

Review of the Literature

Chronic pain/dysfunction in whiplash-associated disorders

J Manipulative Physiol Ther 2001;24:44-51 (January 2001, Volume 24, No. 1)

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FROM ABSTRACT:

Objective:

The purposes of this article are:

- (1) to review current knowledge of and recent concepts pertaining to the causes of chronic pain and/or dysfunction following whiplash-type injuries.
- (2) to acquaint those who treat these types of injuries with possible mechanisms of continued pain and or dysfunction following whiplash.

Results:

Pain is a complex phenomenon that has great variability. Chronic pain appears to involve a deficient descending inhibitory process and/or ongoing excitatory input.

Conclusions:

There are a wide variety of reactions by individuals to any given type of stimulus. Injury may lead to increases in neuronal activity and prolonged changes in the nervous system. Chronic pain may be seen as part of a central disturbance accompanied by disinhibition or sensitization of central pain modulation, mirrored in the immune and endocrine systems. Patients with chronic whiplash syndrome may have a generalized central hyperexcitability from a loss of tonic inhibitory input (disinhibition) and/or ongoing excitatory input contributing to dorsal horn hyperexcitability. Dysfunction of the motor system may also occur, with or without pain. The purpose of treatment should be not only to relieve pain but also to allow for proper proprioception.

In this article, Dr. Davis also notes:

“The types of injury produced in most low-speed motor vehicle collisions are soft tissue injuries involving the spine and nervous system.”

These injuries are inertial injuries and not crush injuries.

In a low-velocity whiplash injury, there is an S-shaped curvature of the cervical spine, and lower cervical motions exceed their physiological limits.

The soft tissue is rarely torn completely, but stretched beyond its elastic limit, causing an incomplete injury. This subfailure injury alters the tissue's mechanical properties.

"Microscopic collagen fiber failure begins at 3% to 5% strain."

Strain greater than 7% - 8% may cause the load carrying capacity of the ligament to be lost, even when the ligament appears macroscopically intact.

Between individuals, "There is a wide range of variability in:

- (1) ligament strength between individuals,
- (2) the body positions of occupants in the vehicle,
- (3) the amount of muscle activation and inhibition,
- (4) the size of the spinal canals, and
- (5) the excitability of the nervous system."

"A whiplash-type injury occurs in deep tissue that may involve the facets, disk, ligaments, or muscles."

Deep tissue pain lasts longer and does not follow dermatomal patterns as superficial pain does.

Chronic whiplash pain patients have a significantly lower pain threshold than do normal controls.

Nociception

The perception of pain involves activation of nociceptors in the periphery, which then activate second-order neurons in the spinal cord and then go to the thalamus and brain.

Areas of the brain, thalamus, and brainstem can initiate descending pain inhibition. This descending pain inhibition modulates pain at the dorsal horn of the spinal cord.

"Acute pain can induce long-term neuronal remodeling and sensitization."
[synaptogenesis / neuroplasticity, and wind-up]

Following peripheral tissue injury, released substances initiate nociception.

These substances include:

Potassium from the damaged cells

Serotonin from platelets

Bradykinin from the plasma

Histamine from mast cells

Prostaglandins (PGE₂) from the damaged cells
 Leukotrienes from the damaged cells, and
 Substance P (SP), from the primary afferent fibers

This nociceptive afferent input to the dorsal horn of the spinal cord activates the NMDA and AMPA excitatory amino acid receptors.

“Glutamate is the main excitatory neurotransmitter in the central nervous system and has been implicated in neurodevelopment, synaptogenesis, synaptic plasticity, and in long-term potentiation (LTP).”

Glutamate has also been implicated in neurodegenerative disorders, and neurotoxicity. **[This is important. Read: Excitotoxins by Blaylock, 1997; In Bad Taste by Schwartz, 1999; The Crazy-makers by Simontacchi, 2000]**

Glutamate is an excitatory neurotransmitter in the dorsal horn and its effects are enhanced by SP. “Glutamate and SP coexist in primary afferent terminals and are co-expressed and act synergistically in the dorsal horn.”

Intracellular messengers, like arachidonic acid, are linked to excitatory amino acid receptors and may also play a critical role in the development of persistent nociception after tissue injury. **[Important: arachidonic acid is derived from animal fat and omega-6 fatty acids]**

Inflammation

“Inflammation increases the sensitivity of the receptors in the periphery and in the central nervous system by altering membrane properties of nociceptors, permitting a higher discharge frequency and contributing to hyperalgesia, and by activating synapses that are usually inactive.”

Inflammatory sensitization of peripheral nociceptors can be very rapid and enhances pain.

Inflammation increases the sensitivity in the peripheral terminals of nociceptive fibers.

Inflammation causes mechanoreceptors, which normally inhibit nociception, to sprout into lamina II of the dorsal horn and express SP as C pain fibers do.

Inflammation induces central sensitization in the spinal cord.

Cytokines are small proteins that are essential for healing of connective

tissue after injury.

“Cytokines released from an injury may be proinflammatory or anti-inflammatory.”

Tumor necrosis factor, which is a proinflammatory cytokine, can induce the hyperalgesic response of inflammation.

[Important, as this is also related to diet. Recall #51-00 and #52-00]

“Cytokines may act as a link between the nervous and immune systems.”

Mechanisms of chronic pain

“Chronic pain can be due to tissue injury, nervous system injury, or both.”

“Pain may be stimulus-dependent or stimulus-independent.”

“In the development of chronic pain, wind-up-type mechanisms and LTP play roles in neuroplasticity to cause hyperalgesia and allodynia.”

“The term central sensitization refers to an increase in spinal cord neuronal excitability and a decrease in threshold.”

“Wind-up, a progressive increase in the magnitude of the C-fiber evoked response, may also produce some characteristics of central sensitization, including expansion of the receptive fields and enhanced responses to C-fiber stimulation.”

The NMDA receptor appears to be important for synaptic plasticity.

The NMDA channel is blocked by magnesium (Mg^{2+}). **[Important]**

The NMDA receptor is a high-capacity calcium (Ca^{2+}) channel, and Ca^{2+} ions flow into the cell during NMDA receptor activation.

Calcium triggers a number of intracellular biochemical processes that are important for LTP of the particular synapse, including the activation of immediate early genes coding for factors regulating protein synthesis.

This leads to persistent changes in neuronal excitability and wind-up.

Chronic pain is characterized by an abnormal sensitivity that may be due to generation of pain from low-threshold mechanoreceptive fibers that normally generate innocuous sensations.

A decrease in non-nociceptive input [**i.e. a subluxation**] may lead to pain by a deafferentation mechanism, which may occur as early as 1 day after injury.

“Sparse nociceptive activity from minor pathologic conditions (minor nerve trauma or tissue inflammation) can become excruciatingly painful as a result of central integration of the neural responses.”

Initiated by tissue injury, persistent small afferent input results in a hyperalgesia at the site of injury and allodynia in areas adjacent to the injury site.

Hyperalgesia reflects a sensitization of the peripheral terminal.
Allodynia reflects a central sensitization.

Patients with chronic whiplash syndrome and with fibromyalgia have a generalized central hyperexcitability of the nervous system.

There is evidence that chronic pain may be seen as part of a central disturbance accompanied by disinhibition or sensitization of central pain modulation, which is also mirrored in the immune and endocrine systems.

Recent research indicates that pain and immune function mechanisms have mutual features.

“Immune parameters have been shown to be related to activity in brain areas involved in pain perception, emotion, and attention.”

Dysfunction

Because the cervical spine is richly supplied with mechanoreceptors and muscle spindles, whiplash trauma can play a role in locomotor system dysfunction as well as chronic pain. Distorted articular proprioception interferes with the precise continuous input necessary for coordinated normal patterns of motion, balance, coordination, and equilibrium.

“A whiplash injury can cause distortion of the posture control system, including oculomotor dysfunction.”

“Some patients who claimed no symptoms after trauma showed oculomotor dysfunction and repositioning dysfunction.”

“A proprioceptive dysfunction might be one of the most important factors for understanding the morbidity after a non-contact whiplash injury to the neck.”

Inhibition

“Peripheral injury that produces inflammation can result in central sensitization and hyperalgesia.”

Also, “a decrease in the effectiveness of inhibitory synaptic transmission leads to increased responsiveness of spinal reflex pathways and pain sensations.”

“Damage to the descending inhibitory systems enhances wind-up, indicating that wind-up is influenced by supraspinal, descending inhibitory pathways.”

“A disturbed inhibitory mechanism may result in widespread deep hyperalgesia.”

“Some patients may be genetically predisposed to decreased amounts of opioid receptors.” “The greater the quantity of opioid receptors one has, the more likely it is that the result will be less perception of pain.”

“Ischemia can reduce the expression of mu-opioid receptors in the dorsal horn.” **[Important: this is one reason we desire to improve blood flow through chiropractic, exercise, and diet]**

“The midbrain periaqueductal gray (PAG), rostral ventromedial medulla, and spinal cord are components of the endogenous pain modulating pathway.”

These brain stem-descending pathways are involved in modulation of spinal nociceptive neurons, and their imbalance can be a mechanism in acute and chronic pain conditions.

“The endogenous descending antinociceptive system, including the serotonergic and noradrenergic descending pathways from the medulla and pons into the spinal cord, may be influenced by environmental stimuli.”
[i.e. including an adjustment]

“The descending serotonergic pathway is more effective in suppressing neuronal hyperexcitability in the deep dorsal horn.”

“The principal action of serotonin in this process is to limit neuronal excitability.”

“Gamma-aminobutyric acid (GABA) also reduces nociceptive reflexes, hyperalgesia, and allodynia.”

In the spinal cord, GABA is concentrated in interneurons of the dorsal horn and contributes to normal tonic inhibition of pain. If this GABA-dependent tonic

inhibition is not functioning properly, pathologic states of increased spinal cord excitability result.

Nociceptive transmission in the dorsal horn is subject to tonic-descending inhibition, which may prevent plastic changes in nociceptive transmission in the spinal cord.

Modulation stimulation

Impulses in primary afferent nerve fibers may produce short- or long-lasting modifications in spinal nociception.

“Somatosensory **[i.e. an adjustment]** thalamic stimulation may activate pain modulation circuits.”

Stimulation of the ventralposterior lateral nucleus of the thalamus has reduced mechanical allodynia in experiments.

[this area receives information from mechanoreceptors]

A loss of non-nociceptive input into the thalamus **[i.e. reduced joint mechanoreception]** may allow nociceptive neuronal input to be prominent.

“This deep-tissue stimulation **[i.e. an adjustment]** on the contralateral side activates inhibitory descending projections from higher centers.”

“The resultant descending inhibition reduces the expression of LTP in dorsal horn cells, and that long-term descending inhibition may override a segmental facilitation.”

Physical activity can significantly increase the threshold of the nociceptive reflex.

Manipulation can improve pain tolerance. Spinal manipulation shows a consistent reflex response including a reduction of pain and a decrease in hypertonicity of muscles.

In addition to anti-nociception, manipulation “produces changes in sudomotor, cutaneous vasomotor, respiratory, and cardiac activity, which widespread activation of the central nervous system.”

“Endorphin levels have also been shown to increase after manipulation.”

Conclusion

"Injury may lead to increases in neuronal activity that are reflected in gene expression and prolonged changes in the nervous system. The functional result is hyperalgesia and spontaneous pain associated with tissue injury."

"Pain can be biochemical, with apparently normal structure."

"Patients suffering from chronic whiplash syndrome may have a generalized central hyperexcitability from a loss of tonic inhibitory input (disinhibition) and/or an increase in excitatory input contributing to dorsal horn hyperexcitability."

"The aim of treatment should be not only to relieve pain but also to allow for proper proprioception."

This is an excellent review on chronic pain from whiplash injury. It contains an excellent review of the literature, 133 references.

This article has it all, including:

- Altered Receptor Thresholds
- Inflammation and Inflammatory Cytokines and Inflammatory Prostaglandins
- Receptive Field Enlargement
- Excitatory NMDA Receptors
- Neuronal Channel Ca^{++} Influx
- Neuronal Channel Mg^{++} Blockage of the Ca^{++} Ion influx
- Glutamate Excitatory Neurotransmitter and Pain
- Glutamate Neurotransmitter and Neurodegeneration / Excitotoxicity
- GABA Inhibitory Neurotransmitter
- Mu-Opiate Receptors and Pain Inhibition
- Serotonin and Pain Inhibition
- Periaqueductal Grey (PAG) and Pain Inhibition
- Dysafferentation of Mechanoreception and Pain
- Mechanical Stimulation and pain Inhibition
- Synaptogenesis / Neuroplasticity
- Wind-up
- Long Term Potentiation (LTP)
- Pain – Nervous System – Immune System Link
- ETC.

Remember that Dr. Davis has a reference book pertaining to soft tissue trauma that he used in his expert and testimony cases as well in narrative report preparation. You can purchase the book from him. His phone number is (626) 331-6361.

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