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ORIGINAL ARTICLE

Neurophysiological classification of the Carpal Tunnel Syndrome

Classificação neurofisiológica da Síndrome do Túnel do Carpo

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ABSTRACT

The aim of this study was to evaluate the clinical correlation of the neurophysiological scale of the Carpal Tunnel Syndrome (CTS). The hands were classified in 6 grades: minimum/grade 1 (comparative test / altered short segment, normal sensitive and motor conductions), mild/grade 2 (altered sensitive conduction, normal motor conduction), moderate/grade 3 (altered sensitive and motor conductions, normal sensitive amplitude), moderate/grade 4 (altered sensitive and motor conductions, low sensitive amplitude), severe/grade 5 (absent sensitive conduction, altered motor conduction) and extremely severe/grade 6 (absent sensitive and motor conductions). A prospective study was carried out in 400 hands with CTS. 56 hands (14%) were classified as grade 1,109 hands (27.3%) as grade 2, 129 hands (32.3%) as grade 3, 78 hands (19.5%) as grade 4, 22 hands (5.5%) as grade 5 and 6 hands (1.5%) as grade 6. There was a significant positive correlation ($p < 0.01$) between the neurophysiological scale of CTS and the patients' ages, the duration of CTS, the frequency of reported classical CTS history and the frequency of night pain symptoms, paresthesia and numbness. Additionally, there was a significant positive correlation between the neurophysiological scale and the frequency of Tinel`s sign, hypoesthesia on the 2nd digit, weakness and hypotrophy of the thenar muscles.

KEYWORDS

hand, carpal tunnel syndrome, electromyography

RESUMO

O objetivo deste trabalho foi avaliar a correlação clínica da escala neurofisiológica da Síndrome do Túnel do Carpo (STC). As mãos foram classificadas em 6 graus: mínimo/grau 1 (teste comparativo/segmento curto alterado, conduções sensitiva e motora normais), leve/grau 2 (condução sensitiva alterada, condução motora normal), moderada/grau 3 (conduções sensitiva e motora alteradas, amplitude sensitiva normal), moderada/grau 4 (conduções sensitiva e motora alteradas, amplitude sensitiva baixa), grave/grau 5 (condução sensitiva ausente, condução motora alterada) e extremo/grau 6 (conduções sensitiva e motora ausentes). Foi realizado um estudo prospectivo em 400 mãos com STC. Foram classificadas 56 mãos (14,0%) como grau 1, 109 mãos (27,3%) como grau 2, 129 mãos (32,3%) como grau 3, 78 mãos (19,5%) como grau 4, 22 mãos (5,5%) como grau 5 e 6 mãos (1,5%) como grau 6. Houve uma correlação positiva significativa ($p<0,01$) da escala neurofisiológica da STC com a idade dos pacientes, o tempo de duração da STC, a freqüência de relato de história clássica de STC e a freqüência dos sintomas dor noturna, parestesia e dormência. Também houve uma correlação positiva significativa entre a freqüência do sinal de Tinel, hipoestesia no 2° dedo, fraqueza e hipotrofia dos músculos tenares com a escala neurofisiológica da STC.

PALAVRAS-CHAVE

mão, síndrome do túnel carpal, eletromiografia

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INTRODUCTION

The carpal tunnel syndrome (CTS) consists in the compression of the median nerve at the level of carpal tunnel and it is the most frequent mononeuropathy of the upper limbs.[1,2,3]

The electroneuromyography, in addition to being the main test for the diagnosis of this neuropathy, is essential to perform the differential diagnosis of other neuromuscular pathologies and to indicate the degree of CTS severity (3).

In the last years, several studies have been published with the neurophysiological classifications of CTS intensity.[1,2,4] However, to date, there is no universally standardized neurophysiological classification for the CTS.[4,5]

The objective of the present study is to evaluate the clinical correlation of the Neurophysiological Scale of the CTS standardized at our Service of Electroneuromyography.

MATERIALS AND METHODS

Patients

An electroneuromiographer (Viking Quest 9.0 Viasys/Nicolet) was used in this study by the same examiner. All examinations were carried out bilaterally. The study of sensitive conduction was performed according to the techniques recommended by the American Association of Electrodiagnostic Medicine (AAEM), with the monitored skin surface temperature always higher than 32°C.[6,7]

The sensitive responses were antidromic, with percutaneous electrical stimulation on the wrist and uptake with a surface claw electrode at a fixed distance of 14 cm on the 2nd digit for the median nerve and on the 5th digit for the ulnar nerve. We also performed the study of antidromic sensitive conduction of the median nerve in the palm-wrist segment with percutaneous electric stimulation in the palmar region at a fixed distance of 7 cm of the electrode uptake on the 2nd digit. The motor responses were obtained with supramaximum stimuli on the wrist and the elbow, at a fixed distance of 7 cm between the stimulation spot in the wrist and the surface uptake bar electrode on the thenar eminence muscles for the median nerve and on the hypothenar muscles for the ulnar nerve.

The muscle study with concentric needle electrode was carried out in the following muscles: short thumb abductor, 1st dorsal interosseous muscle and round pronator muscle, with the objective of ruling out radiculopathy and peripheral polyneuropathy at the differential diagnosis. The uptake of spontaneous myoelectrical activities (fibrillations or positive waves) at the resting phase or the uptake of large-amplitude, long-term and polyphasic voluntary myoelectrical potentials during the slight contraction of the short thumb abductor was considered a sign of muscular denervation. The filters used were 2-10KHz for sensitive conduction and 20-10KHz for the motor conduction and muscle study.

The following neurophysiological parameters of the median nerve were evaluated: 1) palm-wrist segment sensitive velocity (PWV) in the palm-wrist sensibilization test; 2) sensitive conduction velocity (SCV) and peak-to-peak range of the sensitive potential range (SPR) in the wrist-digit sensitive conduction; distal motor latency (DML) and peak-to-peak compound motor potential range (CMPR) in the motor conduction and 4) electromyographic study of the short abductor of thumb (EMG SAT).

The diagnosis of the CTS was established when the sensitive and motor conductions of the ulnar nerves were normal and the studies of nervous conduction of the median nerve were altered according to our abnormality range: PWV < 50.0 m/s; SCV < 50.0 m/s and 3) DML > 4.0 ms.

Neurophysiological Scale of the Carpal Tunnel Syndrome

The neurophysiological scale used in our Service divides the CTS cases in six grades of intensity, according to the neurophysiological findings of the median nerve: 1) Minimum (Grade 1): altered sensibilization test, normal sensitive and motor conduction, normal EMG SAT; 2) Mild (Grade 2): altered sensibilization test and sensitive conduction, normal motor conduction, normal EMG SAT; 3) Moderate (Grade 3): altered sensitive and motor conductions, normal sensitive range, normal EMG SAT or with signs of denervation; 4) Moderate (Grade 4): altered sensitive and motor conductions, decreased sensitive range, EMG SAT with signs of denervation; 5) Severe (Grade 5): absent sensitive conduction, altered motor conduction, EMG SAT with signs of denervation; and 6) Extreme (Grade 6): absent sensitive and motor conduction, EMG SAT with signs of denervation (Table 1).

Our criteria used to consider the sensitive potential range (SPR) of the median nerve as low-range were: 1) in the cases of unilateral CTS, range < 50% of the SPR of the contralateral median nerve or 2) in cases of bilateral CTS, range < 50% of the SPR of the ulnar nerve of the same hand.

Clinical Assessment

The clinical assessment of the patients was performed before the electromyographic study with the objective of preventing interference in the results. The patients reported whether they presented pain that worsened at night, paresthesia (shock or tingling sensation) and numbness (loss of tactile sensation) in the hand and the duration of these symptoms.

The examiner filled out a questionnaire if the clinical history reported by the patient was considered as being a classic one for CTS, according to the criteria of epidemiological classification of CTS (3): presence of specific symptoms (pain that worsens at night, numbness and paresthesia) on the 1st, 2nd, 3rd or 4th digits; the involvement of the entire hand is acceptable; symptom worsening at night and after repetitive movements of the hand or wrist, which is relieved by change in posture or by shaking the hands.

At the physical examination, we observed the presence of Tinel's sign in the wrist, tactile hypoesthesia to the cotton on the 2nd digit, thumb abduction weakness and hypotrophy of the thenar eminence. The evaluation of symptoms, of the clinical history an the physical examination were carried out for each hand, separately.

The clinical assessment of the grades in the neurophysiological scale of CTS was carried out in each hand, separately, and not in each patient, in order to rule out the effect of healthy hands on the assessment of symptom severity.[5]

Statistical Analysis

The statistical analysis was carried out by the SPSS program, version 11.0.1. The Kolmogorov-Smirnov Test was used to assess whether the distribution differed from the normal curve. In cases of parametric numerical variables, the means and standard deviations (SD) were used. The correlation between data was carried out by Pearson's correlation and group comparison was carried out by Student's t test. For the non-parametric variables, means and SD were used and data correlation was performed by Spearman's correlation coefficient; the correlation between groups was performed by Mann-Whitney's U Test.

RESULTS

Of the 219 studied patients, CTS was bilateral in 181 of them (82.6%) and unilateral in 38 patients (17.4%); 189 patients were females (86.3%) and 30 were males (13.7%). Mean age was 51.0 (+ 107) years. Of the 400 hands with CTS studied, 56 hands (14.0%) were classified as Grade 1, 109 hands (27.3%) as Grade 2, 129 hands (32.3%) as Grade 3, 78 hands (19.5%) as Grade 4, 22 hands (5.5%) as Grade 5 and 6 hands (1.5%) as Grade 6.

The sample distribution was similar to the normal one for age and different for the other parameters analyzed by the Kolmogorov-Smirnov test. The clinical and neurological findings of the hands with CTS with the different grades of intensity are presented in Tables 2 and 3, respectively.

The classic history of CTS was reported by 68.3% of the studied hands. Paresthesia was the most frequent symptom (83.25%) followed by numbness (73.25%) and pain that worsens at night (59.25%). The report of the classic history of the CTS and the presence of the all the analyzed symptoms had a significant positive correlation ($p<0.01$) with the grades of the neurophysiological scale, i.e., the frequency of the symptoms and the classic history of the CTS increased in accordance with the CTS grade. There was also a significant positive correlation ($p<0.01$) between age and the time of evolution of the CTS in relation to the neurophysiological scale (Table 2).

Tinel's sign was the most often observed sign at the physical examination of the hands with CTS (41.0%), followed by tactile hypoesthesia on the 2nd digit (38.0%), weakness in the thumb abductor (23.5%) and hypotrophy of the thenar eminence (11.0%). We also observed a significant positive correlation between the neurophysiological scale of the CTS and the presence of Tinel's sign ($p<0.05$), tactile hypoesthesia on the 2nd digit, weakness in the thumb abductor and hypotrophy of the thenar eminence ($p<0.01$), i.e., the higher the CTS grade, the higher the number of symptoms at the physical examination (Table 2).

Regarding the neurophysiological parameters, there was a fairly significant positive correlation ($p<0.01$) of the distal motor latency of the median nerve and the presence of denervation signs in the short abductor of the thumb in relation to the neurophysiological scale. There was a significant negative correlation ($p<0.01$) of the palm-wrist and wrist-digit sensitive velocities of the median nerve and the sensitive and motor potential ranges of the median nerve in relation to the neurophysiological scale of the CTS (Table 3).

DISCUSSION

The quantification of the intensity of the CTS is a crucial step in the electrodiagnosis procedure and it is important for defining prognosis and therapeutic measures.[1,8] However, a universally accepted neurophysiological scale is yet to be designed.[4,5] In 1997, Pádua et al and Stevens published their intensity scales separately, based on the following neurophysiological progression of the CTS: 1) abnormality of comparative and/or segmental tests; 2) slowing of the sensitive conduction in the wrist-digit segment; 3) increase in the distal motor latency; 4) decrease and disappearance of sensitive potentials; 5) decrease and disappearance of motor potentials.[1,2]

The criteria of grade division of the neurophysiological scale of the CTS are simple, based on clear and objective neurophysiological ranges (normal/abnormal nervous conduction, presence/absence of evoked potentials), being easily adapted at any laboratory, regardless of the normal range values standardized at each service of electromyography.

Our neurophysiological scale is very similar to that by Pádua et al1: we separated the hands classified as moderate CTS from the Pádua et al1 scale according to the normality or not of the amplitude of the SPR in the median nerves, which constituted the grades 3 and 4 of our scale, respectively. The reason for this modification was that most hands with CTS (51.8%) are classified as moderate degree and in this class of hands, those that presented low-range SPR in the median nerves had more marked symptoms and higher sensitive and distal motor latencies of these nerves than in those with normal sensitive ranges. However, the SPR of the median nerves must not be evaluated alone and it must be analyzed together with the other neurophysiological parameters.[2]

In our neurophysiological scale we also report the findings of electromyography of the short abductor of the thumb (EMG SAT), which was not performed at the Pádua et al scale.[1] The EMG SAT is less sensitive than the study of the nervous conductions for the diagnosis of CTS, but it is important in the differential diagnosis with other neuromuscular diseases and provides data on axonal degeneration of the median nerve that affects the thenar muscles (2,9). The EMG SAT is generally normal in mild cases of CTS. In moderate (grade 4), severe (grade 5) and extreme (grade 6) cases, signs of denervation can be observed in the EMG SAT. In moderate cases (grade 3), there can be or not signs of denervation at the EMG SAT.

In our study, we observed that 189 patients (47.2%) with CTS presented signs of denervation at the EMG SAT. All the hands with grade 5 and 6 and 76 hands (97.4%) of grade 4 hands had signs of denervation at the EMG SAT.

Two grade-4 hands (2.6%) did not have signs of denervation at the EMG SAT. One grade-1 hand (1.7%) and 2 grade-2 hands presented signs of chronic remodeling of the motor units at the EMG SAT. In these cases, we considered only the nervous conduction findings to classify them in the neurophysiological scale.

All the neurophysiological parameters of the median nerves that

Table 1
Neurophysiological Carpal Tunnel Syndrome scale

GRAU DA STC		NEUROPHYSIOLOGICAL PARAMETER				
		SENSITIVITY TEST	WRIST-DIGIT SENSITIVE VELOCITY	DISTAL MOTOR LATENCY	SENSITIVE POTENTIAL RANGE	ELECTROMYOGRAPHIC STUDY OF SHORT ABDUCTOR OF THUMB
NORMAL	G0	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
MÍNIMO	G1	ALTERED	NORMAL	NORMAL	NORMAL	NORMAL
LEVE	G2	ALTERED	DECREASED	NORMAL	NORMAL	NORMAL
MODERADO	G3	ALTERED	DECREASED	INCREASED	NORMAL	NORMAL OR DENERVATION
	G4	ALTERAD	DECREASED	INCREASED	DECREASED	DENERVATION
GRAVE	G5	ALTERED OR #	#	INCREASED	ABSENT	DENERVATION
EXTREMO	G6	ALTERED OR #	#	#	ABSENT	DENERVATION

Non-measureable due to absence of uptake of nervous sensitive or motor action potential.

Table 2
Index of correlation between the clinical findings and CTS degrees.

VARIABLE	Total	G1	G2	G3	G4	G5	G6	Pearson (r)	Spearman	P
Hands	400	56	109	129	78	22	6	-	-	-
n (%)	(100%)	(14,0%)	(27,3%)	(32,3%)	(19,5%)	(5,5%)	(1,5)			
Age (yrs)	50.9	48,9	50,2	50,5	52,1	57,1	53,1	0,14	-	<0,01
mean (+SD)	(±10.6)	(±7,9)	(±11,3)	(±9,3)	(±12,5)	(±10,8)	(±10,4)			
Time of evolution (months)	24.6 (±38.3)	16,3	16,5	23,7	33,7	49,0	60,0	-	0,18	<0,01
Mean (+SD)	237	(±18,3)	(±22,5)	(±33,4)	(±49,8)	(±69,6)	(±90,7)			
Nocturnal Pain	(59.2%)	23	52	75	62	21	4	-	0,30	<0,01
n (%)	293	(41,0%)	(47,7%)	(58,1%)	(79,4%)	(95,4%)	(66,6%)			
Numbness	(73.2)	31	66	99	69	22	6	-	0,31	<0,01
n (%)	333 (83.2%)	(55,3%)	(60,5%)	(76,7%)	(88,4%)	(100,0%)	(100,0%)			
Paresthesia	273	42	85	111	70	21	4	-	0,14	<0,01
n (%)	(68.3%)	(75,0%)	(77,9%)	(86,0%)	(89,7%)	(96,4%)	(66,6%)			
Classic history	164 (41.0%)	24	61	95	66	21	6	-	0,34	<0,01
n (%)	152 (38.0%)	(42,8%)	(55,9%)	(73,6%)	(84,6%)	(95,4%)	(100,0%)			
Positive Tinel	94 (23.5%)	27	30	52	37	13	5	-	0,11	<0,05
n (%)	44	(48,2%)	(27,5%)	(40,3%)	(47,4%)	(59,0%)	(83,3%)			
Hypoesthesia in the 2nd digit	(11.0%)	19	31	45	37	14	6	-	0,18	<0,01
n (%)		(33,9%)	(28,4%)	(34,8%)	(47,4%)	(63,6%)	(100,0%)			
Weakness of thumb abduction		3	7	30	33	15	6	-	0,43	<0,01
n (%)		(5,3%)	(6,4%)	(23,2%)	(42,3%)	(68,1%)	(100,0%)			
Hypotrophy of thenar eminence		1	2	10	17	9	5	-	0,35	<0,01
n (%)		(1,7%)	(1,8%)	(7,7%)	(21,7%)	(40,9%)	(83,3%)			

SD= standard deviation

Table 3
Index of correlation between the neurophysiological findings and CTS degrees.

VARIABLE	Total	G1	G2	G3	G4	G5	G6	Spearman	P
PWV (m/s)	38,1	45,9	41,3	36,8	26,6	-	-	- 0,79	<0,01
Mean (±SD)	(±7,3)	(±1,4)	(±4,0)	(±4,7)	(±5,1)				
SCV (m/s)	43,4	51,8	46,5	42,8	34,1	-	-	- 0,86	<0,01
Mean (±SD)	(±6,5)	(±1,5)	(±2,6)	(±3,5)	(±4,6)				
DML (ms)	4,4	3,4	3,6	4,4	5,5	7,2	-	+ 0,91	<0,01
Mean (±SD))	(±1,1)	(±0,2)	(±0,2)	(±0,3)	(±0,9)	(±1,5)			
SPR (µV)	28,9	42,9	37,9	30,8	13,7	-	-	- 0,67	<0,01
Mean (±SD)	(±18,7)	(±15,7)	(±19,5)	(±12,1)	(±7,3)				
CMPR (mV)	13,6	15,5	15,6	13,9	11,6	8,2	-	- 0,48	<0,01
Mean (±SD)	(±4,7)	(±4,1)	(±4,1)	(±4,2)	(±3,7)	(±3,5)			
STAM DS n	189	1	2	82	76	22	6	+ 0,78	<0,01
(%)	(47,2%)	(1,7%)	(1,8%)	(63,5%)	(97,4%)	(100,0%)	(100,0%)		

SD= standard deviation; PWV = Palm-wrist sensitive velocity; SCV=wrist-digit sensitive conduction velocity; DML=distal motor latency; SPR= sensitive potential range; CMPR= compound motor potential range; STAM DS= short thumb abductor muscle denervation signs.

were studied (palm-wrist sensitive velocity, wrist-digit sensitive conduction velocity, distal motor latency, sensitive potential range and sensitive and motor range) of patients with CTS present a fairly significant correlation ($p<0.01$) among them and with the grades of our neurophysiological scale. This indicates a high probability of establishing a reliable diagnosis of CTS when all these neurophysiological parameters are analyzed together.

Of all the neurophysiological parameters, the motor range of the median nerve was the one that presented the smallest correlation with the CTS grades, which was also demonstrated by You et al.5 The motor range of the median nerves is the neurophysiological parameter that is least altered in the CTS grades, with normal mean values in grades 1 to 5. Thus, we consider of little use to consider the motor range of the median nerve as a criterion of classification of the neurophysiological scale.

The clinical assessment of patients with CTS poses a problem, as the CTS is often associated to other tendinal-articular pathologies that present similar signs and symptoms and can mislead the diagnosis.7 You et al carried out an interesting study by observing the association of the symptoms with the CTS and found that the symptoms that presented nocturnal worsening, paresthesia and numbness had a higher correlation and were more specific for CTS (primary symptoms) than other, less specific, symptoms such as edema, weakness or motor incoordination (secondary symptoms).5 For this reason, we only assessed the primary symptoms in our study.

As the grade of CTS increases, the report of the classic history of CTS becomes more frequent. We found a tendency toward the increase in pain frequency that worsens at night, paresthesia and numbness in the hands that increases together with the CTS intensity.

Other authors also observed a significant correlation between the clinical and the neurophysiological findings.[1,4,10]

However, we observed that in grade 6, the pain frequency that worsens at night is lower than in grades 4 and 5 and that the frequency of paresthesia in grade 6 is the lowest among all other grades of CTS. A possible explanation for this finding is that in more advanced CTS (grade 6), only a few fine, sensitive fibers survive inside the fibrosed nervous fasciculus, which would justify a lower excitability of the sensitive fibers, causing fewer pain episodes and/or paresthesia and a higher incidence of sensitive deficit on the second digit and weakness and hypotrophy of the thenar eminence muscles.8 Another possible explanation would be an accommodation of the perception of pain and paresthesia in thse patients throughout the years, as in CTS grade 6, the time of evolution of the CTS is longer and the mean age of the patients is usually older than in the other grades of CTS.[9,11]

Tinel's sign in the wrist was the most sensitive sign at the physical examination, occurring in 41% of the hands with CTS. However, it is a little specific sign, which can be present in more than 20% of the hands with normal neurophysiological studies and can be associated to unspecific inflammatory pathologies of the wrist.[7,9] This might be the reason why the correlation of Tinel's sign with the neurophysiological scale was less significant ($p<0.05$) than the correlation with the other findings of the physical examination ($p<0.01$).

The mean age of the patient and of the time of evolution increased according to the grade of the CTS. Older patients tend to present higher tolerance to the symptoms and to accept them as a natural aging process, not seeking treatment at the earlier phase of the process.[11]

The association of another musculoskeletal pathology (tendinitis, arthritis) with the CTS is common and must be considered, mainly in those patients that present very striking and widespread

clinical symptoms, which are discordant with the grade shown by the neurophysiological scale.

The neurophysiological scale of the CTS, in addition to being practical and fast to use, is easily adaptable to any laboratory of electroneuromyography that follows the neurophysiological techniques recommended by the AAEM.[6,7] It provides a more accurate parameter of CTS intensity for the requesting physician, standardizes the criteria of classification in the Services of Electroneuromyography and helps the neurophysiological follow-up of these patients during the treatment.

CONCLUSION

The neurophysiological scale used in our Service presents a good correlation with the primary symptoms, the findings at the physical examination and the neurophysiological findings of CTS. The reporting of a classic history, the presence of primary symptoms (nocturnal pain, paresthesia and numbness) and the presence of sensitive and motor deficits at the physical examination are more frequent when the CTS is more severe. Patients with higher grades of CTS are older and have longer mean evolution time than those with milder degrees of CTS.

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