture have been shown to modify CNS damage, improve healing and plasticity, increase synaptic transmission, and reduce secondary inflammatory cascades (40).

## Fluid Movement and Axon-Reflex Modification of Microvascular Environment

Distal points are highly innervated because sympathetic and sensory fibers join peripheral arteries and travel in the interstitium as nervi vasorum until they exit at their destination and course through connective tissue. As arteries travel distally in a limb, sympathetic and sensory input becomes denser and more attenuated so that distal points tend to convey a stronger autonomic response. Distal interstitium is also less dense and organized than more proximal fascial sheets. The lymphatic streams in distal interstitium are diffuse, and the lymphatic channels are less organized. Within this interstitial area the arteriovenous anastomoses create a constant fluid movement from vascular structures to interstitial and lymphatic fluid streams (41). Thus, distal points are particularly important for microvascular fluid flux and the origin of the lymphatics, serving an important role in immune modulation (42).

## Specific Activities

Acupuncture points exhibit individual specificity for a variety of reasons. The first is the location and distribution of neuromodulatory effects exerted by the point. It is recognized that the increased population of nerves and vessels around verum acupuncture points contributes to their potency when compared to sham points (8). More complex innervation near a point also contributes to increased activity across the spectrum of nervous system input, allowing sympathetic, parasympathetic, sensory (low-threshold), and pain (high-threshold) inputs. Each of these inputs relates to different spinal and central regions of recognition (43). It is rational that distal points, which contain all fiber types in a small area, can provide increased recognition due to the concentration of response to an exceedingly small area of input. This gives distal points an increased magnitude of response to the CNS compared to more proximal or axillary points and justifies the impression of ting points as "awakening" (44).

Lymphatic flow is intrinsically affected by all peripheral acupuncture points, as this is the location of microvascular and lymphatic homeostasis (42). As the lymphatics become more organized, forming into ducts with valves and eventually providing home to lymph nodes, acupuncture points start to have more individualized effects (45). At about the level of the *He Sea* points (elbow and stifle), the first major lymphatic structures are found. Thus, points at this level (ST36, LI10) are likely to have a far more pronounced immunological effect than would more distal points or more proximal points, except those specifically found along lymphatic channels (46). Likewise, major effects altering edema formation in the distal limb will amplify

near these joints and tend to lessen both distally and proximally (again, except with points that are along the veins and lymphatic routes, such as the SP channel).

There are many verum acupuncture points that directly correlate with known myofascial trigger points and others that correlate with the tendinous attachments of muscle groups. These points are ideal for trigger point, muscle spindle, and golgi tendon treatments. Myofascial trigger point targets provide motor function and reflex activities, which regulate the neuromuscular system (example: GB34). The most established use of non-verum acupuncture points is also focused on these structures and constitutes the practice of dry needling in physical therapy practice (16, 30).

Paraspinal needling brings up local and regional neuromodulation aspects that vary quite a bit with needle placement. Organ effects of acupuncture are generally associated with the spinal nerve modulation that can occur at the inner Bladder line, as the ventral branch of the dorsal nerve root exits the fascial plane between the longissimus and iliocostalis muscle groups (36). Thus, most direct organ effects occur along this tissue plane. Additionally, the Bladder line modifies spinal nerve input from 2 to 3 spinal segments cranial to the point because the spinal nerves exit the spinal canal caudal to their place of emergence from the cord. However, the *Hwato Jiaji* (HJ) points are dorsal to the emerging nerve and are innervated from the *same* spinal segment in the dorsal branch of the spinal nerve that does *not* travel caudally before emerging. Therefore, a point at L2-3 on the Bladder line (BL23) is treating the exiting spinal nerve from about T13, while a HJ point at the same level is treating the L2 spinal nerve (47) **(Figure).**

## Example of Neurophysiological Underpinnings of an Acupuncture Treatment

Studies of acupuncture in spinal cord disease offer an enhanced understanding of its potential physiological effects. A generic acupuncture approach to the treatment of an acute, grade 3, thoracolumbar (T13-L1) spinal cord injury in a quadruped can explore these neurophysiologic concepts (**Table 1**). Using typical grading and classic signs,

**Table 1. Spinal Cord Injury Grades**

| Grade | Presentation<br>***All exhibit paraspinal pain* | Favorable Prognosis<br>(walking, control of pain) |
|---|---|---|
| 1 | Normal gait,<br>just painful | 70-100% |
| 2 | Weakly ambulatory or ataxic | 55-100% |
| 3 | Non-ambulatory,<br>unable to stand unassisted | 55-95% |
| 4 | Paraplegic,<br>no voluntary movement<br>Deep pain present,<br>+/- urinary & fecal continence | 40-80% |
| 5 | Paraplegic,<br>no voluntary movement<br>Deep pain absent,<br>+/- urinary & fecal continence | 30-60% |

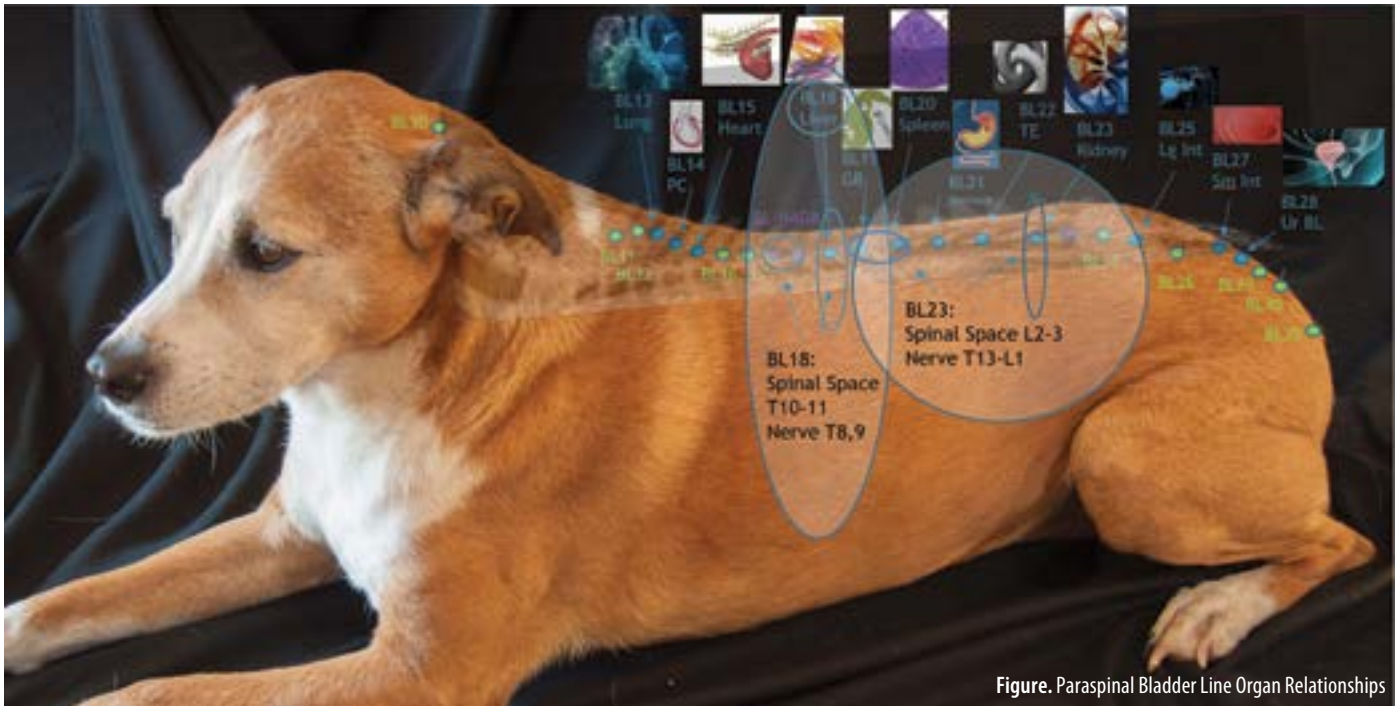


**Figure.** Paraspinal Bladder Line Organ Relationships

assume the patient has pelvic limb paresis with hypertonicity (upper motor neuron lesion), spinal pain, maintenance of deep pain sensation in digits, and absent conscious proprioception. Medications and surgery may be chosen to treat these cases, but acupuncture may be used as an alternative or adjunct treatment. From an acupuncture perspective, this lesion would generally be treated with at least 10 to 20 acupuncture points, with a focus on selecting points that have the greatest number of overlapping benefits. Points chosen from a list of priorities using either Traditional Chinese Veterinary Medicine (TCVM) or Western medical acupuncture (WMA) would likely be the same (**Box**). The number and type of points used in clinical practice might vary from the proposed points based upon patient presentation (acuity, symptoms, associated conditions, and temperament). For the purposes of this discussion, we will explore a detailed evaluation of 12 points that would commonly be chosen for unilateral or bilateral treatment (**Tables 2 and 3**).

All these points will share some general physiological effects common to all acupuncture points, and each of the

**Box. Western Medical Acupuncture Approach to Point Selection for Painful Patient (Spinal Cord Injury)**

- Identify origin of pain and dysfunction to establish the needle placement locations:
  - Fascia and strain patterns
  - Motor and myofascial trigger points
  - Intervertebral disk symptoms
  - Facet joint symptoms
- Acupuncture point choices- at least one point per category. Use points covering multiple categories where possible
  - Homeostatic points: sedation, sympathetic and parasympathetic modulation, global analgesia
  - Proximal (cranial) points (cranial to pain or lesion)
  - Proximate points (for discrete local spinal pain. Use HJ groups to maximize same-segment innervation and local muscle groups) **May not be tolerated in acute injury**
  - Distal (caudal) points (along the spine, caudal to lesion)
  - Peripheral points along ventral branch or peripheral nerve emerging from the spinal segments of interest
  - Myofascial trigger points and *Ah Shi* (painful) points

**Table 2. Acupuncture Point Choices With TCVM and WMA Rationale**

| Point | Neurophysiological rationale (WMA) | TCVM rationale |
|---|---|---|
| **GV14** | Homeostatic, proximal, sympathetic chain, motor regions | Meeting point for 6 Yang channels of hand and foot, Sea of Yang, clears pathogens, expels Wind, tonifies Qi and Yang |
| **Bai Hui** | Homeostatic, distal along spine, sacral transition, macro-fascia, *Ah Shi* point | Activates Qi and alleviates pain. Use with deficiency or excess patterns |
| **BL11** | Paraspinal neuromodulation, proximal along spine, myofascial strain pattern (cervical), compensatory motor groups, *Ah Shi* point | Meeting point: BL, SI, TH, GB. Influential point for bone, Sea of Blood. Benefits bones and joints, expels pathogens, treats pain |
| **BL18** | Paraspinal neuromodulation, proximal along spine, myofascial strain pattern (longissimus) | Spreads Liver Qi, pacifies Wind, cools Fire and clears Damp-Heat. Treats rigidity of neck and spine, and spinal pain |
| **BL23** | Paraspinal neuromodulation, distal along spine, myofascial strain pattern (longissimus) | Spreads Kidney Qi, fortifies Yang, nourishes Yin, benefits Essence, treats lumbar pain and hemiplegia |
| **BL36** | Proximal appendicular motor point, flexor surface (use estim), proximal sciatic point | Activates BL channel, relaxes sinews and alleviates pain, regulates lower *jiao* |
| **BL40** | Peripheral point, flexor surface (estim), lymphatic channel, neuroimmune modulation | *He Sea* and earth point, activates channel. Treats pain in lumbar spine and rear limbs from any etiology |
| **BL54** | Motor point, reflex loops, gluteal muscle and cranial gluteal nerve (widens lumbar segment input) | Master point for pelvic limbs. Treats pain in lumbar region, sacrum and buttocks |
| **KI1** | Peripheral point, flexor surface (estim), immune, lymphatic and fluid flux, sympathetic modulation | *Jing*-Well point, descends excess, calms, rescues Yang. Treats lower limb paralysis, lumbar pain and stiffness |
| **LV3** | Homeostatic peripheral point, autonomic nervous system, nervi vasorum hindlimb | *Yuan*-Source point, ensures Qi and blood flow, treats pain, including lumbar pain, paresis. Combined with LI4 is Four Gates |
| **LI4** | Homeostatic peripheral point, autonomic nervous system, nervi vasorum forelimb, brachiocephalicus and spinal nuclei | *Yuan*-Source point, regulates defensive Qi, expels Wind, alleviates pain, restores Yang. Four Gates with LV3 |
| **ST36** | Homeostatic peripheral point, periarticular reflex loops, autonomic nervous system | *He Sea* and earth point, supports Qi, alleviates pain, revives Yang. Treats lumbar pain, hemiplegia, atrophy |
| **LI10** | Homeostatic, peripheral, periarticular reflex loops, autonomic nervous system | Regulates Qi and blood, alleviates pain, activates channel, *Yang Ming* point, invigorates forelimb |
| **HJ T13-L1** | Homo-segmental neuromodulation, motor points for myofascial strain pattern in longissimus | Treated in TCVM as *Ah Shi* points |

| Table 3. Neurophysiological Aspects of Discussed Points | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Point** | **Micro-fascia** | **Macro-fascia** | **Fluid flux** | **Immune** | **MTrP** | **Visceral** | **Symp/Para homeostasis** | **Central** | **Reflex loops** | **Analgesia** |
| GV14 | + | +++ | - | +++ | ++ | + | +++ | +++ | - | +++ |
| Bai Hui | + | +++ | - | ++ | - | + | +++ | +++ | - | +++ |
| BL11 | + | +++ | - | + | +++ | ++ | + | - | + | +++ |
| BL18 | + | +++ | - | + | ++ | +++ | - | ++ | - | ++ |
| BL23 | + | +++ | - | + | ++ | +++ | - | ++ | - | ++ |
| BL36 | + | ++ | ++ | + | ++ | +++ | - | - | ++ | ++ |
| BL40 | +++ | ++ | +++ | +++ | + | - | + | - | ++ | +++ |
| BL54 | + | +++ | - | - | +++ | ++ | - | - | ++ | + |
| KI1 | + | + | + | ++ | - | - | +++ | + | + | + |
| LV3 | +++ | - | ++ | + | - | - | +++ | +++ | + | +++ |
| LI4 | +++ | - | ++ | + | - | - | +++ | +++ | + | +++ |
| ST36 | ++ | +++ | +++ | ++ | ++ | +++ | +++ | + | ++ | ++ |
| LI10 | +++ | ++ | +++ | ++ | ++ | ++ | +++ | ++ | ++ | + |
| HJ T13-L1 | + | +++ | - | + | +++ | - | - | - | + | + |

**Abbreviations:** MTrP, Myofascial trigger point; Symp/Para, sympathetic and parasympathetic.

distinct points will also contribute unique physiological effects that separate the points. The shared effects include interaction with fascia, mechanotransduction in fibroblasts and other cell types, neuromodulation, analgesia, modulation of fluid motion, and modification of the microvascular environment. Effects that are more specific to each particular point include location and distribution of neuromodulatory effects, degree of immune modulation, muscle or trigger point effects, brain or homeostatic changes, sympathetic and parasympathetic stimulation, remote visceral organ effects, and degree of lymphatic flow modulation (**Table 3)**.

The acupoint GV14 is regarded in TCVM as a point to treat various pain conditions due to the convergence of the 6 Yang channels from the hand and foot. In this aspect it is part of the *Sea of Qi*, which clears pathogenic factors, clears heat, and tonifies Qi and Yang. In this capacity it is central to treatment of obstructive pain (46). From a physiological perspective, GV14 has both micro-fascial and macro-fascial effects, with the macro-fascial effects being most relevant to the observed characteristics. There is no significant fluid or lymphatic presence to this location, and axillary points, with certain exceptions such as LU1, are generally less important than distal points for micro-fascial and microvascular input. The macro-fascial location relates to the fascial sheets that penetrate the thorax. This location is the origin of the sympathetic chain, the distribution of cervical nerve roots from the sympathetic and parasympathetic nervous system, and a region of tremendous cross talk and autonomic nervous system traffic (47). Neuromodulation is the superpower of this point, with autonomic effects that create systemic, homeostatic, and CNS modulation. Immunomodulatory and antipyretic effects at this location are attributed to vagosympathetic neuroimmune effects rather than specific effects on lymphatic tissue. Viscera-related neural cross talk in this region is associated with pulmonary and cardiac regulation, but BL points in the region are better positioned to interact with the spinal nerves as they become superficial.

GV14 also has significant motor input for a centrally located point; it approximates the insertion of the cervical muscle groups, trapezius and rhomboid groups, and the origins of the thoracic axillary groups such as the latissimus, longissimus, and iliocostalis groups. This amplifies the pain-related effects of the point, especially for back and spinal conditions, as the bridge between cervical and thoracolumbar regions. Some of these motor and autonomic effects overlap with the closest BL point, BL11, which will be discussed shortly.

*Bai Hui* is described as *100 Convergences* in TCVM, despite being located at the lumbosacral junction in quadrupeds, rather than at the top of the head as in the human (46, 47). This sacral nature lends its indications for use to urination, as well as to pain in the lumbar region. There is less diffuse information about this point in quadrupeds due to its variation from the human and the consequent alteration of historical perspectives.

From a physiological perspective, *Bai Hui* has several things in common with GV14, in that it resides at the termination of input from the sympathetic chain and at the transition to sacral innervation, which thus hosts significant autonomic and somatic traffic. It also has limited micro-fascial importance and has less motor input than GV14 might. In addition to the spinal relationships, the macro-fascial plane it occupies is the conclusion of the longissimus group and the attachment of the hips and sacrum. Thus, fascia plays a more important role than muscle in this location as

compared to GV14, where both served prominent roles. Visceral input is characterized by its proximity to sacral BL points, which have dramatic roles in pelvic visceral functions such as urination, defecation, and sexual functions.

BL11, BL18, and BL23 can be considered together because of their WMA similarities. Located within the fascial sheet containing the ventral root of the dorsal branch of the spinal nerve, they modify neuronal signals related to their specific spinal nerves and thus overlap with associated visceral structures (47). BL11 is at the beginning of the thoracic spine and treats the caudal cervical nerve roots that have some overlap with cardiac and lung innervation. For BL18, the location is at the T10/T11 spinal segments, but the nerve root is from T8/T9, which overlaps with innervation to the pleura, liver, and diaphragm. The celiac plexus forms just caudal to this region and receives input from these spinal roots. BL23 emerges between spinal segments L2/L3 but contains nerve roots from T13 to L1. In all cases, these points can treat regional spinal pain as well as distant visceral conditions. In addition to neuromodulation, which is the major focus of these points, motor effects can be seen.

All 3 points emerge in the fascial plane between the longissimus and iliocostalis muscle groups. Angling the needle may also potentially provide trigger point treatment in the longissimus. In addition, BL11 occurs as the cervical groups coalesce onto the thoracic segment, making this a major location for both motor and fascia input as well as reflex loops from the forelimbs and neck region. BL18 influences the large latissimus dorsi group and thus the phrenicoabdominal nerve. BL23 interacts with the iliopsoas muscle as it attaches to the ventral aspect of the lumbar vertebral bodies. In this example these points can play roles in organ neuromodulation and perfusion (heart, lungs, liver, and kidney) in addition to pain modulation at the level of the spinal nerves. The points have limited effects on local fluid dynamics but do relate to fluid mechanics at the organ level. Immune modulation from these points is limited, as they are neither peripheral points nor located over lymphatic chains, but they do have some limited immune modulation through vagosympathetic neuroimmune balance. They all have minor effects on brain neurochemistry via their input to the spinal cord.

BL36 is a proximal appendicular point. In general, points in this category hold macro-fascial implications, connecting limbs to the body in major fascial sheets and dense collagenous attachments. BL36 also occurs close to the sciatic nerve and thus serves the role of a proximal point along this peripheral nerve, collaborating with KI1 and LV3 distally along the axon (47). BL36 is located on the flexor surface of the hindlimb. Its use, along with electrical muscle stimulation (estim), would help to restore reflex arc function along the coordinated muscle groups, promoting multi-motor group flexion to offset the extensor spasticity seen with upper motor neuron injury to the spinal cord. In TCVM, BL36 is important for its ability to activate the BL channel, regulate the lower *jiao*, relax sinews, and alleviate pain. It is especially used for sciatic nerve pain radiating down the limb (46).

BL40 holds importance as a *He Sea* and earth point in TCVM (46). It benefits the lumbar region and stifles, activates the channel, and treats pain in the lumbar spine and hindlimbs. In WMA terms, its value is due to its location in the stifle region, on the lymphatic and flexor surface of the pelvic limb (47). In addition to the reflex loop input shared with BL36 and KI1, it will have significant neuroimmune and pain modulating effects. It is the most lymphatic-centric option of the points discussed here, which is a unique and necessary benefit with pelvic limb paralysis as lymphatic flow generally requires motor activity for optimal efficiency. Mid-limb points have an increased tendency to form reflex loops with organ systems, and the urinary bladder input from the pelvic nerves is important in a spinal cord-injured patient (48).

BL54 is a major motor point of the hindlimbs, interacting with the gluteal groups and piriformis and providing input near the joint capsule of the hip (47). Motor function is by far the most important aspect of this point, and through motor reflex loops it can modify motor reflexes. Via nerve pathways it also provides regional and systemic analgesia. In TCVM it is considered a master point for back and pelvic limbs, and it is used to treat pain in the lumbar region, sacrum, and buttocks (46).

KI1 is a distal point which conveys a significant neurostimulatory and microvascular effect. In this presentation it provides sympathetic input and fluid and immune modulation (47). It is also the distal point along the fibular nerve, making it critical for neuronal recruitment and healing after spinal cord injury. It is on the flexor surface of the limb and could provide a good location for estim along the flexor groups when combined with BL40 or BL36. With a T13 lesion, there will be increased extensor tone to the hindlimbs, making the flexor groups important targets for stimulation and awakening. In TCVM, K1 is relevant because it is a *Jing*-Well point that combats descending excess, calms the spirit, revives consciousness, and rescues Yang (46). It treats lower limb paralysis, lumbar pain and stiffness, foot numbness and pain, or inability to stand.

Points LI4 and LV3 are integrally related and are very stimulating points neurophysiologically. In WMA there is a goal to stimulate several critical regions along the entire spinal cord; treating bilaterally and both forelimbs and hindlimbs can help to accomplish this wide distribution of neural input. In addition, both points are found in the distal limb, but not quite as distally as the digits which have less soft tissue and fewer nerve structures for modulation in quadrupeds as compared to humans. At the level of metatarsal (or metacarpal) and phalangeal joints, the innervation and blood flow from the limb form complex loops that can bypass the distal digits and return blood flow to the venous system (47). The degree of innervation at this region is marked and includes significant sympathetic, parasympathetic, and sensory fibers. Thus, these are the most distal points in dogs and cats that carry vast autonomic and somatic information to the nervous system, providing both peripheral effects as well as intense neuroregulatory and immune-modifying benefits. Since this neurological activity also translates into a larger central action, both points can be considered to have homeostatic effects. Likewise, in TCVM both points are thought to have generalized analgesic effects (46). They are *Yuan*-Source points, which is relevant to the lymphatic flow coalescing in this region. Used together, they are known as the *Four Gates*, and they restore blood flow and Qi and treat pain and weakness.
In addition, LI4 has innervation overlap in the cervical region with spinal nuclei of the trigeminal and axillary nerves (47). This explains the TCVM recognition of this point for treating conditions of the face and serves the WMA imperative of creating a far-reaching neuromodulatory input to the nervous system (46).

Points ST36 and LI10 can also be considered together. Acupuncture needle distribution is anecdotally believed to benefit from bilateral as well as multiple-limb treatments to stimulate multiple regions along the spinal cord, rather than just a few or just the affected spinal segments. On both the thoracic and pelvic limb, these points occur just distal to the first identified lymph node chains and in the region of the *He Sea* points. This correlates with the anatomy, as the lymphatic channels are well formed at this level and do function as the "rivers" proposed by TCVM theory. In addition, these 2 locations benefit from significant autonomic reflex loops, with ST36 involved in gastrointestinal regulation and LI10 and other elbow points playing an important role in cardiac reflex loops (49, 50). In TCVM theory, the use or combination of these points is strengthening, with ST36 said to support Qi, alleviate pain, revive Yang, and treat lumbar pain, hemiplegia, and hindlimb atrophy (46). LI10 is said to regulate Qi and blood, alleviate pain, activate the LI channel, and invigorate the forelimb, which can be important especially in cases with absent motor activity in the hindlimbs.

All HJ points are primarily motor and analgesic points. They stand out for being homo-segmental and are often the best points to treat an acutely painful region of the spinal cord. They interact with the spinal stabilizer muscle groups as well as the longissimus. In TCVM, these points are selected to address focal discomfort and do not have any notable alternative associations. In this case they relate to the origin of the spinal pain.

Evaluating this set of acupuncture points is somewhat artificial since patient-based point prescriptions, which cannot be anticipated in this generic process, are intrinsic to a successful acupuncture treatment. However, the concepts behind these points demonstrate the diversity of functions that can be attained and the desirability of a broad approach for the treatment of multi-systemic diseases such as spinal cord injury. A variety of other points could be chosen, using both TCVM and WMA-based thinking to capture the underlying effects discussed for this specific cluster of acupuncture points.

In conclusion, while a scientific discussion of acupuncture may benefit scholarship via evidence-based conversation, when considering a specific case presentation, TCVM and WMA are likely to select similar points, albeit via disparate thought processes. These points come together to address various physiological mechanisms and underlie the complexity and diversity of treatment at an acupuncture point. Depth of needling, type of needles, and associated treatments such as manual therapy, pharmaceuticals, non-pharmaceutical herbal medications, and exercise further complicate evidence-based research on acupuncture but are commonly utilized in clinical medicine. Creating a collaborative conversation between neurophysiological acupuncturists and TCVM acupuncturists is not only possible, but it is also good for the field of acupuncture. Basic scientific evidence of the neurophysiology of acupuncture can serve as a scaffolding for these conversations.

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