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Reflex Effects of Subluxation: The Autonomic Nervous System

Brian S. Budgell, DC[a]

ABSTRACT

Background: The collective experience of the chiropractic profession is that aberrant stimulation at a particular level of the spine may elicit a segmentally organized response, which may manifest itself in dysfunction within organs receiving autonomic innervation at that level. This experience is at odds with classic views of neuroscientists about the potential for somatic stimulation of spinal structures to affect visceral function.

Objective: To review recent findings from basic physiologic research about the effects of somatic stimulation of spinal structures on autonomic nervous system activity and the function of dependent organs.

Data Source: Findings were drawn from a major recent review of the literature on the influences of somatic stimulation on autonomic function and from recent original physiologic studies concerning somatoautonomic and spinovisceral reflexes.

Conclusions: Recent neuroscience research supports a neurophysiologic rationale for the concept that aberrant stimulation of spinal or paraspinal structures may lead to segmentally organized reflex responses of the autonomic nervous system, which in turn may alter visceral function. (J Manipulative Physiol Ther 2000;23:104-6)

Key Indexing Terms: Chiropractic; Autonomic Nervous System; Reflexes

INTRODUCTION

There is no shortage of theories to explain the role of subluxation in disease and the effect of adjustment in relieving symptoms. The autonomic nervous system has often been invoked in constructing mechanisms to account for the effects of spinal dysfunction; recent investigations justify the attention that has been focused on this component of the nervous system.

To discuss the reflex effects of the subluxation on the autonomic nervous system, it is necessary to characterize subluxation. Chiropractic subluxation has been defined in terms that are useful philosophically and politically but not in terms that are of assistance to the physiologist. Nonetheless, clinical experience indicates that the manipulable lesion is often painful and displays some biomechanic abnormality, such as restricted or aberrant motion. We could, therefore, study the effects of nociceptive or mechanical stimulation to investigate a portion of the effects of subluxation on autonomic nervous system function.

[a]RMIT University-Japan, Tokyo, Japan.

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The modern physiologic investigations on the impact of somatosensory input on autonomic functions have been reviewed in a very comprehensive monograph by Sato et al.[1] Of the approximately 750 basic scientific papers that they have cited, only 3 make reference to spinal stimulation. In the past, examination of the effects of stimulation, for example on the limb joint or skin, have been extrapolated to the spine. In the approximately 15 years since the Sato and Swenson[2] study, the chiropractic profession has generated just 6 basic scientific papers that specifically investigate the effects of spinal stimulation on autonomic or visceral function. Despite this small amount of research, results that help guide the clinician in assessment and management are already apparent.

Examination of the earlier history of experimentation that led to the familiar model of the somatoautonomic reflex is necessary to place it in perspective before reviewing the few physiologic investigations of spinovisceral function that have been published.

DISCUSSION

The Cannon Model of the Somatoautonomic Reflex

The term “autonomic” was first applied to the sympathetic and parasympathetic nervous systems around the turn of the century. Experiments of that era frequently used noxious stimulation for consistent results and applied it to easily accessible limb tissues to elicit changes in heart rate and blood pressure, factors that were easily measured. Most experimental models have used anesthetized animals to eliminate the influence of emotional factors. These aspects of experimental design have been essential to successful investigation of somatoautonomic phenomena and led to the development of a model of autonomic response to noxious stimulation characterized as "fight or flight." The essential components of the model were that noxious stimulation applied to any tissue would elicit a generalized response mediated by the brain. This model runs counter to the professed collective experience of chiropractic, which maintains that aberrant stimulation at a particular level of the spine is likely to elicit a segmentally organized response, which in turn may be dysfunctional in organs receiving autonomic innervation at that level.

Revision of the Cannon Model

In early investigations, it was frequently observed that transection of the cervical spinal cord eliminated somatosympathetic reflex discharges. Consequently, it was assumed that these reflexes were mediated at the supraspinal level. Beacham and Perl[3,4] later were able to demonstrate somatosympathetic reflex discharges of spinal origin. Since then many investigators have confirmed the existence of both spinal and supraspinal reflex centers. Kimura et al[5] demonstrated that in central nervous system–intact anesthetized rats, noxious mechanical stimulation of the skin elicits significant responses in heart rate. Pinching virtually anywhere produced some response. There was a segmental tendency, with the strongest responses coming approximately equally from stimulation of the hindpaws or forepaws. In spinalized animals, the segmental tendency was altered but exaggerated. Thus in spinalized animals, forepaw stimulation still gave a significant but relatively weak response, whereas stimulation in the thoracolumbar region produced much-enhanced reflexes. In the animal spinalized at the upper cervical level, responses are particularly elicited from regions innervated from the thoracolumbar region of the spinal cord. Furthermore, stimulation on the right side is significantly more effective than stimulation on the left side. In contrast then to other models, there is clear evidence of spinal reflex centers that mediate segmentally organized responses.

In general, natural stimulation of nociceptors or electric stimulation sufficient to recruit unmyelinated C-fibers have been most effective in eliciting consistent somatoautonomic reflex responses.[6] Reflex effects have been demonstrated throughout the cardiovascular system and in the digestive, urinary, endocrine, and immune systems.[1] In anesthetized animals, innocuous stimulation produces weak, inconsistent responses or no reflex at all. In particular, stimulation of group Ia fibers (from muscle spindles) or group Ib fibers (from Golgi tendon organs) has virtually no effect on autonomic nervous system activity or visceral function.[7] For example in anesthetized cats, movement of the knee joint in its normal physiologic range has no effect on blood pressure or heart rate.[8] However, forced movement beyond the normal physiologic range produces significant increases in these parameters. In addition, in the acutely inflamed joint, these responses are greatly exaggerated. In fact, in the inflamed joint, even movement within the normal range produces reflex increases in blood pressure and heart rate. Similar observations include noxious stimulation eliciting clear and consistent autonomic responses and innocuous stimulation eliciting weak and inconsistent responses or none at all. These observations appear to refute the experience of chiropractors who maintain that dysfunction of the spine need not be painful to elicit visceral dysfunction.

Basic physiologic studies involving stimulation of peripheral tissues in anesthetized animals therefore provide only partial support for the view that spinal dysfunction may have an impact on autonomic function. Segmentally organized spinal reflexes have been demonstrated, but only consistently in response to noxious stimulation.

Spinovisceral Reflexes

Although the limbs and peripheral joints are easily accessible, relatively little work has been conducted on spinal and paraspinal tissues. It is not unreasonable to think that axial tissues may differ in innervation from more peripheral tissues or that sensory input from axial tissues might elicit distinct reflex responses. A single study conducted by Sato and Swenson[2] investigated the effects of mechanic stimulation of the spine on blood pressure, heart rate, and renal sympathetic nerve activity. The application of lateral stress to the lower lumbar or lower thoracic spine produced changes in the monitored parameters that outlasted the length of stimulation. The results were clearly shown as the result of activation of spinal afferents. However, it is unclear if the forces applied from 0.5 to 3.0 kg should be characterized as noxious or innocuous.

More recent studies have used noxious chemical stimulation of interspinous tissues in anesthetized rats. The virtue of this system is that the irritant used, capsaicin, causes a well-characterized response within a subset of polymodal nociceptors, removing mechanical stimulation from consideration. The stimulation is pure and relatively long-lasting pain, as might be encountered in clinical syndromes of spinal pain. Such stimulation has been shown to produce a profound increase in systemic blood pressure and a matching increase in sciatic nerve blood flow.[9] However, although blood pressure remained elevated for 20 minutes or more, sciatic nerve blood flow quickly dropped below prestimulus levels and remained there for approximately 20 minutes before normalizing. This suggests that noxious chemical stimulation of the interspinous tissues evokes 2 competing reflexes: an increase in systemic blood pressure, which initially leads to a passive increase in sciatic nerve blood flow, and constriction of the sciatic vasa nervorum and a decrease in sciatic nerve blood flow. It would appear that with the long-lasting noxious spinal stimulation of capsaicin injection, the reflex constriction of the vasa nervorum becomes fully manifested and overpowers the effect of systemically increased blood pressure.

A related study[10] has examined adrenal nerve activity and catecholamine secretion in response to capsaicin injection of thoracic and lumbar interspinous tissues. In central nervous system–intact and spinalized animals, noxious stimulation of the interspinous tissues normally leads to increases in adrenal sympathetic nerve activity and catecholamine secretion. It was possible to confirm supraspinal and spinal reflex responses to stimulation of A and C fibers. There was a relatively greater response to thoracic stimulation in the spinalized animal. In this regard, the bulk of preganglionic sympathetic neurons serving the adrenal gland in the rat are located between the T7 and T10 level of the cord.

A further study[11] of spinovisceral reflexes reported responses of bladder motility to noxious spinal stimulation. Previous studies had shown that the resting bladder could be stimulated to contract by noxious stimulation of the perineal skin. Noxious stimulation of other areas was ineffective. This suggests that the reflex depended on stimulation within the territory of afferent fibers that enter the cord at the level of parasympathetic outflow to the bladder. However, the more recent study showed that stimulation at either the thoracic or lumbar level could produce a brisk response in bladder tone. This response was mediated at the supraspinal level; the efferent limb of the reflex was within the pelvic nerves that provide parasympathetic innervation to the bladder. In contrast to the adrenal studies, when the reflex is mediated principally at the supraspinal level, there is not a clear segmental organization.

A study just completed has examined responses of gastric motility to capsaicin injection of thoracic and lumbar interspinous tissues. Noxious chemical stimulation of the interspinous tissues was associated with arrest of peristaltic movement and a sharp decline in gastric muscle tone. The decrease in gastric tone was significantly greater in response to thoracic versus lumbar stimulation, was uneffected by bilateral vagotomy, and was preserved in spinalized animals. This is the clearest demonstration to date of a segmentally organized, spinally mediated, visceral response to noxious stimulation of spinal tissues.

CONCLUSION

Autonomically mediated reflex responses to noxious stimulation of spinal tissues have been clearly demonstrated. Where parasympathetic influences dominate, a segmental organization has not been apparent. Where sympathetic mediation has been significant, it has been possible to demonstrate the existence of spinal reflex centers and, to some degree, a measure of segmental organization.

Certain findings cited are consistent with the observations of chiropractic clinicians about the effects of spinal dysfunction on visceral disorders. On the other hand, the bulk of the positive data obtained was elicited with noxious stimulation. There is still little support for the contention that painless spinal dysfunction can affect organ function. This is scarcely surprising considering that all the basic physiologic work cited was performed in anesthetized animals. However, new evidence suggests that muscle spindles in cervical paraspinal muscles may in fact be capable of eliciting somatoautonomic reflexes.[12] In addition, there is recent evidence from studies in conscious human beings that innocuous somatic stimulation of the neck may influence cardiovascular function.[13] Additional and similarly well-conceived studies of basic physiology and clinical phenomena are needed to construct an explanation for the promising observations of practitioners of spinal manipulation.

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