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Somatic dysfunction, osteopathic manipulative treatment, and the nervous system: A few facts, some theories, many questions

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The purpose of this paper is to summarize the ways in which the nervous system is involved in somatic dysfunction, as well as its manifestations and the ways in which it organizes and mediates the benefits of osteopathic manipulative treatment.* It will be shown that, encouraging as our progress has been in uncovering these mechanisms, much remains to be learned. We can only speculate with varying degrees of certainty about the kinds of mechanisms that may be implicated, and even as to what extent the mechanisms are common to dysfunction and treatment. This paper offers some of the better-documented speculations and indicates the kinds of questions and hypotheses to be addressed.

One of the most reliable of the hypotheses is that the entire nervous system—from the highest centers of the brain to the peripheral neurons—is involved in all somatic dysfunction and in every manipulative treatment. Nevertheless, most of the neurophysiologic research in this area (including the author's) has focused on the segmental and peripheral nervous system while purporting to explain how local somatic disturbances and their treatment affect the person as a whole.

How do local somatic disturbances and manipulation relate to the person as a whole? Experience makes clear that the personality of the patient influences the nature, site, and clinical impact of somatic dysfunction. It is also clear that the personality of the patient (and that of the physician), as is true of all clinical encounters, influences the response to manipulative treatment. We know little, however, about how personality exerts its influence. Therefore, it seems that investigative attention to the nervous system as a whole is long overdue.

Osteopathic manipulative therapy is not only treatment of a part of the body, or even of the body itself, but of a person, who is unique and distinct from all other persons. The patient is not a passive recipient, but rather an active participant by virtue of his or her total response to, and influence on, the treatment. Moreover, manipulation is treatment given by another unique person, not merely a technique.

For these reasons, I have viewed every manipulative treatment as a "complex transaction between two human beings. In the course of each treatment two persons are physically, physiologically, and psychologically linked in a cybernetic loop in which each responds continually to the other's responses to his own changing input. As in less physical forms of therapy, the physician seeks to guide the patient to behavior patterns that are less costly and more favorable to his health."[1] Every treatment conducted in this manner is in effect a dialogue, largely wordless.

The next section examines nervous mechanisms through which the patient's personality and perceptions may condition his or her part of the dialogue and his or her responses to the clinician's manual queries and assertions.

Mechanisms in the translation of personality into bodily responses

Through what mechanism does the patient's personality exert its influence in determining the site, nature, and severity of the somatic dysfunction and the outcome of manual therapy? I suggest the following as possible mechanisms.

Posture and attitude

While biomechanical dysfunction is usually viewed as a causative or contributing factor in the patient's problem, it is itself a consequence of the imperfections in that person's total adaptation to the relentless force of gravity. That adaptation, which is visible in posture and locomotion, is, to the discerning clinician, eloquent expression of the patient's total personality and view of the world and of self. It is no semantic accident that "posture" and "attitude" apply to both the physical and

*Although craniosacral manipulation has features and mechanisms in common with manipulation of spine, trunk, and extremities, its unique aspects require separate consideration beyond the scope of this paper.

psychologic domains. Given the unity of body and mind, posture and attitude reflect the history and status of both and help in determining where and how the body framework is vulnerable. As has been said,[2] "(T)he able physician quite literally has at his fingertips an extensive document of the patient's history, including indications of general health and the extent of structural adaptation to the environment."

Descending pathways

One mechanism that is widely recognized but only partly understood is the assortment of neuronal pathways descending from various parts of the brain that elicit and modulate motor and autonomic activity patterns that are organized in the cord. The impulse patterns carried in these descending pathways are controlled by the cerebral cortex, hypothalamus, reticular formation, various brainstem centers and nuclei, and many others. Through these changing patterns, perceptions and their associated affects or feelings may profoundly influence the bodily state, muscular activity, the workings of the homeostatic and healing mechanisms, and the patient's response to the clinician's ministrations. This area awaits further exploration in both clinic and laboratory.

Neuroendocrine mechanisms

The neuroendocrine system is another category of mechanisms through which the personality and perceptions of the patient condition his or her musculoskeletal system and response to a given manipulative treatment. This complex system, which involves the limbic system, the hypothalamus, and the pituitary, adrenal cortex, adrenal medulla, and other endocrine glands, has received such thorough study in the healing professions, thanks especially to Hans Selye, that it needs only to be identified as another area in need of exploration in this context.[3]

Endocoids

The last category of mechanisms to be discussed has yet to be conceptually related to manipulation. Foreseen many years ago by A.T. Still, it has often been designated as the "body's own medicines," and recently as "endocoids."[4] In 1897, Still[5] characterized man's brain as "God's drug store," which "had in it all liquids, drugs, lubricating oils, opiates, acids, and anti-acids and every quality of drugs that the wisdom of God thought necessary for human happiness and health."

This remarkably prescient concept has been amply confirmed and elaborated in recent years. Approximately 40 peptides that are formed in the brain and released under appropriate circumstances, and which have a great variety of actions, have been identified. The best known of these are, of course, the endogenous opioids—the enkephalins and endorphins. In addition to their analgesic actions, the opioids also affect appetitive behaviors, circulation, respiration, temperature regulation, and immune function, and they are implicated in shock, spinal cord injury, and stroke.[6] But there are many other brain peptides with diverse influences, some of them on the formation and release of still other endocoids elsewhere in the body. These, in turn, have actions that profoundly affect the homeostatic, healing, defensive, and reparative mechanisms in the body.

We have begun to recognize that the body—the brain in particular—is a well-stocked apothecary, and that it manufactures its own medicines, writes its own prescriptions, and administers each dose—all without side effects. There can be no question that these mechanisms and substances are crucially involved in mediating the therapeutic effects of manipulation. Here is another area of research with enormous possibilities.

To summarize thus far: It has been emphasized that every manipulative treatment is an interaction between two absolutely unique persons, and several mechanisms have been proposed as mediating the influence of the patient's personal qualities and perceptions on the somatic problem and on the outcome of the manipulative encounter.

Segmental neurophysiologic mechanisms

It is now appropriate to ask several questions: What are the neurophysiologic mechanisms underlying the local or segmental disturbances to which manipulative therapy is directed? How and to what extent are these mechanisms under the influence of the thoughts, emotions, and perceptions of the person? Conversely, how and to what extent do the segmental processes influence those going on in the brain?

This section summarizes research findings and theories regarding the neurophysiologic mechanisms that are associated with disturbances in spinal and paraspinal function and illustrate their 2-way interplay with the brain.

Chronic segmental facilitation

Denslow and coworkers[7,8] demonstrated in human subjects that motor neuron pools in spinal cord segments related to areas of somatic dysfunction were maintained in a state of facilitation. That is, they were chronically hyperirritable and, therefore, hyperresponsive to impulses reaching them from any source in the body. Sources includ-

ed not only proprioceptors, cutaneous receptors, and other sensory inputs to the nervous system, but various cerebral centers as well. For example, startling the subject or inducing mild anxiety caused exaggerated and prolonged muscle responses in the dysfunctional segments. Muscles innervated from these segments are, therefore, kept in a state of hypertonus much of the day, with inevitable impediments to spinal motion and with structural and functional consequences to the muscle (and person) over a period of time.

Sympathicotonia

Using sudomotor and vasomotor responses as physiologic indicators, another team of investigators[9-14] at the Kirksville College of Osteopathic Medicine found that facilitation extended to the sympathetic pathways originating in the affected segments. Thus, when the subject was exposed to physical, environmental, and psychologic stimuli similar to those encountered in daily life, the sympathetic responses in those segments were also exaggerated and prolonged. The disturbed segments behaved as though they were continually in or bordering on a state of "physiologic alarm." Organs and tissues receiving their innervation from these segments may be subject to prolonged, intensive barrages of sympathetic impulses. The pathophysiologic consequences (ischemia among them) vary, of course, according to the functional properties of the target tissue or organ, but also according to the other circumstances in the person's life and his or her responses to them.

In view of the fact that local or segmental sympathetic hyperactivity has been shown to be a common factor in a large variety of syndromes,[14] the origin of the hyperactivity and its pathogenic role remain a rich area for further exploration. Interchange between the facilitated sympathetic pathways and the higher centers would be of especially great interest. In experimental studies in which the kidney was the target of sympathetic hyperactivity, Hix[15] illustrated the kinds of disturbances in visceral physiology that may occur.

Afferent sources of facilitation

What are the sources of afferent impulses that provoke the state of facilitation in the affected segments of the spinal cord? There are, as yet, no certain answers, other than the obvious but not invariable involvement of pain endings. Almost certainly implicated are receptors and endings in muscles, tendons, ligaments, and joints. Irritative disturbances (for example, entrapments) of nerves, roots, and ganglia are also involved in many cases. Segmental facilitation may also result from afferent bombardment arising in pathologic or painful viscera, as occurs in association with referred pain.

Muscle spindles have received special theoretic attention in this regard. The exaggerated tone and "braking" action of muscles in areas of somatic dysfunction have been ascribed to spindles that are hypersensitive to changes in muscle length. The hypersensitivity is thought to be caused by incorrect spinal-cord setting of the gamma neuron control of intrafusal muscle fibers. The reflex effect is exaggerated and rapidly mounting resistance to lengthening of the muscle.[16] The high "gamma gain" may be the basis for the so-called physiologic barriers to vertebral motion. When the local gain is further turned up by excitatory impulses descending from higher centers, the impairment of vertebral motion is exacerbated. According to this hypothesis, effective manipulation is that which results in resetting of the gamma gain. The theory appears to be consistent with clinical experience,[17] but it awaits testing in the laboratory.

Another theory[18] that has been offered might be described as vertigo or nausea at the spinal level. According to this reasoning, signals reaching the cord from various musculoskeletal reporting stations (proprioceptors and other receptors in musculoskeletal tissues and possibly skin) are so conflicting ("garbled") that appropriate, adaptive responses are not possible. For example, high-gain spindles, in reporting greater-than-real muscle lengths, would contradict reports from joint receptors regarding the relative positions and motions of the vertebrae to which the muscle is attached.

From this hypothesis it can be seen that effective manipulation is that that results in the re-establishment of coherent patterns of sensory input. This is presumed to be accomplished by appropriate adjustment of such factors as interosseous relationships and lengths and tensions of myofascial tissues.[14]

The individual and combined roles of the various somatic receptors and sensory endings in somatic dysfunction and manipulative therapy, are, in the author's opinion, among the most important in need of investigation. We would learn much about the involvement of various myofascial and osseous structures, and perhaps about the common denominator in the various types of manipulative approaches.

Plasticity of the central nervous system

As the term chronic segmental facilitation implies, facilitation may be maintained over periods of months and even years. How is it maintained? Several hypotheses have been offered: (1) Facilita-

tion is maintained by continued firing of the receptors and endings that contribute to the aberrant sensory input; (2) other sources of afferent bombardment are successively invoked as more and more tissues are reflexly or biomechanically affected; and (3) enduring, self-sustaining changes in excitability and in patterns of synaptic transmission are induced in the affected portion of the spinal cord.

The first two theories, especially the first, are those most commonly inferred. However, continuous firing over such long periods of time has always been in question in view of the tendency of tissues to make some pathophysiologic adaptation to continued stress (for example, fibrosis of muscle) and for the firing of receptors to become attenuated. It seems likely, therefore, that the disturbed input is more important in the induction and perhaps early reinforcement of facilitation than in its long-term maintenance.

Over a period of several years, Patterson and associates[19,20] have adduced considerable evidence for the third hypothesis from their own experimental studies and from those of earlier investigators. That evidence supports the concept that the spinal cord, like higher centers of the central nervous system, is highly plastic. That is, spinal reflexes can also be conditioned by repetition or prolongation of a given stimulus. According to the hypothesis, like the brain, the cord can learn and remember new behavior patterns. Whether the engram (or memory), once recorded, needs reinforcement by some kind of afferent stimulation is an open question.

This is another exciting and important area that merits broader investigation. It would be of great interest, for example, to determine whether the recording of new engrams in the cord is, as in the brain, associated with increased neuronal synthesis of nucleoproteins.

Trophic functions of nerves

Also involved in somatic dysfunction are neural influences that are based on the transfer of specific proteins synthesized by the neuron to the innervated tissue. This delivery is accomplished by axonal transport and junctional traversal.[21-25] These "trophic" proteins are thought to exert long-term influences on the developmental, morphologic, metabolic, and functional qualities of the tissues—even on their viability.

Biomechanical abnormalities in the musculoskeletal system may cause trophic disturbances in at least two ways: (1) by mechanical deformation (compression, stretching, angulation, torsion) of nerves, which impedes axonal transport; and (2) by sustained hyperactivity of neurons in facilitated segments of the spinal cord, which slows axonal transport[26] and which, because of metabolic changes, may affect protein synthesis by the neurons. It appears likely that manipulative treatment would alleviate such impairments of neurotrophic function.[25] Still[27] foresaw this development years ago when he identified as a cause of disease the "partial or complete failure of the nerves to properly conduct the fluids of life."

It would be an enormous contribution to our knowledge and understanding to isolate and characterize the neuronal proteins that reach the target organs, and to determine their cellular and intracellular destinations and their participation in the cellular processes. The highly developed techniques in protein chemistry and immunochemistry are available for such study. From the clinical viewpoint, it would be of great interest to examine in various tissues the pathophysiologic consequences of impaired synthesis and axoplasmic transport of proteins in hyperactive neurons of facilitated segments.

Segmental focusing of cerebral influences

Because of the hyperexcitability of the efferent neurons, facilitated segments of the spinal cord appear to behave as "neurologic lenses" that "focus" impulse traffic from diverse sources, thus channeling it through peripheral motor and sympathetic pathways to the tissues innervated from those segments.[28] The impulse traffic would thus have a "magnified" effect on the target tissues.

Among the impulses channeled through the facilitated segments are those delivered from the higher centers by the descending pathways discussed earlier. While heavy excitatory traffic in these descending pathways (in anger, fear, or anxiety, for example) has systemic consequences, tissues innervated by facilitated segments would be especially victimized. Under these conditions, one would expect the response to manipulation to be constrained in proportion to the descending excitatory traffic.

In view of the observation[26] that high rates of stimulation of peripheral nerves retard axoplasmic transport, trophic consequences of the hyperexcitability of neurons in dysfunctional segments are especially likely in patients who are under emotional stress.

The role segmental somatic dysfunctions play in what is commonly designated as psychogenic illness is another exciting area awaiting study.

The ascending influence

Do the local disturbances and their manipulative treatment have reciprocal influence on the higher

centers? Patients who undergo manipulative therapy often experience the relief of debilitating pain, a renewed sense of ease and lightness of motion, and exhilaration, quieting of anxiety, lifting of depression, release of tears, improvement of memory, or other changes in mood and behavior. For them, there can be no denial of the effect of somatic dysfunction and skilled manipulation on cerebral function. Nevertheless, well-controlled studies that document these phenomena or that examine the underlying mechanisms have yet to be done.

We can reliably assume the involvement in these phenomena of the various somesthetic and pain pathways ascending in the cord and terminating in various centers of the brain, with some of their messages reaching consciousness. The participation of the endorphins, other neuropeptides, and other neuroendocrine mechanisms is almost certainly involved, and needing to be researched.

Experimental evidence that sympathetic fibers penetrating the brain influence various cerebral functions (as previously reviewed by the author[14]) suggests that manipulative effects on sympathetic activity may be involved, but this area also awaits study.

In short, clinical experience indicates that somatic dysfunction and manipulation are powerful influences on brain function and on the perceptions and even personality of the patients. This experience, which has been only anecdotally reported but amply confirmed over many decades, raises many fundamental questions and exciting clinical implications that also are in need of research and development.

Summary

This paper summarizes hypotheses regarding the ways in which the nervous system organizes and mediates the consequences of somatic dysfunction and the benefits of osteopathic manipulative treatment. It is shown that most of the hypotheses, however plausible, have yet to be tested, and that there are relatively few certainties about the neural mechanisms and many exciting questions awaiting investigators in the laboratory and in the clinic.

It is proposed that the entire nervous system is involved in organizing and mediating these influences, that every manipulative encounter is a transaction between two unique human beings and not just the application of a technique to a part of the body, and that modern manipulative therapy is essentially a wordless dialogue, the clinical outcome of which is influenced by the personalities and perceptions of the participants.

It is shown that several well-researched mechanisms are available, so to speak, that could account for the translation of patient perceptions into determinants of the nature and sites of musculoskeletal vulnerability and of bodily responses to manipulation. Opportunities for research in this area also are identified.

Several theories are reviewed that concern the role of the spinal cord in mediating the impact on the person of somatic dysfunction and manipulative therapy and that are under the influence of higher centers. These theories are well supported by experimental studies and are consistent with clinical experience. Areas in this category that are awaiting further investigation are identified.

The question of reciprocal influence of somatic dysfunction and its manipulative treatment on personality, mood, behavior, and various brain functions is also discussed as an area for future research.

A final note: In exploring the nervous mechanisms through which the mind influences the nature and site of somatic dysfunction, its clinical impact, and its response to manipulative treatment, no implication that mind and consciousness (whatever their definition) are the products purely of neuronal activity was intended.

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