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Original article

## Muscle spasm of the neck in cervical sprain and its correlation to the severity of the injury

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**SUMMARY.** To identify the correlation between the degree of severity of a whiplash injury (Quebec classification) in the acute phase and the muscle spasm of the neck, a study was conducted between September and December 2002. This was a prospective, transverse, correlation, and observation study in 24 patients, 12 females and 12 males with an average  $26.2 \pm 8.3$  years of age, suffering from whiplash injury and meeting the established selection criteria. Variables were: Quebec classification grade of clinical injury, muscle group of the neck involved, arches of motion, electromyography spontaneous activity, age, and gender. G-II Quebec injury was seen in 14 patients (58.3%) while G-I was seen in 6 patients (25%) and G-III, in 4 patients (16.7%). There was clinical involvement of posterior muscles in 100% of cases; 66.7% (16 patients) in lateral muscles; and 70.8% (17 patients) in anterior muscles with average mobility in 13 patients; poor mobility in 9 patients; and good mobility in 2 patients. Electromyography activity in sternocleidomastoid muscles was 4 MU (12 patients) and 5 MU (3 patients). Activity in scalene muscles was 4 MU (9 patients), 5 MU (6 patients). Activity in upper trapeze 4 MU (9 patients) and 5 MU (13 patients); paravertebral muscles 4 MU (12 patients) 5 MU (11 patients). The relationship between the injury grade and electromyography activity in the Kruskal-Wallis test was significant ( $p < 0.05$ ) for the upper trapeze ( $\alpha 0.043$ ) and paravertebral ( $\alpha 0.006$ ), a confirmed relationship with Pearson's  $r$  in upper trapeze ( $\alpha 0.014$ ) and paravertebral ( $\alpha 0.000$ ). Grade Quebec II in-

**RESUMEN.** Con el objeto de identificar la correlación entre grado de severidad de la lesión por latigazo (clasificación de Quebec) en fase aguda y el espasmo muscular del cuello, entre septiembre y diciembre de 2002 se realizó un estudio observacional-prospectivo-transversal-correlacional en 24 pacientes con lesión por latigazo que cumplieron criterios de selección, 12 mujeres y 12 hombres, con promedio de  $26.2 \pm 8.3$  años. Las variables fueron: grado de lesión clínica de Quebec, grupo muscular del cuello afectado, arcos de movilidad, actividad espontánea electromiográfica, edad y sexo. La lesión de Quebec G-II ocurrió en 14 pacientes (58.3%), G-I en 6 (25%), G-III en 4 (16.7%); hubo afección clínica a músculos posteriores en 100% de casos, 66.7% (16) en laterales y 70.8% (17) en anteriores, con movilidad regular en 13 pacientes, mala en 9 y buena en 2. La actividad electromiográfica en esternocleidomastoideo fue de 4 Um (12 pacientes) y 5 Um (3); en escalenos 4 Um (9) 5 Um (6); en trapecio superior 4 Um (9) y 5 Um (13), paravertebrales 4 Um (12) 5 Um (11). La relación entre grado de lesión y actividad electromiográfica en prueba de Kruskal-Wallis fue significativa ( $p < 0.05$ ) para trapecio superior ( $\alpha 0.043$ ) y paravertebrales ( $\alpha 0.006$ ), relación confirmada con  $r$  de Pearson en trapecio superior ( $\alpha 0.014$ ) y paravertebrales ( $\alpha 0.000$ ). La lesión de Quebec grado II es más frecuente, limita el rango de movimiento en cuello del 25 al 50%, su correlación con espasmo clínico y actividad electromiográfica es significativa en músculos posteriores en grados de severidad.

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**juries are more frequent. They limit the range of motion of the neck between 25 to 50% and their correlation to clinical spasm and electromyography activity is significant in posterior muscles in terms of degrees of severity.**

**Key words:** neck, muscle spasm, sprain, cervical vertebra, electromyography, whiplash cervical injury.

**Palabras clave:** cuello, espasmo muscular, esguince, vértebra cervical, electromiografía, lesión cervical por contragolpe.

## Background history

The cervical spine made by 7 vertebrae is divided into the high cervical segment and the low cervical segment. The high segment is made by vertebrae C1 and C2 (atloaxial complex) and the low segment is made by vertebrae C3 through C7. Vertebral bodies are small with lateral, acute borders of the upper platform making the unciform process. The most typical anatomic features of transverse processes are foramens for the vertebral artery to pass through. Most mobility of the cervical spine occurs in the atloaxial complex. Ranges of motion of the cervical spine are as follows: flexion 100 to 110°; extension, 130°; lateral inclination motions are about 45°; and rotational motions range from 80 to 90° on each side.<sup>9,13</sup>

Biomechanics and motor control of the head and neck are important to know what the pathophysiology of neck injuries is. Movements made by the head in humans are made by using over 20 pairs of muscles. Many of these muscles cross two or more joints or may have several insertion sites. Their movements are associated to sight, hearing, smelling, and taste. The neck muscles provide stability to the head, neck and proximal portion of the chest. In spite of their significance, though, research about their morphology and functionality in live people has been very difficult.<sup>1,3</sup> Non invasive techniques such as MRI or CAT scans have been used to inaccurately determine the areas of these muscles. However, their limited resolution does not show their architecture. EMG methods for surface muscles have also been favorably used. These methods, none the less, are more difficult to use in deeper muscles.

Some studies conducted in cadavers have determined the following groups:<sup>2,5,15</sup>

1. Muscles joining the head to the shoulders: sternocleidomastoid (sternomastoid, sternooccipital and cleidooccipital muscles) and trapeze (trapeze, acromio-trapeze and spino-trapeze muscles).
2. Muscles joining the head to the spine: longitudinal dorsal muscle (splenius and cervical), suboccipital muscles (posterior rectus major and minor), ventral muscles (anterior rectus major, lateral minor).

3. Muscles joining the spine to the chest, scalene (anterior, medial, and posterior) muscles.
4. Muscles joining the scapula to the spine: rhomboid (major and minor), scapula levator muscle. Spinal flexion is limited by posterior muscles on the back neck and ligaments. Extension is limited by the common anterior ligament and anterior muscles and visceral structures. Lateral inflexion is limited by joint pillars and intertransverse ligaments.

About 20% of people involved in a car accident refer symptoms of the cervical region. Of these, 25% will refer chronic pain of this region. The pathophysiology of painful syndromes reported as a sequel of an injury due to rear end vehicle collision is still controversial and poorly defined. In 1928 Crowe described the effects of the acceleration-deceleration mechanism conditioning hypertension followed by hyperflexion known as whiplash.<sup>17,20</sup>

Collision (by impact) starts a sequence of events affecting the cervical spine joints, ligaments and muscles.

A sudden neck movement induces head projection backwards and results in an acute stretching reflex of the reflexor muscles of the neck before the muscle relaxes, followed by a projection forward of the head thus conditioning the stretching reflex of the extensor muscles.<sup>6,10,12</sup> This injury possibly affects the intraspindle fibers albeit extraspindle fibers are also damaged when the force is excessive resulting in edema and small bleeding due to partial damage of the muscle fibers conditioning a fibrous node (trigger area) preserved or spasm leading to a limited mobility and likely chronic symptoms.<sup>15,21</sup> A recent definition of whiplash is found in Barnsely et al. They describe it as an injury of one or more spine elements occurring when inertia forces are applied to the head in a car accident resulting in neck pain. An impact at 32 km/h (20 mph) is considered as the trigger followed by a succession of head movements and symptoms given by the head position in motion at the time of impact. When the head is in rotation, it can cause an injury on other levels such as the joint facets, vertebral discs, or alar ligaments. The most common of these is neck pain (the International Pain Association defines it as an unpleasant sensitive and emotional experience associated to tissue damage), followed by neck rigidity, headache, shoulder pain, back pain, difficulty in

concentrating, and memory loss, tinnitus, depression; insomnia, and anxiety have also been reported. These symptoms are not related to objective findings in X-ray studies.<sup>14,16,19</sup>

The injury classification is important. It will depend on the type of therapy even if to this date there is still an ongoing controversy about it. The Quebec classification is the most complete accepted classification.<sup>19</sup>

G.0	No symptoms or signs of injury
G.I	Neck pain and rigidity
G.II	Neck pain and muscle skeletal signs
G.III	Neck pain and neurological signs
G.IV	Neck pain and fracture or dislocation

There are also alterations that may appear in any of these Quebec classification grades, namely hearing loss, vertigo, tinnitus, headache, memory loss, dysphagia, and temporomandibular joint pain.

Musculoskeletal symptoms are decreased in the absence of deep tendon reflexes while neurological symptoms are weakness and sensory alterations. Many studies have recommended several kinds of therapy in the acute phase with pain killers, NSAIDS, antidepressants, muscle relaxant drugs, local infiltrations, the use of immobilization with a cervical collar, anesthetics, and physical therapy. A study showed that mobility reduction in acute injuries is very significant for all mobility arches, namely flexion, extension, lateral flexion, and neck rotation.<sup>4,8,11,18</sup>

After the injury, patients were divided into 3 groups according to the severity of the injury (mild, moderate and severe). Extension followed by flexion, lateral flexion and rotation were found to be limited. Treatment during the first week included cervical braces and medical therapy which was extended for two more weeks. The reduced neck motion was found to persist for 3 months after the injury.<sup>7,9,14</sup>

In a prospective study, methylprednisolone acetate was given to patients with whiplash injury within the first 8 hours of the injury. Doses were 30 mg/kg during the first hour and 5.4 mg/kg over the next 7 hours. Results showed a significant difference in improvement in those patients who were given the treatment compared to other cases where no infiltration was performed.<sup>16,11</sup> There are many types of braces in the market providing neck stability. They are used under many circumstances including trauma or surgery. In a study, several kinds of immobilization means were used such as soft collars, Philadelphia collars, Philadelphia collars with extension, and SOMI devices. Mobility was evaluated for each type with active and passive neck ranges of motion. At the end of the study, no single collar was shown to prevent full motion restriction albeit there are differences between them. The SOMI device is the one that best limits C1 to C5 mobility of the cervical spine followed by the Philadelphia collar with extension, the Philadelphia collar, and the soft collar, in that order.

The relationship between a whiplash injury and the whiplash syndrome is still confusing. The persistence of headache and neck pain for over 6 months has been found

to be the result of chronic injury and the variety of symptoms that may be found include neck pain, headache, cognitive impairment, dark visual field, and vertigo. The whiplash syndrome is thought to be conditioned by nociceptive and neuropathic stimuli. The first term refers to signals received by the CNS as a result of sensitive receptor activation and neuropathic symptoms refer to somatosensory process disorders. Other studies claim there is not sufficient evidence in nociceptive or neuropathic processes and pain is caused by a psychological factor. In the whiplash stage, there is a risk of injury to potentially pain causing structures. Neural segments of the cranial vertebral joint elongate mainly involving the nerve roots of C1, C2 and the dorsal node of C2. Joint facets of the middle and low cervical spine are another mechanism of chronic pain. Posterior segment compression of these facets (pinching mechanism) results in a local injury to the tissue. This is considered as a nociceptive pain. On the other hand, the facet joint capsule is richly furnished with nociceptive receptors and during facet compressions, cartilage inflammation has been shown to lead to chronic changes in perfacet tissue and consequently in chronic pain. After a whiplash injury, pain of the posterior portion of the neck has been seen to persist caused by the zygoapoficiary joint which is innervated by the cervical medial brachial dorsal nerve.<sup>12</sup> The most affected parts seen have been C2-C3 with headache, C5-C6 and C6-C7 with shoulder pain. With this process local infiltration with anesthetics is indicated resulting in decreased chronic symptoms for more than 85 % of patients.

In a recent case report, the secondary posterior rectus minor muscle was found to be atrophied in a whiplash injury. This evaluation was made by MRI where muscle fat infiltration was found without determining the cause for infiltration. Infiltration was considered to be due to disuse (neurogenic atrophy). Electromyography alterations were also found reporting persistent acute positive waves.

The upper cervical spine anatomy suggests the dorsal branch of C1 is trapped in extreme mobility of the atlaxial joint and the posterior rectus major muscle. The average age when this injury occurs more frequently is in the 2<sup>nd</sup> or 3<sup>rd</sup> decade of age of the individual. The output generated by this whiplash capsular ligament injury is an acute injury tending to become chronic. In the acute phase, muscle spasm is established resulting in neck pain and rigidity of the muscle group involved. Evaluating by electromyography (EMG) a muscle with spasm is possible because its spontaneous activity is altered. Electromyography evaluates the motor system integrity.

Electromyography stages are:<sup>10,17,21</sup>

- Insertion activity
- Spontaneous activity
- Motor unit potential
- Interference patterns

In a relaxed or healthy muscle, electrical activity is considered as having electromyography values ranging from 1 to 3 MU. Values higher than 3 MU are considered as muscle spasm.

### Material and methods

An observation, prospective, cross section and correlation study was conducted at the spine clinic of the “La Villa” General Hospital between September and December 2002 to identify the correlation between the degree of severity in acute whiplash injury and the muscle spasm of the neck. The first 36 hours after the injury were considered as the acute phase of the injury. Twenty four patients meeting the inclusion criteria were recruited. Inclusion criteria involved:

- patients with acute whiplash injury
- ages between the 2<sup>nd</sup> and 4<sup>th</sup> decade of life
- patients treated at the Emergency Room of the “La Villa” General Hospital between September and December 2002
- patients signing their consent to undergo EMG testing

Variables studied included: degree of clinical whiplash injury, muscle groups involved, arches of motion, spontaneous EMG activity of muscles studied, age, and gender (See *Table 1*).

The degree of severity of the whiplash clinical injury was assessed according to the Quebec classification as follows.

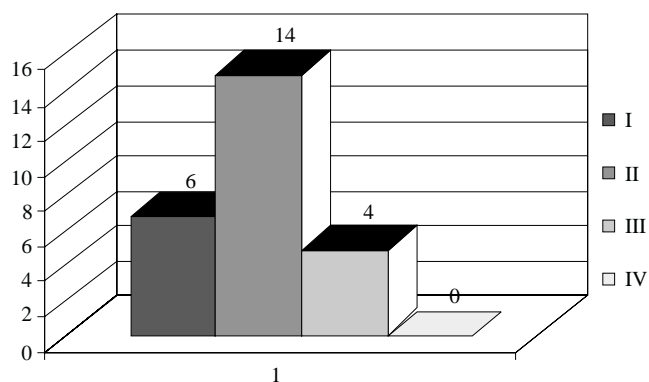
- I. Neck pain and rigidity
- II. Neck pain and musculoskeletal symptoms
- III. Neck pain and neurological symptoms
- IV. Neck pain and fracture of dislocation, musculoskeletal signs; decreased mobility and spasms, neurological signs; decreased or absent tendon reflexes, weakness, or sensitive alteration.

The muscle groups were evaluated with or without clinically palpable spasm by pain and increased tone. They were divided into anterior, lateral and posterior groups. Arches of neck motion in flexion, extension, right and left lateralization, and right and left rotation were graded as good (complete arch), average (50% to 75% of arch) and poor (less than 50% of arch). EMG evaluation of the spontaneous activity of the sternocleidomastoid, scalene, superior trapeze, and paravertebral muscles was performed with a transcutaneous electrode introduced in muscles relaxed or in spasm. Muscles were rated as relaxed (1 or 2 MU) and muscles were considered in spasm with a 3 and more MU rate.

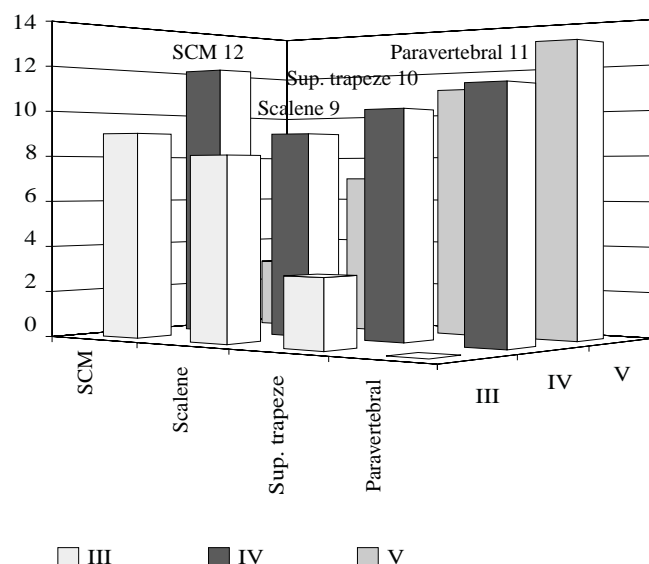
Statistical and descriptive analysis was performed by deriving the means, standard deviations, charts, tables, inference analysis to calculate correlations with Kiskal-Wallis testing and Pearson's *r* testing.

**Table 1. Variables**

Quebec Classification	I II III IV		Ordinal
Muscles involved	Anterior group Lateral group Posterior group	with/without (spasm)	Nominal
Arches of motion	Good Average Poor	motor unit (MU)	Ordinal
EMG assessment of Spontaneous activity	SCM Scalene Superior Trapeze Paravertebral		Quantitative
Gender	Females Males		Qualitative
Age	2 <sup>nd</sup> Decade 3 <sup>rd</sup> Decade 4 <sup>th</sup> Decade		Qualitative



**Chart 1.** Quebec classification of injuries.



**Chart 2.** EMG evaluation of spontaneous activity.

## Results

The study included 12 male (50%) and 12 female (50%) patients with an average age of  $26.2 \pm 8.3$  years. Grade G II of the Quebec classification prevailed with 14 patients (58.3%). G I injuries involved 6 (25%) patients and G III injuries affected 4 (16.7%) patients (*Chart 1*).

Clinical posterior muscle spasm was seen in all patients (100%); lateral muscle spasm involved 16 (66.7%) patients; and the anterior muscle spasm was seen in 17 (70.8%) patients. Average range of motion was seen in 13 (54.2%) of patients; poor range of motion was seen in 9 (37.5%) patients, and good range of motion was seen in 2 (8.3%).

Spontaneous activity assessed by EMG of the sternocleidomastoid muscle was 4 MU in 12 patients and 5 MU in 3 patients; activity of the scalene muscles was measured as 4 MU in 9 patients and 5 MU in 6 patients; the superior trapeze muscle showed a 4 MU activity in 9 patients and 5 MU activity in 13 patients; and for paravertebral muscles the activity was 4 MU in 12 patients and 5 MU in 11 patients (*Chart 2*).

The relationship between the injury grade and the electromyography activity in the Kruskal-Wallis test was significant ( $p < 0.05$ ) for the superior trapeze muscle with an  $\alpha$  value of 0.043. For paravertebral muscles, a value was 0.006. This relationship was confirmed with the Pearson's  $r$  statistical test showing a value of 0.014 for the superior trapeze muscle and an  $\alpha$  value of 0.000 for paravertebral muscles.

## Discussion

Neck injuries resulting from rear end vehicle collision, also known as "whiplash" injuries occur because of inertia forces applied on the head in a car accident where about 20% of people having been involved report symptoms of what is known as an epidemiological problem. The sudden movement of the neck starts a sequence of events affecting the cervical spin joints, ligaments, and muscles. The most affected fibers are intraspindle fibers although extraspindle fibers are also damaged when the injuring force is excessive. Edema and small bleeding condition a myoaponeurotic fibrous node maintained as an irritant focus or spasm leading to limited motion and probably chronic symptoms. Treatment of acute injuries includes rigid bracing, rest, muscle relaxant drugs, and pain killers for 3 to 4 weeks. Over 80% of patients report improvement and being able to go back to their daily activities after this treatment. Neck symptoms persisting for more than 6 months translate into a chronic injury considered as a whiplash syndrome produced by nociceptive and neuropathic stimuli. In Mexico City, neck injuries from car accidents are quite common because of a poor transit culture and alcohol drinking by drivers albeit no reliable statistics about their incidence is available. Better knowledge of the pathophysiology of the injury will allow us to properly evaluate these injuries and hence, provide better treatment.

## Conclusions

In our sample, the most common injury was the Quebec G II injury. Results are similar to those reported by the medical literature. This injury conditions a limited neck arch of motion by 25% to 50%. The correlation between the degree of severity of the injury according to the Quebec classification, and the EMG activity of muscles studied was significant for the posterior group of muscles (superior trapeze and paravertebral muscles) in grades II and III. EMG values described in motor units (MU) were different in these muscles.

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