Sensory-Motor Index is Useful Parameter in Electroneurographical Diagnosis of Carpal Tunnel Syndrome

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Abstract

It was performed electroneurographic (ENG) studies with surface electrodes and examined nervus medianus (NM) in 60 patients (38 females), average age of 50,28 years (X±SD=50,28±11), with clinical diagnosis of carpal tunnel syndrome (CTS) and at least one border or discrete abnormal value of conventional electrophysiological tests. It was also examined 57 healthy individuals (33 females) as control group, average age of 45,65 years (X±SD=45,65±9,68). The sensitivity and specificity of sensory-motor index (SMI), terminal latency index (TLI) and residual latency (RL) were calculated and compared. SMI is determinate by using following formula: distal distance (DD) (in cm)/distal motor latency (DML) (in ms) + sensory conduction velocity (SCV) (in m/s)/motor conduction velocity (MCV) (in m/s) of NM. SCV of NM was measured by antidromic technique in segment wrist-index finger and MCV of NM in forearm segment above wrist. SMI mean value of control group was 3,45 (X±SD=3,45±0,45) with lower limit of normal value 2,82 and in patients with CTS 2,13 (X±SD=2,13 ±0,37). The sensitivity of SMI in patients with CTS was 98,51%. SMI is useful parameter in electroneurographical diagnosis of CTS and it's determination is easy and fast and specially important in cases with border or discrete abnormal values of other NM electrophysiological parameters, when SMI values can indicate incipient phase of CTS evolution. In rare cases (about 1%) of CTS with selective NM motor axons affection, SMI may have normal value (false negative result), but DML is always prolonged in this cases. SMI is not dependent on age and DD values in patients with CTS and control subjects.

KEY WORDS: sensory-motor index, carpal tunnel syndrome

Introduction

Carpal tunnel syndrome (CTS) is the most frequent compression neuropathy. Prevalence rates of CTS in a general population of 170 000 inhabitants in a southern region of Sweden were 3,8% detected by clinical examination, 4,9% by nerve conduction testing and 2,7% by clinical and electrophysiological examinations (1). In two different areas of the United Kingdom the average annual incidences (per 100 000) were 139,4 (2). There is no generally accepted standard for the diagnosis of CTS (3). Distal motor latency (DML) of nervus medianus (NM) in ms is absolute measure of motor axons conduction time after stimulation of distal segment of nerve at wrist above retinaculum flexorum (ligamentum carpi transversum) with standardized distal distance (DD) in cm to recording electrode above musculus abductor pollicis brevis. At Mayo Clinic and some other Laboratories DD between the recording electrode and the wrist stimulation point were 7 cm (3,4), no more than 7 cm (5), 6,5 cm (6) and 6 cm (7). According to Manual of nerve conduction velocity and clinical neurophysiology DD is 8 cm with 4,2 ms as upper limit of normal NM DML value (8). As upper limit of normal NM DML value other authors accepted also 4,2 ms (6), 4,3 ms (7), 4,4 ms (4,5) and 4,6 ms (3) with different DD values. Many other Laboratories use methods with lower upper limits of normal NM DML, for instance 4,0 ms (9). Furthermore, in children, adults (often female) with small hands or with large hands, with scar after hand injuries, the standardized DD can not be stimulation point of NM. Also, small hand increases a risk factor for CTS (10). Because of different recommended criteria, some relative measures (coefficient and index) could be determined. Distal latency coefficient (DLC) is ratio between DD value (in cm) and DML (in ms) =cm/ms (11). For determination of terminal latency index (TLI), in use is following formula: DD(in mm, or 10 x DD-in cm)/MCV (m/s) x DML (ms); in normal subjects the range of the TLI was 0,36 to 0,55 and 0,36 to 0,54 respectively, with lower limit of normal TLI ≥0,34 (12). For residual latency (RL) in use is following formula: DML (ms) – DD (in mm-or 10 x DD-in cm)/MCV (m/s). Upper limit of normal NM RML is 2,6. RL is less dependent on patient's age than DML. In this paper we describe sensory-motor index (SMI) for electrophysiological evaluation of NM damage degree in the CTS and we can determinate it by using following formula: DD (in cm)/DML (ms) + SCV (m/s)/MCV (m/s). SCV of NM was measured by antidromic technique in segment wrist-index finger and MCV NM in forearm segment above wrist (13). In previous study it was not consider sensitivity of SMI for electroneurographical diagnosis of CTS and comparison with sensitivity of other indexes also has not been done. CTS, sensory and/or motor axons of NM are affected in different proportion and degree and the absolute measures of NM conduction often have border values in incipient phase of CTS. It is simply and fast way to make electrophysiological diagnosis in this cases and to confirm the suspected clinical diagnosis of SCT beside many others motor and sensory more detailed segmentary NM conduction techniques (wrist-palm and palm-index, middle and ring fingers), combined sensory index determining (14,15) and different ipsilateral (median-ulnar, median-radial) and contralateral comparison methods. Some of motor segmental studies have a number of pitfalls and technical problems and have been considered unreliable and time consuming (5,16).

Patients and Methods

Electromyography (EMG) examinations were performed with needle concentric electrode and we examined hand and arm muscles (thenar and hypothenar, m. extensor digitorum communis and m.triceps brachii); for electroneurographic (ENG) examinations we used surface electrode and examined 67 NM in 60 patients (38 females) average age 50,28 years (X±SD=50,28±11) with clinical diagnosis of SCT and at least one border or discrete abnormal conventional electrophysiological test of the two following: prolonged DML and reduced NM SCV in segment wrist-index finger (D2-SCV). For NM DML examination the compound muscular action potential (CMAP) was recorded with surface electrodes above abductor pollicis brevis muscle after NM stimulation at the wrist above retinaculum flexorum with DD 6,5 cm (6/67, 8,96% in SCT group; 10/57, 17,54% in control subjects), 7 cm (47/67, 70,15% in SCT subjects; 30/57, 52,63% in control subjects) and 8 cm (14/67, 20,89% in SCT subjects; 17/57, 29,81% in control subjects) depending an hand size. MCV NM we determined in segment forearm upper part-wrist. We also ENG examined 57 NM segments (DML, MCV, D2-SCV) in healthy individuals (57 persons, 33 females) of control group, average age 45,65 years (X±SD= 45,65±9,68), DML was considered abnormal when it was longer than 4,2 ms after NM stimulation 6,5 cm from recording electrode, longer than 4,4 ms after NM stimulation 7 cm from recording electrode and longer than 4,6 ms after NM stimulation 8 cm from recording electrode. Antidromic D2-SCV NM and MCV NM were abnormal when they were less than 48 m/s and 45 m/s respectively. The skin temperature of the hand at midpalm was maintained at 32°C or higher. All EMG and ENG testing was carried out with a France "Racia 21P" EMG apparatus, by first author. SMI, TLI and RL we determined in the way described previously. Statistical analysis we performed to determine arithmetical mean value (X) and standard deviation (SD) of NM parameters and after that we determined the rate of sensitivity and specificity for each of those parameters in patients with CTS and control subjects. Sensitivity of each index was calculated as number of hands with positive (pathological) values/number of hands with really positive clinical and electrophysiological tests x 100%. Specificity of each index was calculated as number of hands with negative (normal) values/number of hands with really negative clinical and electrophysiological tests x 100%. Results were evaluated for statistical significance using Student's t-test (at $p^{*}<0,05$; $p^{**}<0,01$; $p^{***}<0,001$). We also determined Pearson correlation (sig. 2-tailed) coefficient (r) between SMI, TLI and RL and other parameters in patients with CTS and control subjects.

Results

There were statistical significant differences between the mean values of NM parameters in patients with CTS and control subjects (Table 1). SMI and RL have the highest rates of sensitivity (98,51%) and RL has the highest rate of specificity (91,23%) (Table 2). The largest negative correlation coefficient (r) value was registered between SMI and RL (Table 3). The largest positive correlation coefficient (r) value was registered between TLI and SMI and the largest negative correlation coefficient (r) value was registered between TLI and RL (Table 4). The largest positive correlation coefficient (r) value was registered between RL and DML (Table 5).

N	Parameter	SCT (X±SD, range), N=67	Control (X±SD, range) N=57	p
1.	DML (ms)	5,84±1,90 (4-15)	3,14±0,44 (2,3-4)	***
2.	MCV (m/s)	49,61±10,45 (18,2- 71)	58,6±5,75 (49-70,98)	**
3.	SCV (m/s)	39,39±11,42 (10-69,5)	64,36±9,16 (50-85)	***
4.	SMI	2,13±0,37 (1,42-3,15)	3,45±0,45 (2,82-4,52)	***
5.	TLI	0,27±0,06 (0,16-0,38)	0,39±0,13 (0,29-0,61)	***
6.	RL	4,29±1,55 (2,4-10,61)	1,90±0,46 (0,9-3,56)	***

TABLE 1. The mean values of nervus medianus neurography parameters

DML=distal motor latency; MCV=motor conduction velocity; SCV=sensory conduction velocity; SMI=sensory-motor index; TLI=terminal latency index; RL=residual latency; N=number; X=arithmetical mean value; SD=standard deviation; p=*<0,05; **<0,01; ***<0,001

N	Parameter	Upper (lower) limit	CTS (N/67)	Sensitivity (%)	Control (N/57)	Specificity (%)
1.	SMI	2,82	1/67 (3,15)	98,51	-	-
2.	TLI	0,34	5/67 (0,35 x 2; 0,37 x 2; 0,46)	92,54	11/57 (0,29 x 2; 0,30 x 2;0,31 x 3; 0,32; 0,33 x 3)	80,70
3.	RL	2,6	1/67 (2,40)	98,51	5/57 (2,68; 2,70; 2,71; 2,73; 2,75)	91,23

TABLE 2. Rate of sensitivity and specificity of nervus medianus indexes

DML=distal motor latency; MCV=motor conduction velocity; SCV=sensory conduction velocity; SMI=sensory-motor index; TLI=terminal latency index; RL=residual latency; N=number; X=arithmetical mean value; SD=standard deviation; p=*<0,05; **<0,01; ***<0,001

N	Parameter	CTS (r) N=67	P	Control (r) N=57	p
1.	Age (yrs)	-0,117	n.s.s.	-0,224	n.s.s.
2.	DML (ms)	-0,677	***	-0,840	***
3.	DD (cm)	-0,053	n.s.s.	0,164	n.s.s.
4.	MCV (m/s)	0,178	n.s.s.	-0,193	n.s.s.
5.	SCV (m/s)	0,660	***	0,585	***
6.	TLI	0,650	***	0,480	***
7.	RL	-0,759	***	-0,905	***

TABLE 3. Pearson correlation between coefficient sensory-motor index and other parameters

CTS=carpal tunnel syndrome; DML=distal motor latency; DD= distal distance; MCV=motor conduction velocity; SCV=sensory conduction velocity; TLi=terminal latency index; RL=residual latency; N=number; r=correlation coefficient; p=n.s.s.-not statistically significant; *<0,05; **<0,01; ***<0,001

N	Parameter	CTS (r) N=67	P	Control (r) N=57	P
1.	Age (yrs)	-0.051	n.s.s.	-0,082	n.s.s.
2.	DML (ms)	-0,321	**	-0,435	**
3.	DD (cm)	0,302	*	0,152	n.s.s.
4.	MCV (m/s)	-0,436	***	-0,218	n.s.s.
5.	SCV (m/s)	-0,052	n.s.s.	0,032	n.s.s.
6.	SMI	0,650	***	0,480	***
7.	RL	-0,533	***	-0,516	***

TABLE 4. Pearson correlation coefficient between terminal latency index and other parameters

CTS=carpal tunnel syndrome; DML=distal motor latency; DD=distal distance; MCV=motor conduction latency; SCV=sensory conduction latency; SMI=sensory-motor index; RL=residual latency; N=number; r=correlation coefficient; p=n.s.s.-not statistically significant; *<0,05; **<0,01; ***<0,001

N	Parameter	CTS (r) N=67	P	Control (r) N=57	P
1.	Age (yrs)	0,130	n.s.s.	0,227	n.s.s.
2.	DML (ms)	0,970	***	0,949	***
3.	DD (cm)	0,235	n.s.s.	0,076	n.s.s.
4.	MCV (m/s)	-0,436	***	0,349	**
5.	SCV (m/s)	-0,324	**	-0,329	*
6.	SMI	-0,759	***	-0,905	***
7.	TLI	-0,533	***	-0,516	***

TABLE 5. Pearson correlation coefficient between residual latency and other parameters

CTS=carpal tunnel syndrome; DML=distal motor latency; DD=distal distance; MCV=motor conduction latency; SCV=sensory conduction latency; SMI=sensory-motor index; TLI=terminal latency index; N=number; r=correlation coefficient; p=n.s.s.-not statistically significant; *<0,05; **<0,01; ***<0,001

Discussion

We registered the SMI mean value of 13±0,37 in patients with CTS, in range from 1,42 to 3,15 and from 3,45±0,45 in control subjects, with range from 2,82 to 4,52. All patients with CTS had SMI value up to 2,72 except one (1/60 individuals, 1,67%; l/67 nerves, 1,49%) who had a normal SMI value (3,15). This patient had selective affection of NM motor axons in carpal tunnel, with prolonged DML (5 ms), reduced NM MCV (39,7 m/s) and normal NM SCV-D2 value (69,5 m/s). EMG finding in thenar muscles of this patient indicated neurogenic lesion and EMG finding in other hand and arm muscles (hypothenar, m.extensor digitorum communis, and m.triceps brachii) was normal. This is the only false negative result at patients with CTS in this study, and the rate of SMI sensitivity in CTS was 98,51%. The rate of specificity couldn't be calculated because we first tried to define 2,82 as lower limit of normal SMI value. In recent study the frequency of exclusive electrophysiological motor involvement in CTS was rare, 1,2% (31/2727 hands) and it would be related to preferential compression of the intraneural motor fascicles clumped superficially in the most volar-radial nerve quadrant or, more likely, to the fact that the recurrent thenar branch may exit the carpal tunnel through a separate ligamentous tunnel within the transverse carpal ligament where it might be preferentially or selectively compressed (5). In one earlier study, transligamental position of NM motor branch for thenar muscles, which penetrate retinaculum flexorum, was registered in 26% no selected cases in autopsy and 50% patients with CTS during chirurgical exploration and this anatomical variation could be important in patients with CTS (17). SMI is not dependent on age and DD value in patients with CTS and control subjects and this is the advantage of this parameter. We registered the TLI mean value of 0,27±0,06 in patients with CTS, in range from 0,16 to 0,38, and 0,39±0,13 in control subjects, in range 0,29 to 0,61. Other authors (127) in 83 patients with CTS registered TLI mean value of 0,24±0,05 with maximum value 0,33 and in control subjects 0,44±0,04, in range 0,36-0,54. But their control subjects were significantly younger than patients with CTS and that fact might have some influence on their results. We found that TLI value correlate with DML, DD and MCV values in patients with CTS and only with DML value in control subjects. Our results indicate that this parameter has good sensitivity (92,54%) in CTS, but relatively weak specificity rate (80,7%) in conditions when we didn't analyze TLI value of 0,34 as normal in group of patients with CTS, since four patients with CTS in our study had TLI value 0,34. If we accepted this value as normal, the specificity rate in patients with CTS would be 73,68% (15/57 false positive results). We recommend that TLI value 0,35 or higher should considered as normal, and that does not correspond with opinion that value of 0,34 or higher is considered normal for NM (12). The advantage of this parameter is low SD, but the main disadvantages are false negative and false positive results. We registered the RL mean value of 4,29±1,55 in patients with CTS, with range from 2,4 to 10,61 and 1,90±0,46 in control subjects, with range from 0,9 to 3,56. We found that this parameter had higher rate of sensitivity (98,51%) and specificity (89,47%) than TLI, but the same rate of sensitivity as SMI. RL had a larger SD than SMI in patients with CTS and control subjects. It is disadvantage of this parameters compared to SMI. SMI is parameter which could be determined in simply and fast way and it is very useful in making electrophysiological diagnosis in some cases and confirming the suspected clinical diagnosis of CTS.

Conclusion

1. Sensory-motor index (SMI) mean value in healthy subjects of control group was 3,45 (X±SD=3,45±0,45) with lower limit of normal value of 2,82, and in patients with carpal tunnel syndrome (CTS) was 2,13 (X±SD=2,13 ±0,37).
2. The sensitivity of SMI in patients with CTS was 98,51% and this is useful parameter in electroneurographical diagnosis of CTS.
3. In rare case (about 1%) of CTS with selective nervus medianus (NM) motor axons affection, SMI may have normal value, but distal motor latency is always prolonged in this cases.
4. SMI is not dependent on age and distal distance (DD) values.
5. SMI determination is especially important in cases with border or discrete abnormal values of other NM electrophysiological parameters, when SMI values can indicate incipient phase of CTS.

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