Original Article

Somatosensory Evoked Potentials Study in Cervical Spondylotic Myelopathy Patients

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Fac Med Baghdad 2014 ;Vol.56, No.1
Received: Dec., 2013
Accepted Jan. 2014

Summary:

Background: Cervical spondylotic myelopathy (CSM) is considered the most serious consequence of cervical spondylosis and accounts for the majority of non_traumatic paraparesis and/or quadriparesis. The electrical property of the spinal cord and its susceptibility to injuries renders electrophysiology relevant to the management of CSM. Somatosensory evoked potentials study (SEPs) is an objective assessment of the functional integrity of the neural pathway.

Objective: Utilizing both of the median and the posterior tibial SEPs in evaluating the functional integrity of the cervical spinal cord in patients with CSM and to correlate the SEPs findings with the clinical and MRI findings.

Patients and methods: Twenty two patients with CSM (11 male and 11 female) ranging in age from 29 to 77 years with a mean age of (56 ±11) years and matched with 25 healthy subjects of the control group were enrolled in this study.

Results: In this study, 86.36% of patients had abnormal SEPs study (either tibial or median or both tests abnormal), with 68.2% abnormal tibial and 63.6% abnormal median. There was no difference between right and left side study of neither median nor tibial SEPs studies (P>0.05). Loss of N13, loss or delayed N20 and loss or delayed N13-N20 were the most frequent abnormalities for median SEPs and loss or delayed P37 and LP-P37 were most frequent abnormalities in tibial SEPs. Results showed that normal SEPs findings mostly correlated with mild and early myelopathy (grade-1 and grade-2 Nurick). Abnormal SEPs findings are useful in prediction the progression of myelopathy in patients with mild clinical neurological deficits in the early stages of the disease.

Conclusion: This study concluded that both median and tibial SEPs montages are useful important objective assessment of the spinal cord function to evaluate patients with CSM since MRI and SEPs may evaluate different aspects of the disease process.

Key words: cervical spondylotic myelopathy, somatosensory evoked potentials.

Introduction:

Cervical spondylotic myelopathy (CSM) is a degenerative disorder of the cervical spine that characterized by narrowing and compression of the spinal cord as a result of cervical spondylosis (1). It accounts for the majority of non-traumatic paraparesis and/or quadriparesis in patients older than 55 years. The aging process results in degenerative changes in the cervical spine that, in advanced stages, can cause compression of the spinal cord (2).

There are three important pathophysiological factors in the development of CSM (3): The static factors (2), dynamic pathological factors (4) and spinal cord ischemia that probably plays a role in the development of CSM, particularly in later stages (5, 6). CSM occurs insidiously, in the early stages, patients often present with neck stiffness and stabbing pain in the preaxial or postaxial border of the arms (7). Then patients with a high compressive myelopathy (C3-C5) can present with a syndrome of "numb, clumsy hands" (8). Those patients with a lower myelopathy typically present with a syndrome of weakness, stiffness, and proprioceptive loss in the legs (8). These patients often exhibit signs of spasticity and unsteadiness of gait with difficulties on walking, some patients report urinary urgency, frequency, and/or hesitancy on urination (8) and (9). Clinical signs are a mixture of upper and lower motor neuron findings, as the exiting nerve root may also be compressed at the spondylotic level, causing lower motor neuron signs at this level and upper motor neuron signs below this level (10). The diagnosis is usually made by MRI; however, many authors have reported somatosensory-evoked potentials (SEPs) to be a useful neurophysiological study for detecting an objective functional abnormality of the spinal cord (11). When the clinical presentations of CSM are equivocal, SEPs may be useful to establish a clinical diagnosis. However MRI largely remains an imaging, structural, or anatomic test and therefore gives more accurate information about structural problems; SEPs assess the functionality and supplies

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information about the physiology of a certain anatomic pathway. Treatment of CSM is usually conservative in nature (use of nonsteroidal anti-inflammatory drugs, physical modalities, and lifestyle modifications) (12, 13). Surgery is the treatment of choice for most physicians when features of myelopathy on MRI are present. SEPs have an application in the detection of posterior column involvement in CSM patients since little correlation exists between the severity of radiological spondylosis findings and the presence or severity of myelopathy (14) and provide information concerning the integrity of the sensory pathway through the brain, brain stem, spinal cord, dorsal roots, and peripheral nerves.

Subjects and methods:

This study was performed during the period from February 2013 to August 2013 in Baghdad at the clinical neurophysiology unit of the Neurosciences Hospital. CSM patients were selected from the Neurosurgery and Neurology wards of the Hospital and some patients were referred from outside private clinics. Twenty five healthy volunteers (9 males and 16 females) ranging in age from 39 to 67 years with a mean age of (52 ± 7.5) years and 22 patients with CSM were contributed in the study (11 Males and 11 females) ranging in age from 29 to 77 years with a mean age of (56 ±11) years were enrolled in this study. They were examined and assessed clinically by a senior neurologist and the diagnosis was confirmed by MRI. Patients included in our study had undergone MRI of the cervical spine and had findings of pronounced spondylosis; at least some degree of spinal cord compression was an obligatory finding for the inclusion of the patient in the study. Any patient with known history of any neurological disease or had diabetes was excluded from the study. All subjects were investigated by: 1. Median and Sural SNCV bilaterally in order to exclude any asymptomatic clinical entrapment or neuropathy that might affect the test (Any subject with abnormal median or sural SNCV was excluded from the study) 2. Median and tibial SEPs studies bilaterally. Nihon Kohden's Neuropack, MEB-9400K EMG system was used for all the electrophysiological studies. The test was carried out in a semi-darkened quiet room which is away from other electrical machines and temperature was monitored and kept between 26-28C during the test. The subject was asked to lie supine on the coach with the limbs kept extended and relaxed and was advised not to move or blink continuously during the test to decrease muscle artifacts which may increase the noise and affect the evoked potential waves. We used the minimal 4 Channels montage recommended by ACNS (15) for upper and lower SEPs studies. We used median nerve stimulation at the wrist for upper limb SEPs. Four channels record Erbs point peripheral potential (N9)**,** cervical spinal potential (N13)**,** subcortical response (P14/N18) and cortical response (N20). And we used posterior tibial nerve stimulation at the ankle for lower limb SEPs. Four channels record cortical response from ipsilateral centroparietal area (P37/N45), cortical response from central centroparietal area (P37/N45), subcortical response (P31/N34) and lumber spinal potential LP (N21), also we recorded peripheral compound potential at popliteal fossa Pf. The intensity of stimulus was adjusted according to the minimal contraction in intrinsic muscles supplied by the stimulated nerve. Analysis time was 100ms. To ensure reproducibility of the waves, an average of at least 500 trials for the main cortical SSEP waves and 1000 responses in spinal and sub cortical components, we repeated at least two blocks of stimuli and for some patients three or five blocks were needed.

Results:

Results of comparing the age and gender of the control group with the patients in our study were not significant P>0.05. Because the height of our subjects was not recorded and age was not taken into account for evoked potential measurements, upper limit of normal values in this study was mean+3SD (16). Amplitudes vary considerably among patients and within the same patient at different times and they are not used for routine clinical interpretation (17; 18); therefore, they were not included in the criteria of abnormality in our study. Results were considered abnormal for median SEPs when cervical N13 and/or cortical N20 was absent and/or N9-P14, P14-N20 IPLs or both were absent or delayed (Delayed response in our study: exceeded the mean of control +3SD) on either right or left side, and for tibial SEPs when cortical P37 was absent and/or LP-P37 was absent or delayed on either right or left side.

(Table 1): Comparing Median and Tibial SEPs tests for Patients

			Tibial SEPs study		Total
			Normal Tibial SEPs study	Abnormal TibialSEPs study	
Median SEPs study	Normal Median SEPs study	No. of patients	3	5	8
		% of Total	13.6%	22.7%	36.4%
	Abnormal Median SEPs study	No. of patients	4	10	14
		% of Total	18.2%	45.5%	63.6%
Total		No. of patients and % of Total	7 31.8%	15 68.2%	22 100%

P>0.05

(Table 2): Comparing right and left cortical response between patients and control group

	Right N20			Left N20		
	Abnormal		Normal	Abnormal		Normal
	absent	delayed		Absent	delayed	
Patients group	3 13.6%	2 9.1%	17 77.3%	8 36.4%	1 4.5%	13 59.1%
Control group	0 0%	0 0%	25 100%	0 0%	0 0%	25 100%

P= 0.042 for right N20 (significant), P= 0.002 for left N20 (significant).

(Table 3): compare right and left cervical responses (N13) of patients with control group

	Right N13			Left N13		
	Abnormal		Normal	Abnormal		normal
	Absent	delayed		Absent	Delayed	
Patients group	12 54.5%	0 0%	10 45.5%	7 31.8%	1 4.5%	14 63.6%
Control group	0 0%	0 0%	25 100%	0 0%	0 0%	25 100%

P= 0.009 for left N13 (significant)/P= 0.0005 for right N13 (significant)

(Table 4): compare right and left P37 of patients with control group

	Right P37			Left P37		
	Abnormal		Normal	Abnormal		Normal
	Absent	delayed		absent	delayed	
Patient group	6 27.3%	9 40.9%	7 31.8%	10 45.5%	4 18.2%	8 36.4%
Control group	0 0%	0 0%	25 100%	0 0%	0 0%	25 100%

P< 0.0005 for right and left P37.

(Table 5): Median SEPs results in patients according to their Nurick grades

Median SEPs results		Nurick grading					Total number of patients
		Grade1	Grade2	Grade3	Grade4	Grade5	
Normal median study	Count and % of patients	4 50%	2 25%	1 12.5%	1 12.5%	0 0%	8 100%
Abnormal median study	Count and % of patients	4 28.6%	4 28.6%	4 28.6%	1 7.1%	1 7.1%	14 100%

P=0.74 (N.S.)

(Table 6): Tibial SEPs results in patients according to their Nurick grades

Tibial SEPs results		Nurick grading of the patients					Total number of patients
		Grade1	Grade2	Grade3	Grade4	Grade5	
Normal tibial study	Count and % of patients	5 71.4%	0 0%	2 28.6%	0 0%	0 0%	7 100%
Abnormal tibial study	Count and % of patients	3 20%	6 40%	3 20%	2 13.3%	1 6.7%	15 100%

P= 0.09 (N.S.).

Discussion:

SEPs study is an objective assessment of the functional integrity of the neural pathway. Earlier studies have shown evoked potentials to be useful in detecting myelopathy in patients with CSM; however, the prognostic value of these tests had so far rarely been examined in detail (11). Recently, authors of various studies have suggested that preoperative SEPs and other forms of neurophysiological monitoring may potentially provide prognostic information regarding the clinical outcome of decompression surgery in patients with CSM (19; 16; 20). In the present study, 19(86.36%) out of 22 patients had abnormal SEPs study. These results agree with Magdolna who found 85% with abnormal SEPs in the group of myelopathy patients (21). However, this result is more than the result of Lyczak et al (22) and more than Lyu et al (16) and Nove et al (23), and this might be because all patients in the present study had at least mild degree of spinal cord compression on MRI and mild symptoms of myelopathy clinically, while others studied a larger groups of patients with cervical spondylosis. It

suggests the important value of SEPs in diagnosis and prognosis of CSM patients in different stages of the disease and this agree with the study of Ding et al who suggested that unidentifiable SEPs waves in CSM patients are indicative of a relatively poor outcome (24). There have been many reports regarding the utility of upper and lower SEPs studies in CSM patients. In our study there was no difference between median and tibial SEPs results (Table1) and this agree with the result of Lyu and his team (16), and disagree with the study of (Perlik and Fisher and the study of Yu and Jones) (25, 26) who suggested tibial SEPs to be the most sensitive test for CSM and the study of Veilleux and Daube, who claimed that ulnar potentials are more sensitive than tibial SEPs (27). However, in our study, 5 patients (22.7%) had only abnormal tibial SEPs with normal median SEPs and 4(18.2%) patients had abnormal median study with normal tibial study. This result increases the necessity to perform both upper and lower SEPs studies for patients with CSM. We found that most of the abnormalities were bilateral and there was no difference between right and left side study of neither median nor tibial SEPs studies ($P>0.05$). For median SEPs cortical response N20 was significant ($P<0.0005$) compared to control group (Table2). Loss of cortical response was more frequent than delayed response. Subcortical potentials P14 and N18 (compared to the control group) were not significant in the study. Loss of cervical spinal potential N13 was highest significant results ($P<0.0001$) associated more frequently with loss of N13 more than delayed responses (Table3). N9 peripheral component of Erbs point was within normal limits for all patients and control group. IPLs were significant regarding N9-N13, N9-N20, P14-N20 and N13-N20. N13-N20 was the most significant with 63.6% right and 54.5% left side abnormality. In the present study 8 patients had normal median SEPs. Many studies suggested that normal median SEPs is a good prognostic factor and that is because the functional integrity of the cord is still keeping well (16, 20). Cortical response P37 following tibial stimulation was highly significant compared to control group ($P<0.0005$) (Table4). Abnormal tibial SEPs associated with slightly more frequent loss of components than delayed responses so both P37 and LP-P37 were highly significant. Subcortical response P31 and N34 were significant compared to control group ($P<0.0005$). This suggest that tibial SEPs test is valuable in the diagnosis and monitoring of CSM patients and this agree with Lyczak et al who reported abnormal SEPs in 56% of patients with cervical myelopathy using tibial nerve SEPs (22). In our study we classified the patients on the basis of gait disturbance according to Nurick scale (28). Results of median and tibial SEPs (compared to Nurick classification of the patients) were both not significant statistically ($P>0.05$) (Tables 5 and 6); however, tibial SEPs were more informative than that of median SEPs. Four (50%) out of total 8 patients with normal median SEPs results were grade-1, 2(25%) were grade-2 and 12.5% for each of grade-3 and grade-4, while 5(71%) out of total 7 patients with normal tibial SEPs tests were grade-1 and 2(28.6%) were grade-3. This is mostly due to the basis of the Nurick classification that depend on gait disturbance and regarding tibial SEPs being not significant statistically ($P=0.09$) could be explained due the lack of equal distribution of the patients through the clinical grades of our data as there was only 2 patients in grade4 and 1 patient in grade5 while 8 and 6 for grade1 and grade2 respectively. Ten (45.5%) out of total 22 patients had both median and tibial SEPs studies abnormal, 2 of them were grade-1 and 4 of them were grade-2, 2 with grade-3 and 1 was grade-4 and 1 was grade-5. This result increases the value of SEPs in the diagnosis of early stages of myelopathy and in predicting the progression of neurological deficits in patients with subclinical non-confirmative picture of myelopathy. This result agree with the study of Bednarik et al. and Kadanka et al. (29, 30). Also agree with Nové et al who found in his study that MRI and clinical data were agreeing in CSM in only 50% of patients and suggested that SEPs proved to be more sensitive to detect somatosensory dysfunctionning in CSM than clinical testing and radiological data (22). This result agrees also with Bednarik et al. and Morshita et al. (29, 31). In our study, we suggest that results of abnormal SEPs at early stages of myelopathy (grade-1 and grade-2) could change treatment modalities (from conservative to surgical) and help in prevention of progression of the disease to the following worse grades. This suggestion agree with the study of Magdolna who studied 51 patients with cervical spondylosis and found that electrophysiological evaluation of the spinal cord in cases of MRI proven cervical spondylotic spinal cord compression has its greatest value when patients present with mild, non-specific symptoms with respect to myelopathy and SSEP results play an important role in the appropriate management of patients (21). On the other hand, results showed that 3 (13.6%) patients out of total 22 had normal median and tibial SEPs study and they were all grade-1 Nurick. This may show that normal SEPs findings are related with less symptomatic (early stages) myelopathy (21).

Conclusion:

We concluded that both median and tibial SEPs montages are important to be performed to evaluate patients with CSM as SEPs and MRI may evaluate different aspects of the disease process. Normal SEPs findings mostly correlate with mild and early myelopathy and the abnormality of N13, N20 and their related IPLs are the most sensitive components in median SEPs, P37 and LP-P37 are the most sensitive components in tibial SEPs in CSM patients. We recommend that SEPs study should be performed for every patient with CSM whether on conservative or

scheduled for surgery to evaluate the effectiveness of the treatment.

Author contributions:

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