SENIOR RESEARCH PROJECT

REVIEW OF LITERATURE

Spinal Manipulative Therapy in the Management of Nocturnal Enuresis

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Reviews of the Literature

Spinal Manipulative Therapy in the Management of Nocturnal Enuresis

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ABSTRACT

Objective: A review of the literature concerning the anatomy and neurophysiology of the urinary bladder, somatovisceral reflexes, and the effects of spinal manipulative therapy (SMT) are presented. Review of these topics are intended to introduce a scientific neurophysiological model for the use of SMT in the management of nocturnal enuresis.

Data Source: Articles reviewed were obtained by conducting a computer-aided search of papers indexed in *Medline.* Additionaly, the computer index for Logan College Library was searched. Finally, the bibliographies of pertinent articles and books were manually searched.

Conclusions: Sufficient empirical data has yet to support the efficacy of SMT in nocturnal enuretic treatment. However, spinal manipulation of the sacroiliac joints has been shown to decrease interneuronal activity in the sacral spinal cord. This decreased activity is theorized to increase the threshold for firing of the pelvic nerve, which would in turn prevent detrusor muscle contraction. Additional research regarding physiological effects of SMT on the urinary bladder would be helpful in expanding this model.

Key Indexing Terms: Urinary Bladder, Somatovisceral Reflex, Spinal Manipulation, Nocturnal Enuresis.

INTRODUCTION

Nocturnal enuresis, known to the lay person as bedwetting, is defined as involuntary discharge of urine during sleep after the age by which bladder control should have been established, usually five years of age (1). The exact cause of primary nocturnal enuresis is unknown and a multifactorial etiology is widely accepted, including psychosocial factors, allergies, sleep disturbances, genetic factors and abnormal antidiuretic hormone levels (2). This paper proposes an additional etiology, restriction of the sacroiliac joints.

This literature review is not intended to encompass the entire scope of diagnosis and treatment of nocturnal enuresis. Furthermore, serious pathology should be ruled out before considering the incorporation of spinal manipulation into the treatment protocol. The neurophysiological rationale presented should be considered a foundation that future research can build upon.

DISCUSSION

Anatomy of urinary bladder

The lower urinary tract includes the ureters, bladder, sphincters, and the urethra. Gender variation is found only in the length of the urethra (the male urethra being longer). The urinary bladder itself is composed of two parts, the body and the neck. The body of the bladder is the chamber that stores urine. The neck, which is actually an extension of the body, passes anteriorly and inferiorly into the urogenital triangle and is continuous with the urethra (3).

The smooth muscle surrounding the body of the bladder is known as the detrusor muscle. When this muscle is stimulated the entire bladder contracts at once and the bladder pressure is increased. If the pressure inside the bladder excedes the sphincter tone the bladder will empty.

On the posterior wall of the bladder, above the bladder neck, is the triangular area called the trigone. The apex is formed by the neck of the bladder while the ureters enter the bladder at the upper angles of the triangle (3).

The bladder neck is also called the posterior urethra because its relationship to the urethra. The muscle in this area is usually called the internal sphincter. Its natural tone prevents emptying of the bladder until the pressure in the body reaches a critical threshold. The bladder neck (posterior urethra) is continuous with the urethra. The distinction is made when the neck passes through the urogenital diaphragm, which contains the external sphincter muscle. This muscle is voluntary skeletal muscle in contrast to the muscle of the bladder body and neck, which is entirely smooth muscle. Being under voluntary control, this muscle can prevent urination even when the autonomic controls are attempting to empty the bladder (3).

It is necessary to emphasize the physiological differences between the internal and external sphincter. The external sphincter is a component of the levator ani muscle, is composed of predominantly fast-twitch fibers, fatigues easily, and is responsible for interruption of the urinary stream. In contrast, the fibers of the internal muscle are slow-twitch and therefore fatigue-resistant, allowing for continuous tonic activity (4). Therefore, although the external sphincter can prevent urination, its physiology is not designed for long-term prevention. Furthermore, the external musculature is under mostly voluntary control (there are some involuntary fibers) and therefore plays a small role in preventing urination while asleep.

Sensory innervation

Micturition (urination) occurs when the bladder fills to a point that sensory stretch receptors in the bladder wall fire and send impulses to the spinal cord to cause reflex contraction of the detrusor muscle. Pascual et al. mapped out the area of the spinal cord where the afferent nerves from the bladder of rats terminate. They concluded that there is a "common pattern of termination of primary afferents from the bladder" at the S1-S2 cord level. The sensory impulses traveled via the pelvic nerve (which is a parasympathetic nerve) and the most consistent termination point was in Lissauer's tract and laminae I and II (5). These areas are located in the gray matter at the most dorsal portion of the spinal cord. From this point, short neurons within the cord called interneurons connect the afferent nerve to the interomediolateral nucleus (or lateral horn) of the sacral cord, where the cell bodies of the parasympathetic efferents arise.

Sympathetic afferent impulses, transmitted via the hypogastric nerve, terminate in a similar location in the cord (dorsal aspect of the gray matter) but at the level T11 - L2. Interneurons at these levels will convey the impulses to the interomediolateral portion of the cord, where the sympathetic nerve cell bodies originate. Sensory muscle spindles in the external sphincter muscle generate impulses that are carried via the pudendal nerve to the sacral spinal cord. These neurons will synapse onto the lower motor, or alpha motor, neurons which are the efferent limb of this normal skeletal muscle reflex (5).

Motor Innervation

The basics of motor supply to the bladder area have already been briefly mentioned. All pelvic organs have triple motor innervation. First, the parasympathetic fibers arise from the lateral horn of S1-S3 and course the pelvic nerve. When stimulated, the pelvic nerve will activate cholenergic receptors the body of the bladder and detrusor contraction will occur. Next, the sympathetic fibers arise from the lateral horn of T11-L2 and course the hypogastric nerve. When stimulated, a pressure increase in the internal sphincter is observed, while detrusor activity decreases (3,7). This is explained by differences in receptor population. The receptors in the body of the bladder are predominately beta-adrenergic, while those in the neck are alpha-adrenergic (6). Finally, the somatic nerve fibers arise in the anterior horn of S2-S3 cord level and course the pudendal nerve. Stimulation to these fibers induces external sphincter and pelvic floor musculature contraction (7).

Guyton describes the micturition reflex as a "completely automatic cord reflex", but states that it "can be inhibited or facilitated by the brain". He specifically mentions control exerted by the brain stem and the cerebral cortex (3). Sensations of fullness, urgency, and pain also attest to supraspinal involvement in the physiology of this area. Therefore, storage of urine and coordinated micturition involves a complex interaction of all the above mentioned neural connections.

Spinal cord reflexes

Spinal cord reflexes require a stimulated receptor, afferent nerve, spinal cord, efferent nerve, and responding tissue. By definition of the word "reflex", the response to the stimulus is involuntary. Furthermore, the stimulated tissue and the responding tissue may be either somatic or visceral. The word "soma" is the Greek word for "body" and somatic tissues are those of the body wall, such as muscles, tendons, ligaments and bones (1). In contrast, the "viscera" includes internal organs enclosed within the thoracic, abdominal, or pelvic cavities (1). There are four possible combinations of reflexes (with the first word the stimulated tissue and the second word the responding tissue): somato-somatic, viscero-visceral, viscero-somatic, and most important to this discussion somato-viceral.

A basic example of the somato-somatic reflex is the so-called "knee jerk." Receptors in somatic tissue (muscle spindles of the quadriceps muscle) are stimulated, afferent nerves convey the impulse to the cord, integration occurs, and the lower motor neuron carries the impulse to the quadriceps and causes a somatic tissue to respond. Notice that reflexes do not require nociception, or pain. Also, the stimulated and the responding tissues do not have to be the same type of tissue. For example, stimulation of pain receptors in a ligament can cause a muscle to respond with contraction, or spasm.

An example of a viscero-visceral reflex is the gastroenteric reflex. Stimulation of the stretch receptors in the stomach wall will reflexively cause peristaltic activity of the small intestine (1). Again, notice that this reflex is not initiated by nociception. Another example of the viscero-visceral reflex occurs with inflamation of the appendix. This irritation causes stimulation of the lateral horn of the thoracic spinal cord. The sympathetic fibers that arise from the lateral horn then stimulate contraction of the ileocecal valve.

Published work in the British Medical Journal looked at clinical evidence of the viscero-somatic reflex (8). Twenty five patients with confirmed acute myocardial infarctions were studied while 22 patients with no known history of heart disease were used as controls. Osteopathic physicians palpated the paravertebral musculature of T1-T8. Their descriptions were limited to standardized terminology and included "firm, boggy, ropiness, temperature change," etc. This study found the control group to have a low incidence of soft tissue changes which were distributed evenly throughout the upper thoracic spine. However, "examination of the group with myocardial infarction disclosed a significantly higher incidence of soft tissue changes...confined almost entirely to the upper four thoracic levels". Furthermore, the authors of this research state that, "it is plausible to attribute their aetiology to efferent and afferent reflex activity during the evolution of myocardial infarction..." and that "this activity may, by way of visceral afferents, constitute an arc through the related spinal cord levels which might be manifested over the posterior spinal nerves as somatic foci of irritation" (8).

Somato-visceral reflex

The final spinal cord reflex is the somato-visceral reflex. An understanding of this reflex provides the rationale for utilizing spinal manipulative therapy (SMT) in the management of nocturnal enuresis. This reflex involves stimulation of somatic tissue that will reflexively affect visceral tissue. Sato has described research on the somatocardiac, somatogastric, and the somatovesical reflexes (9). He concludes that "further basic investigation of these phenomena should have considerable significance for spinal manipulative therapy"(9). Of utmost interest to this paper is the somatovesical reflex.

The somatovesical reflex describes somatic tissue stimulation that causes detrusor muscle contraction. Sato studied rats with intact spinal cords and found that stimulation of the perineal skin would produce a reflexive increase in efferent discharge of the pelvic nerve (10). Remember, the pelvic nerve carries the parasympathetic efferent fibers for detrusor contraction. It should be noted that pinching (noxious stimulus) and touching (nonnoxious stimulus) produced similar results.

Current neurophysiological research has provided the anatomical explanation for the somatovesical reflex. It has been shown that the afferent fibers of the pudendal nerve, which provide sensation to the perineum, terminate in the same anatomical location as the afferent fibers of the urinary bladder (5). Therefore, it is reasonable that stimulation of the perineal skin (or any other somatic tissue whose afferents terminate at that level) would lower the threshold of firing of the parasympathetic efferents to the urinary bladder.

Sato's work described thus far was focused on stimulation of cutaneous tissue to elicit a visceral response. In a later study, Sato and Swenson examined autonomic response to spinal tissue stimulation (11). Either lower thoracic or lower lumbar spinal segments of rats were clamped in blocks of four. The superior and inferior vertebra (of the four vertebra block) were clamped while the two vertebra in the middle remained freely moveable. Then lateral stress was placed on the two middle segments while the sympathetic nerve activity and the rat's blood pressure were evaluated. Significant changes in neurological activity and blood pressure were noted. The authors state that this study "demonstrated potent somatovisceral reflexes from mechanical stimulation of the spinal column" (11).

Facilitation

Denslow, Korr, and Krems (12) were some of the first researchers to publish observations regarding "segmental facilitation". Their research involved application of pressure to the spinous processes of humans while taking EMG readings in the erector spinae muscles. They found that activity at certain spinal levels was more easily triggered than at other levels. Furthermore, these findings were reproducible on the same subject while the spinal level of hyperexcitabilty varied from subject to subject. The researchers concluded that these areas of the spine were "facilitated", provided above normal levels of sensory input into the spinal cord, and therefore contraction of the erectors occurred with less stimulation at these levels (12).

Building on the previous study, Patterson and Steinmetz examined reflex excitability in rats (13). The researchers of this study stimulated hind limb flexion for 45, 60 or 90 minutes and allowed the rats to rest. Then the amount of remaining hind limb flexion was recorded at 24, 48 and 72 hours post-stimulation. They state that some flexion is still observed up to 72 hours after the initial stimulus is removed (13). Therefore, the excitability of efferent nerves (motor to skeletal muscle in this case) is altered up to 72 hours after a sensory bombardment is removed.

Spinal Manipulation

There is agreement that any form of therapy for nocturnal enuresis is directed at affecting the neurological activity of the urinary bladder. For example, the first line of treatment should always focus on fluid restriction and voiding before going to bed. This will decrease the stretch on the bladder and therefore decrease reflex detrusor contractions. More aggressive therapy may include the use of tricyclic antidepressants, prescribed for there anticholinergic effects upon the detrusor muscle (14). Similarly, a synthetic form of antidiuretic hormone may be given to decrease urine production (15) so that the bladder stretch receptors are not brought to threshold.

Although no study to date has directly evaluated the bladder's neurological response to spinal manipulation, conclusions can be drawn based on existing research of spinal manipulative therapy (SMT). A large spectrum of effects have been documented following SMT, two of which include increased plasma beta-endorphin levels (16) and increased number of B lymphocytes (17). Of more relevance to this paper, however, is research that examines the neurological effects of SMT. One such study concluded that "thoracolumbar spinal manipulation appears to induce a mild segmental somato-sympathetic reflex with resultant vasoconstriction in the lower extremity vascular bed" (18).

Induced vertebral lesions or "subluxation mimics" at the level of T6 were shown to inhibit myoelectric activity of the stomach and duodenal bulb. The researchers of this study suggest that "nontraumatic misalignment forces on spinal structures may have profound effects on visceral physiological activity" (19). It would follow, therefore, that removal of these stress forces would improve the visceral physiological activity. This reasoning was in fact tested. Pikalov and Kharin constructed a clinical study to compare SMT to traditional medicine in the treatment of duodenal ulcer treatment (20). The use of SMT resulted in clinical remission an average of 10 days earlier than traditional care. The most common area determined to require SMT was the thoracic spine and the authors suggest that the mechanism of effectiveness may involve "normalization of segmental trophic innervation of the intestinal mucosal layer" (20).

Irvine Korr, one of the leading researchers in the field of neurology related to SMT, states that effective manipulation will re-establish coherent patterns of sensory input (21). Empirical evidence of this statement was established by H. Thabe (22). He showed that afferent information from restricted sacroiliac (SI) joints causes spontaneous EMG activity in their respective segmental muscle. Furthermore, manipulation of the SI joint caused disappearance of the spontaneous EMG activity, while mobilization (non-thrust techniques) did not eliminate the activity (22).

Afferentation from restricted SI joints clearly causes increased interneuronal activity at the sacral cord level and results in spontaneous firing of the lower motor neurons. It is, therefore, reasonable to assume that the increase in interneuronal activity also stimulates the lateral horn and can lower the threshold of firing of the parasympathetic nerves arising from this area. More importantly, the previous study shows that spinal manipulation to the

SI joints will decrease this afferentation and therefore decrease the interneuronal activity at the sacral spinal cord.

CONCLUSION

Urinary bladder voiding is caused by stimulation of the parasympathetic fibers arising from the lateral horn of the sacral spinal cord. Furthermore, sacroiliac joint restriction increases neuronal activity of the sacral spinal cord and could decrease the threshold of firing of the pelvic nerve. Spinal manipulation of the SI joint will decrease this neuronal activity, which in theory would increasing the threshold for firing of the pelvic nerve, and prevent unconscious voiding of urine. Thus, manipulation of the SI joints is a plausible treatment option to be incorporated into nocturnal enuresis treatment.

To date there have been only two large studies conducted on the efficacy of SMT in treating nocturnal enuresis. Leboeúf et al. investigated treatment of 171 enuretic children (23). Treatment consisted of manipulation of the areas of aberrant spinal movement as detected y observation and palpation. Over a 3 month period, 15.5% of the children studied showed significant reduction in the number of enuretic episodes (23). However, the annual remission rate for enuresis is 10% - 20%, providing poor evidence that SMT is a viable treatment alternative. It should be noted that the methodology of this study has been questioned due to the fact that the manipulation was performed by chiropractic interns and the study had no control group.

Due to the previous studies limitations, Reed et al. initiated a similar clinical trial with 46 children, 15 of which acted as controls (24). Again, areas of aberrant motion were adjusted, with the pelvis and upper cervical spine being the two most common areas of treatment. This study showed a statistically significant reduction in the frequency of wet nights in the treatment group as compared to the control group. The authors of this research conclude that chiropractic manipulation is effective in treating primary nocturnal enuresis (24).

Although this paper offers a neurological rationale for incorporating SMT into the treatment protocol of nocturnal enuresis, more empirical data will be necessary to confirm it's efficacy. Several areas of future research would be helpful including: determination of the frequency of SI restriction in enuretic children, the sacral parasympathetic response to SI joint manipulation, and a longer duration controlled clinical trial of SMT in enuretic treatment.

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