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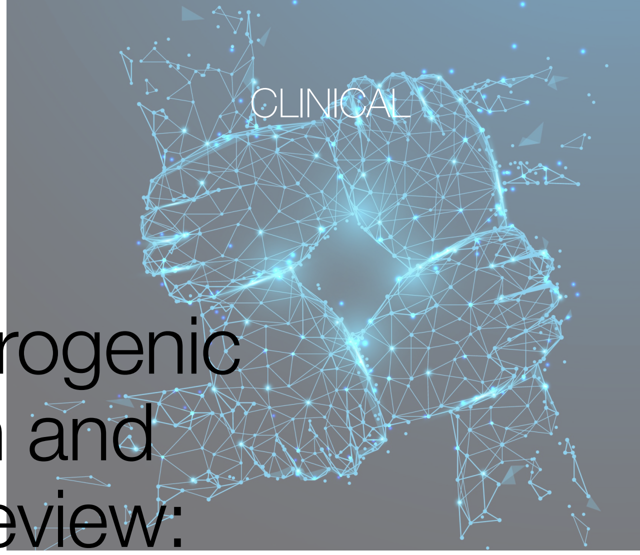

Neurodynamics of vertebrogenic somatosensory activation and Autonomic Reflexes - a review:

Part 8 The Cranial Nerves and the Cervical Spine

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Abstract: Cervicogenic correlation with the cranial nerves suggests a convenient accessibility for influencing certain syndromes, with the most recognised one being cervicogenic headaches although a number of other conditions are also noted.

Indexing terms: Vertebral subluxation; Neurophysiology; Cranial Nerves; Cervical spine.

Introduction

In regard to the cervicocranial syndrome, Lewit states that '*This syndrome covers headaches of cervical origin as well as other disturbances mainly of equilibrium, including minor neurological disorders such as nystagmus.*' (1)

Considerable evidence of spinogenic influence upon ANS innervated structures is noted through the cranial nerves. Sound physiological research and reported clinical outcomes can be a recognised vertebral factor in a range of apparent somatocranial parasympathetic conditions. Herrick utilised the term '*craniospinal*' back in 1915 in an apparent recognition of the relationship between the cranial and spinal nerves. It was also noted by Greek anatomist Herophilus, c335-280 BC. (2, 3, 4)

> *'... Considerable evidence of spinogenic influence upon ANS innervated structures is noted through the cranial nerves. Sound physiological research and reported clinical outcomes can be a recognised vertebral factor in a range of apparent somatocranial parasympathetic conditions'*

Glasgow et al recognised the cervicogenic association and the ANS under the heading '*Special significance of cervical articular innervation*.' They associated the possibility of such neurological symptoms as postural instability, vertigo, nystagmus and ataxia, when cervical articulations were compromised. (5)

Eriksen summarised examples of cranial nerve pathophysiology (particularly cranial nerves I, III, IV, VI) under manipulative care, mostly chiropractic. His text summarised eleven case reports of vision and oculomotor conditions (pp 339-44), seven papers on auditory dysfunction (pp 345-6, 391, 393), and some 40 related to cervicogenic vertigo and cervicogenic headache (pp 258-86). (6) Other authors have also identified a spinal association. (7, 8, 9, 10, 11, 12, 13)

Following whiplash injuries, Jackson acknowledged craniocervical neural connections and sympathetic communications as being '*plausible explanations*' for those symptoms. She supported manipulation for cervical joint dysfunction. She also noted that cranial structures may be disturbed due to '*irritation of the cervical sympathetic supply.'* This included neurological symptoms such as visual blurring, pain in or behind the eye, disturbances in equilibrium, tinnitus, and dysphagia. (14)

Vaňásková and colleagues noted a vertebrogenic factor with dysphagia, a condition which may involve more than one cranial nerve. They concluded '*Dynamic scintigraphy can objectify oesophageal dysfunction in patients affected by disturbed cervical function and can be used to assess success.*' (15, 16)

Zuo and colleagues identified a bidirectional neural connection between the cervical spine and sympathetic ganglia in the rabbit which was suspected of providing information explaining the pathogenesis of cervicogenic vertigo. (17)

As chiropractors, Foreman and Croft have been called as expert witnesses in whiplash litigation. They nominated a range of cranio-autonomic symptoms associated with cervical spine disturbances. These include: *Barré-Liéou syndrome*, vertigo, blurred vision, tinnitus, and transitory deafness. (18, 19)

Rieke states that the cervicollic head-righting reflex was dependent on receptor '*input of the upper two or three cervical nerves*' and the midbrain colliculus. She noted similar motor nerve contribution with the vestibulospinal and cervico-ocular reflexes. In addition Rieke found that these functional disorders of C0-C3 were noted factors in disturbance of the cervical sympathetics and proprioceptors. (20)

Olfactory Nerve (CN I)

Cases of olfactory dysfunction being resolved under chiropractic care have been recorded, while an association between the olfactory and trigeminal nerves has also been reported. (21, 22, 23, 24, 25)

Optic Nerve (CN II)

Villablanca and colleagues regard the optic nerve as not being strictly a cranial nerve as it is histologically a collection of axons, and a direct extension of a brain tract. The medical doctor Gorman noted positive outcomes in visual perception associated with cervical spine manipulation.

Other cranial nerves are noted associating the cervical spine with nystagmus (III, IV, VI). (26, 27, 28, 29, 30, 31, 32, 33)

Trigeminal (CN V)

In a 2003 review of the trigeminocervical complex in association with migraine, Bartsch and Goadsby attributed influence from the upper cervical spine in both generating and contributing to a functional relevance in migraineurs.

Two years later, Barsch noted how nociceptive input from neck structures of the upper cervical spine could influence this cranial nerve complex. In 2005, these authors noted cervicogenic sensitisation in that noxious input may occur on the central neuron level and the possible role of segmental mechanisms. (34, 35)

Some cephalalgias are recognised as an autonomic dysfunction primarily involving the trigeminal nerve and hypothalamus. The trigemino-autonomic reflex and hypothalamic activation involved with particular headaches has been described as the trigemino-cervical complex. Other headaches are recognised as being directly of cervical origin, involving the cervical spinal nerves.

It is suggested that management which is directed primarily towards pain reduction with a greater occipital nerve block, or occipital nerve stimulation, may be symptomatic approaches, when the underlying etiological influence affecting those nerves may be initiated by noxious sensory input from disturbed cervical articular facets. (36, 37, 38, 39, 40, 41, 42, 43)

The trigeminocervical complex was also implicated in a physiotherapy study on facial pain by La Touche et al, and others. (44, 45, 46, 47) They found nociceptive modulation of noxious cervical articular input led to sympathoexcitatory response. This had the capacity to beneficially affect head and facial pain as an '*hypoalgesic*' outcome. A range of symptoms are also thought to be associated with cervicogenic disturbance of the trigeminal nerve.

Eriksen has summarised six papers relating to the manipulative and manual care of patients suffering with trigeminal neuralgia. He also cited reference to a Chinese study with positive outcome of 8 of 12 patients who responded to cervical manipulation for trigeminal neuralgia. (48, 49)

In a further medical study, Giblin et al demonstrated the cervicogenic origin for certain headaches. They found that amelioration by a nerve blockade (radiofrequency ablation) of the cervical nociceptive input by lesioning the third occipital nerve, the medial branch of the posterior division of the C3 spinal nerve. This would appear to be a more biologically invasive intervention than addressing the nociceptive input from the articular surfaces by manipulative means. LaTouche et al indicated that the cervical mobilisation intervention resulted in a nociceptive modulation of the trigeminocervical complex. (39, 46, 47, 48, 49, 50, 51, 52, 53, 54)

In addition, Montétrey and Basbaum noted a possible neurospinal pathway of somatovisceral and viscerovisceral reflex activation which implicated the *trigeminal nucleus cordalis* with the *glossopharyngeal* and also the *vagus* cranial nerves. (55)

In 1989, Tamura researched the relationship of cranial symptoms with injuries to the cervical spine being the somatic factor. He found a clear correlation between C3/C4 radicular defects and the *Barré-Liéou Syndrome*. He also stated that '*one difficulty in assessing this syndrome was that cranial symptoms are related to excessive movement of the neck*', a biomechanical hypermobile segment. In this study, the compromise of the cervical nerve root sleeves was attributed to soft disc herniation. (56)

The clinical finding of a C1-C2 segment hypermobility attributed to capsular and ligament laxity associated with whiplash was also noted as being associated with neck pain and *Barré-Liéou Syndrome* by Steilin et al. Again, a vertebrogenic somatosensory element would be implicated. (57)

Certain manual procedures are designated in chiropractic and directed at separate vertebrae to counter hypermobile segments. In such cases, attention may then be directed to the adjacent, or specific nearby segments, which may have undergone compensatory locking or hypomobility. Once these fixations are released, movement is averaged out over 3 or 4 vertebrae, potentially putting less mechanical segmental stress at the hypermobile level.

Abducent Nerve (CN VI) (See also CN II)

Other than a possible connection with nystagmus (see CN N II), no evidence was found implicating the *abducent* cranial nerve under manual therapy. Like the spinal accessory nerve, it has a purely somatic motor function. The *abducent* nerve is involved with external abduction of the eye. [See also *External rectus* CN 6, *Superior oblique* CN 4, Others CN 3]

Facial Nerve (CN VII)

Facial nerve palsy (Bell's palsy) has also been noted as responding to cervical spine adjustment. This association effectively portrays integration between the cranial parasympathetic nervous system and somatic spinal influence. (58, 59, 60, 61)

Vestibulocochlear (CN VIII)

Convincing evidence as to the role of the cervical spine in relation to some forms of vestibular stability also demonstrates somato-autonomic integration. A segmental biomechanical VSC may contribute to the development of vertiginous symptoms following cervical whiplash or other cervical biomechanical disturbance. (62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72)

Independent evidence demonstrates emerging interest in a possible cervicogenic role in tinnitus. (73, 74, 75, 76, 77)

Glossopharyngeal (CN IX)

A further clinical expression of somatoautonomic (somatoparasympathetic) association is tongue-tie syndrome (ankyloglossia) in infants. (See also Part VII) (78, 79, 80, 81, 82, 83, 84, 85, 86)

Older patients with dysphonia have also been found by chiropractors and osteopaths to present with cervical spine disturbance, implicating involvement of CN IX. Case reports of resolution of these symptoms by spinal adjustments were noted. (87, 88, 89)

Vagus (CN X)

Noxious sensory input from a mechanically disturbed cervical spine has the potential to influence visceral physiology through activation of vagal nuclei notably due to its anatomical proximity to the vagal nuclei in the brainstem. The extensive vagal network has considerable parasympathetic influence on visceral function. The vagal nuclei in the brainstem have the potential to duly influence visceral physiology due to its anatomical proximity to a physically disturbed cervical spine and its noxious somatosensory input. This has been documented in the literature. Efficacious clinical outcomes through manual therapy as seen in infantile colic. In addition, research with animal subjects would independently corroborate involvement of a probable vertebrogenic factor. (90, 91, 92, 93, 94)

Evidence suggests that somatosensory activation may influence vagus nerve innervation to the heart through a '*somato-vagal reflex*'. Terui and Koizuma state that in anaesthetised dogs '*The vagus nerve discharge evoked by sinus nerve stimulation was inhibited during reflex inhibition produced by somatic nerve stimulation.*' Further, the study noted reciprocal relationship between somato-vagal and somatosympathetic reflexes in recording a cardiac response. The *sinus* nerve (or *carotid sinus* nerve) is a branch of the *glossopharyngeal* cranial nerve (IX). (95)

Depending on whether the patient was subject to SMT in a horizontal or tilted position, a 2008 study by Henley et al, found that the parasympathetic vagal response differed in its sympathetic response, as monitored through heart rate variability (HRV). It was found that parasympathetic responses were dominant in the horizontal posture. They concluded that osteopathic manipulative therapy demonstrated an association with the autonomic nervous system. They also concluded that HRV was a means by which to monitor biological response of the ANS to manipulative intervention. (96)

It is noted that not only is the *vagus* primarily a parasympathetic nerve, it also has a sympathetic nervous system element. There is mounting evidence in the medical literature of subcutaneous and transcutaneous instruments that stimulate the vagus nerves. These have been employed in a range of conditions. (97, 98, 99, 100)

Different Effects of Left and Right Vagus

New research on the use of *vagus* nerve stimulation to address postural orthostatic tachycardia syndrome (POTS), and other forms of dysautonomia was presented by Dr Dietrich from *Vanderbilt University's Autonomic Dysfunction Centre*. In a video of his address, he noted differences in innervations between the left and right vagus (101, 4:48 through to 6:30). He stated that the right vagus carries 80% of its efferent fibres to the heart, while the left vagus carries 80% of its efferents to the brain. He also discussed vagal innervation of a specific part of the ear (101, 10:58).

An earlier study concluded that '*Patients with orthostatic vasovagal reactions have impaired vagal baroreflex responses to arterial pressure changes below resting levels but normal initial responses to upright tilt. Subtle vasovagal physiology begins before overt presyncope. The final trigger of human orthostatic vasovagal reactions appears to be the abrupt disappearance of muscle sympathetic nerve activity.*' (102)

Spinal Accessory (CN XI)

The spinal accessory nerve has a cranial and a spinal root with a purely somatic function. The cranial root shares its origin with the nucleus ambiguous, and partly with the dorsal nucleus of the vagus nerve. It is primarily a somatic motor nerve and originates in the cervical portion of the spinal cord. It mainly supplies the sternocleidomastoid, trapezius, and laryngeal muscles.

When Waddell found these muscles to be weak, he addressed them by correcting dysfunction of the cervical spine through manipulation. One of his patient's impaired singing voice was monitored, and recovered following this chiropractic care. Hülse and Wood both attributed a functional deficit of the cervical spine in similar cases which were positively resolved. (103, 104, 105, 106)

Hypoglossal Nerve (CN XII)

Clinical evidence exists indicating that the cervical spine and the *hypoglossal* nerve have been implicated as factors associated with breast feeding and swallowing difficulties. These symptoms are also recorded as having responded to cervical spine manipulation, in order to normalise the cervical dysfunction and its neural influence. (14,107, 108, 109, 110)

Cranial Nerves 0 or XIII, and XIV

In researching this paper, it was interesting to discover reference to a designated Cranial nerve 0, also called the *terminal* nerve or *nervus terminalis*. It has also been named as Cranial nerve XIII. It has its origin in the lamina terminalis at the cribriform plate of the ethmoid bone (as does the *olfactory* nerve, CN I). It was initially found in animals and thought to be associated with the detection of pheromones. However, Sonne and Lopez-Ojeda state that it has been identified in humans for over a century, but remains unrecognised in much of the medical literature. It appears to be associated with gonadotropin releasing hormones and other functions. (111, 112, 113)

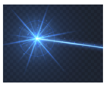
The authors note the identification of a Cranial nerve XIV. According to Bordoni and Zanier, it is referred to as *nervus intermedius* and lies between cranial nerves VII and VIII. They also emphasised the importance of nerve variables to surgeons, chiropractors, osteopaths, and other manual therapists. (114)

As case reports continue to mount, (115) it is suggested that due to the anatomical level of their origin most cranial nerves as well as their proximity to the cervical spine, when manipulative care is indicated, a need for segmental specificity is critical.

As a further possible anatomical integration with the cervical spine, Menétrey and Basbaum suggested that the nucleus of the *tractus solitaries* may act as a relay for somatic and visceral afferents through cranial nerves, *Trigeminal* (V), *Glossopharyngeal* (IX), *Vagus* (X), and *Spinal Accessory* (XI). That research was conducted on rat specimens and as such, the role of the cervical spine would appear to be central, but also necessitates the avoidance of sensory irritation originating from the cervical spine. (116)

Conclusion

The integration of the cervical spine with the parasympathetic cranial nerves provides an opportunity to influence a range of pathophysiological conditions.



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