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Quantifying Post-Accident Neurological Symptoms Other than Concussion

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Abstract

***Introduction:** The Rivermead scale is used frequently to assess the post-concussion syndrome in patients after car accidents, but these patients also experience other post-accident neurological symptoms, other than concussion. This article presents a new scale to measure these symptoms and examines its clinical correlates.*

***Materials and Methods:** 89 patients applying for compensation with their car insurer after an MVA were interviewed (mean age 42.0, SD=14.0, 34 males, 55 females) via the Rivermead Post-Concussion Symptoms Questionnaire, Brief Pain Inventory, Insomnia Severity Index, and the scale for retrospective assessment of the Immediate Concussion Symptoms (ICS). They were also administered the first version of the scale listing chronic post-MVA neurological symptoms (PMNS) which consists of items dealing with hand tremor, impaired muscular control over limbs, tingling, numbness, or reduced feeling in the limbs, and incontinence.*

***Results:** The most frequently reported symptoms on the PMNS scale were numbness in the limbs (67.4%), tingling in the limbs (67.4% of the patients), impaired muscular control over leg (44.9%), hand tremor (42.7%), and impaired muscular control over arm or hand (40.4%). The PMNS scale (mean 10.4, SD=7.1, Cronbach's alpha=.82) significantly correlated with Rivermead score (r=.47), with measures of accident related pain (r=.39), insomnia (r=.36), number of previous car accidents (r=.28), the syndrome of word finding difficulty (r=.22), with the accident related PTSD (r=.33), and with depressive mood (r=.40), anger (r=.29), and anxiety (r=.27), but not with age and gender (p>.05). The Cronbach coefficient of internal consistency of the PMNS was satisfactory (.82).*

***Conclusions:** The post-accident neurological symptoms (as represented by PMNS scale scores) correlate with the Rivermead, pain, impaired sleep and mood.*

Keywords: *concussion, post-concussion syndrome, cauda equina, Rivermead, tinnitus, axonal shearing*

Introduction

The post-concussion syndrome in survivors of motor vehicle accidents (MVAs) can be clinically assessed easily by rating scales such as the Rivermead Post-Concussion Symptoms Questionnaire [1], but its diagnosis is still often missed by busy physicians or psychologists. It has been erroneously assumed in the past by many professionals that cerebral concussions occur rarely, if ever, without visible external head injuries. Since the published autopsy reports by the famous neuropathologist Bennet Omalu [2, 3] and his peers [4], it is now more widely known that cerebral concussions do occur frequently without visible external head injuries, and without a full loss of consciousness, e.g., with lesser physical impacts such as those experienced by football or hockey players. Phenomena such as so called axonal shearing with subsequent neurotoxicity and microvascular trauma are involved. The gray and the white part of the brain slide over each other due to their differential density as the head rotates during such impacts and axonal shearing occurs with subsequent neurotoxicity[5]. Besides the post-concussive syndrome, these post-

MVA patients usually also suffer from whiplash injuries that are epitomized by neck and back pain. The neuropathological signs such as tingling, numbness, or decreased tactile sensitivity in some of the limbs are familiar to most post-MVA patients. In certain extremes, these injuries may escalate into the cauda equina syndrome (CES) which may be associated with impaired continence. Whiplash syndrome in post-MVA patients may also include hand tremor and various degrees of impaired muscular control over their limbs that, in some cases, can occur in brief or weak episodes, but in other cases may be more permanent and disabling. This study focuses on developing a new scale (the Post-MVA Neurological Symptoms scale) to quantify this group of post-accident neurological symptoms and on examining its statistical properties and its correlates.

Materials and Method

Our sample included 89 patients applying for compensation with their car insurer after an MVA (mean age 42.0 years, SD=14.0, age range 18 to 83, 34 males, 55 females). Their MVA occurred between 4 to 142 weeks ago (mean=52.3, SD=32.3). All of them still experienced active post-MVA symptoms during this assessment. When involved in the MVA, all these patients were in cars, except for 8 who were pedestrians, 2 motorcyclists, and one on a bicycle. Most of those in cars were in a vehicle that was rear-ended (41.6%). Frontal collisions (7.9%), side collisions (11.2%), and other MVAs were less frequent in this sample. At the moment of the impact, 70.8%were the drivers and16.9% the passengers. The majority (64.0%) had no previous serious MVAs associated with injuries. One previous serious MVA was reported by 33.7% and 2 MVAs by 2.2% of these patients.

They were interviewed about the circumstances of their MVA and completed the Brief Pain Inventory [6], Insomnia Severity Index [7], Items 10 to 12 of the Whiplash Disability Questionnaire [8] (i.e., items assessing depression, anger, and anxiety on a scale from 0=absent to 10=always present), and the Rivermead Post-Concussion Symptoms Questionnaire [1]. All patients also completed the Post-MVA Neurological Symptoms (PMNS) scale, designed to quantify the neuropsychological symptoms of the whiplash spectrum. The early version of the PMNS scale as used in this study consisted of 8 items: (1) hand tremor, (2) reduced muscular control over leg, (3) reduced muscular control over arm or hand, (4) tingling, (5) numbness, (6) reduced tactile sensitivity in the limbs, (7) reduced bladder control, and (8) reduced bowel control. Each of these was scored separately on a scale from 0 to 4 (0=symptom absent, 1=present initially after MVA but no longer being a problem now, 2=present but mild, 3=present and moderate, 4=present and severe).

In the present study, the questionnaire also assessed the tinnitus (scored in the same manner as the Rivermead items) and also speech problems: (1) stutter, (2) difficulty articulating words, and (3) word finding difficulty. Each of these 3 speech items was scored as 0=absent or 1=present and the 3 scores were added up to form a separate index dealing with post-MVA speech impairment.

All patients also completed the scale for retrospective assessment of the immediate concussion symptoms (ICA), published recently [5].

Results

The proportion of persons endorsing the 8 PMNS items as still present (scores from 2 to 4) were as follows: hand tremor (42.7%), reduced muscular control over leg (44.9%), reduced muscular control over arm or hand (40.4%), tingling (67.4%), numbness 67.4%), reduced tactile sensitivity in the limbs (31.5%), reduced bladder control (20.2%), and reduced bowel control (14.6%). If the patient had pre-existing (pre-MVA) symptoms on any of these items, the score for the pre-existing symptom was deducted from the score for the current symptom to obtain an unbiased estimate of the impairment caused by the MVA: this occurred only in 3 cases all of which involved pre-existing bladder and bowel control problems.

The total scores on PMNS scale ranged from 0 (5.6% of patients) to 27 (one patient only, i.e., 1.1%), with the average at 10.4 (SD=7.1). The Cronbach alpha coefficient of internal consistency was .82, i.e., satisfactory. The item total correlations (with the item of interest always removed from the total) were all significant: these correlations ranged from .51 to .69 for the first 6 items, but they were lower for the last 2 items, i.e., for the reduced bladder control (.36) and for bowel control (.34), perhaps also to their lower occurrence.

The PMNS scale significantly correlated with Rivermead's total score calculated as a sum of all 16 Rivermead items (r=.47), with measures of MVA related pain (r=.39), insomnia (r=.36), number of previous MVAs (r=.28), the syndrome of word finding difficulty (r=.22), and with tinnitus severity (r=.29). The PMNS scale also significantly correlated with Items 10 to 12 of the Whiplash Disability Questionnaire [8], i.e., with the items measuring the depressive mood (r=.40), anger (r=.29), and anxiety (r=.27). The PMNS scale was not significantly correlated (p>.05, 2-tailed) with age and gender and to incidence of stutter and difficulty articulating words.

The Rivermead total score correlated with tinnitus severity (r=.40), and with all 3 speech impediment items: word finding difficulty (r=.37), stutter (r=.23), and difficulty articulating words (r=.36). The intercorrelations of the 3 speech items ranged from .28 to .38.

The PMNS scale was not significantly correlated with retrospectively reported initial signs of cerebral concussion (measured via the ICS scale [5]), i.e., those occurring over the first minutes after the accident (r=.12, p=.146, 1-tailed), perhaps because the recovery from long term whiplash symptoms (as assessed via PMNS scale) proceeds at its own particular speed or also perhaps because the patients' memories of the immediate aftermath of their MVA, now in the remote past, are somewhat inaccurate. As already reported elsewhere [5], the ICS scores correlated significantly, but not highly, with the Rivermead measure of the post-concussion syndrome (r=.34).

Discussion

The PMNS scale has satisfactory internal consistency and item total correlations. Its correlations to the Rivermead scale, the PTSD, insomnia, and mood symptoms are consistent with its construct validity. The scale is useful for assessing survivors of MVAs who experienced the sudden acceleration & deceleration that tends to cause whiplash injuries and axonal shearing.

The significant PMNS correlation to Rivermead scores (r=.47) is consistent with theoretical overlap between the classical post-concussion symptoms and symptoms in the whiplash spectrum: both brain and/or spine injures may contribute to symptoms such as impaired balance, headaches, or paresthesias.

Frequently missed in medical and psychological assessments of patients with post-accident symptoms is the diagnosis of cauda equina syndrome (CES) which is a rare condition characterized by intense pain in lower back and gluteus, incontinence or urinary retention, numbness and tingling in the "saddle area" (the rectal and genital areas and the inner thighs), and impaired sexual function. If undiagnosed in a timely manner, especially if associated with sudden intense onset such as within 24 hours, the consequences may involve irreversible leg paralysis and permanent incontinence. The CES has been observed to occur in some persons after MVAs [9].

The co-authors of the present article, Hernández-Aguilar and Mateos-Moreno, explain some of the consequences of injuries to thoracolumbar and lower segments of the spine within their complex neuroanatomical context in following words: "The peripheral control of the pelvic plexus is given by nerves that emerge from the spinal cord in sympathetic thoracolumbar and sacral parasympathetic segments [10]. These fibers relay towards autonomic structures or ganglia to later send autonomic efferences to the bladder, prostate, seminal vesicles, rectum and penis, maintaining control over these organs. In the rat, it is the major pelvic ganglion (MPG) that makes this relay, and in the human, it is the inferior hypogastric plexus, its analogue [11, 12]. The alteration in the neurotransmission of preganglionic information has been reported to induce changes in the function of specific organs due to the absence of noradrenaline and acetylcholine as in the prostate. For example, studies reveal that bilateral MPG ganglionectomy causes histological alterations such as a decrease in the number of secretory vacuoles and mitochondria in epithelial cells [13]. Likewise, axotomy of the pelvic and / or hypogastric nerves (nerves that converge with the MPG) induces metaplastic changes in prostate, as well as loss of epithelial conformation and infiltration of immune cells. These changes, it has been hypothesized, could be the prelude to prostatic diseases such as prostate cancer [14, 15]. On the other hand, it has also been documented that with preganglionic lesions such as moderate concussions (at T1 and T9 levels) in rats, as well as human patients with spinal cord damage, there are negative changes in the relaxation of the detrusor muscle of the bladder

and in urodynamic function, suggesting a damage in medullary neurons that send projections to the bladder [16, 17]."

At present, for routine clinical work and research, it is now recommend using an updated version of the PMNS scale (publication is forthcoming) to which the following 5 items have been added: impaired balance, severity of tinnitus, the syndrome of word finding difficulty, stutter, and difficulty articulating words: all 13 items of the PMNS scale are to be scored in the same manner from 0 to 4 as in Rivermead scale. This updated PMNS scale is now also available from the first author in Spanish and in German.

In clinical assessments, it is strongly recommended using the PMNS scale jointly with the Rivermead scale to more adequately map the spectrum of neurological impairment after an MVA.

Conclusions

Neurological post-accident symptoms can be assessed and quantified via the PMNS scale presented in this article. Its concurrent validity is supported by its significant correlations to Rivermead scale of the post-concussion syndrome, and to measures of post-MVA pain and insomnia.

Acknowledgement

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