Relationship between clinical probability of carpal tunnel syndrome and neurophysiological studies

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Purpose. To determine the sensitivity and specificity of a series of clinical features and risk factors in carpal tunnel syndrome (CTS) and suggest a diagnostic measure to clinically estimate probability of disease.

Materials and methods. A prospective, cross-sectional study was performed of 100 patients consecutively referred to us for a neurophysiological evaluation of CTS. Patients were chronologically divided into two groups of 50 cases each (93 and 90 symptomatic hands respectively). Evaluation procedures included a clinical interview and physical examination to test for the classic signs of CTS, as well as comparative sensory peripheral median nerve conduction studies. The combined sensory index (CSI) was also determined and used as a reference tool to calculate the sensitivity and specificity of clinical features in the first group of patients and in the control group.

Results. Female gender, bilateral involvement and persistence of symptoms for 6 months or more were identified as risk factors. The pattern of critical clinical features associated with electrophysiological damage included numbness, nocturnal paresthesia and pain, symptoms in areas innervated by the median nerve, muscular weakness, positive Phalen maneuver or a positive Tinel's sign. On the basis of these results, we suggest a clinical model for estimating clinical probability prior to the electrophysiological test (PAT). A linear regression analysis found a significant association between PAT and CSI in the second group of patients (F[1.148] = 49.7; p < 0.000).

Conclusion. PAT can be considered useful as diagnostic measure of the clinical features of CTS.

Key words: *carpal tunnel syndrome, diagnosis, electrophysiology, neural conduction, signs, symptoms.*

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Relación entre probabilidad clínica de síndrome del túnel del carpo y estudios neurofisiológicos

Objetivos. Determinar la sensibilidad y la especificidad de los rasgos clínicos y los factores sociodemográficos en el síndrome del túnel carpiano (STC) y proponer una medida para estimar la probabilidad clínica de presentar la enfermedad.

Material y método. Se realizó un estudio prospectivo, descriptivo y transversal de 100 pacientes referidos para evaluación neurofisiológica de STC, divididos cronológicamente en dos grupos de 50 casos (93 y 90 manos sintomáticas, respectivamente). También fueron estudiados 30 sujetos sanos (60 manos asintomáticas). A todos se les realizó interrogatorio y examen físico, orientados al diagnóstico de STC, y estudios de conducción nerviosa periférica comparativos del nervio mediano; se determinó el índice sensorial combinado (ISC), el cual se utilizó como criterio de referencia para conocer la eficacia diagnóstica de los rasgos clínicos en el primer grupo de pacientes y en el grupo control.

Resultados. Se identificaron como factores sociodemográficos significativos: sexo femenino, tiempo de evolución de 6 meses o superior y afectación bilateral. Los rasgos clínicos de adormecimiento, dolor, parestesias nocturnas, localización de éstos en el territorio del nervio mediano, debilidad muscular, maniobra de Phalen o signo de Tinel positivos estuvieron significativamente asociados con alteraciones neurofisiológicas. A partir de estos resultados se propone la estimación de la probabilidad clínica anterior a la prueba diagnóstica (PAP). Un análisis de regresión lineal, efectuado en el segundo grupo de pacientes, mostró una asociación significativa entre PAP e ISC (F[1,148] = 49,7; p < 0,000).

Conclusiones. La PAP puede considerarse de utilidad como medida resumen de la presencia de rasgos clínicos significativos en el STC.

Palabras clave: *síndrome del túnel del carpo, diagnóstico, electrofisiología, conducción nerviosa, signos, síntomas.*

INTRODUCTION

The carpal tunnel syndrome (CTS) is produced by the compression of the median nerve in its passage through the carpal canal[1]. It is a highly frequent cause of numbness, pain and paresthesia in the hand, the forearm and, occasionally, the rest of the upper limb[1,2]. Despite the fact that it is a relatively trivial condition that improves with surgical treatment in 90% of the cases[3], its management is not always uncomplicated, due to the fact that some of the typical signs and symptoms may appear in other neuropathic and musculo-skeletal conditions of the upper limbs and the scapular waist [1,4,5].

In these cases, complementary testing consists in studies of peripheral median nerve conduction (NCS)[2,6]; however, the number of patients that are treated in the earlier stages of the condition is rising and this has increased the proportion of cases showing symptoms suggestive of CTS but with a negative NCS[7-12].

Attempts at increasing the sensitivity of NCS have been carried out by introducing median-ulnar and median-radial comparative studies[13,14]. Diagnosis is reached estimating the difference between the action potential of the sensitive nerve (APSN) that is obtained by means of palm and fourth finger stimulation in the case of the median and ulnar nerves, and with stimulation of the first finger in the case of the median and radial nerves. The total sum of the differences that are found in these studies has been termed combined sensory index (CSI), this being a summary measure that prevents technical errors and adds the effects caused by alterations of the studies[14].

Another interesting way of increasing NCS sensitivity consists in the use of normality limits that vary depending on clinical probability or prior to the complementary test (PAT) in cases presenting CTS[15]. In other words, when seeking to confirm the presence of this syndrome, neurophysiologists should not consider the same normality limits for patients with different PAT's, since a patient with a low clinical CTS probability requires more rigorous normality limits to confirm clinical suspicion. According to the Bayes theorem, the most probable clinical diagnosis is obtained through the deployment of sequential observations, medical history findings, patient's record, and physical test, diagnostic probability thus being assessed from the existing clinical features of the patient[16].

It is therefore necessary to know which of these features are more closely associated with electro-physiological alterations in order to reach a more adequate construal of NCS's, which entails the need to know how to assess PAT from clinical and socio-demographic features.

This work studies the diagnostic efficiency of a group of clinical features that were found in patients with slight to moderate CTS. On the basis of these results, a meas-ure is proposed for estimating clinical probability, or prior to complementary tests in cases presenting the condition.

MATERIALS AND METHODS

We carried out a prospective, cross-sectional and descriptive study on a sample group of 100 patients referred to the Electromyography Laboratory due to clinical suspicion of CTS, and on 30 healthy individuals (60 asymptomatic hands, 23 female and 7 male patients, between 26 and 61 years of age, with a median of 41.2 and a standard deviation of 9.49). The findings in the first 50 consecutive patients (group 1, formed by 93 symptomatic hands, 45 female and 5 male patients, between 19 and 72 years of age, with a median of 43.5 and a standard deviation of 10.6) enabled us to describe a group of significant clinical features and to suggest a measure for estimating individual probabilities of the disease that was later evaluated in the 50 remaining patients (group 2, formed by 90 symptomatic hands, 45 female and 5 male patients, between 17 and 68 years of age, with a median of 45.6 and a standard deviation of 10.9).

After being informed about its objectives and characteristics, all the individuals accepted the conditions of the study, which was in turn sanctioned by the Ethics Commission of the center. The exclusion criteria were the following: a record containing neurologic diseases; endocrinopathies or other diseases that affect peripheral nerves secondarily or that result from exposure to toxic substances, medicine or other drugs; trauma, fractures or surgical treatment of the upper limbs, or that prevent the register of APSN during NCS. The inclusion criteria for the healthy group were: no record of general or neurological diseases, negative clinical interview and physical examination and no habitual drug or toxic substance consumption.

All individuals underwent a clinico-neurophysiological evaluation of both hands that was guided to the CTS diagnosis, the results of which were registered on a form designed to this effect. We confirmed the existence of the following clinical features: pain, numbness, nocturnal or continuous paresthesia, and muscular weakness related to thumb abduction. We determined the region where these were situated by means of a hand diagram and we verified whether there was proximal irradiation to the rest of the upper limb.

We confirmed the existence of thenar and hypoesthetic area atrophy in the hand, we examined strength in the short abductor thumb muscle and we searched for the presence of Tinel's and Phalen's sign.

Before counting with the results of the clinical examination, we carried out the three comparative sensitive orthodromic NCS's: median-ulnar with palm stimulation of the fourth finger and median-radial with first finger stimulation; the total sum of the three latency differences enabled the determination of the CSI, following the methodology described by Robinson et al[13]. The values above 1.1 milliseconds (ms) were considered to be positive results for CTS.

The NCS's were performed at a room temperature of between 22 and 26° C, with a NEUROPACK MEM-3202 electromyograph. Register conditions were: filter cut-off frequency between 15 and 3,000 Hz, activated filter at 60 Hz, 1 ms/div analysis time and a 20 ÌV/div sensitivity. Stimulus duration was 0.1 ms, with a 2 Hz frequency and supramaximum intensity, which enabled us to obtain two reproducible curves after an average number of 32 rehearsals with each one.

For stimulation and register we used surface electrodes that were placed as is described by other authors[17,18]. Chlorided 1cm-diameter silver discs were used for the NCS's in the distal regions of the forearm. Sticking plaster and conducting paste were used to keep the discs in place, the plaster being previously cleansed with alcohol so as to guarantee impedance levels inferior to 512 ohm.

Clinical features were considered as binary variables. We used the X^2 test to compare the frequency of the general features (age and gender variables) in groups 1 and 2 and in the healthy group, with a signification level of ≤ 0.05. We carried out a variance analysis (ANOVA) to compare the mean age values in the three groups we studied. Once we had obtained the results for group 1 and for the healthy group, we worked out the percentages of symptomatic hands, sensitivity (the capacity to detect the actually ill patients), specificity (the capacity to discard the actually healthy individuals) and diagnostic precision (a measure that comprises the two measures just mentioned) of the different clinical features. We took the results of the CSI as reference criteria[19]. Taking into account the sensitivity,

specificity, and diagnostic precision values, we assigned relative values to the most significant clinical features and we suggested a model for estimating the clinical probability of the disease, which we used with group 2. In this second group, we carried out a lineal regression analysis with the aim of determining the association between the clinical affection represented by the PAT and the nervous damage defined electrophysiologically in the CSI.

RESULTS

Both in the two groups of patients as well as in the group of healthy individuals, there was a significant prevalence of the female gender (90%) over the male gender, with $X^2_{(1)}= 216$, $p < 0.000$; in the healthy group we found 76.6% of the female individuals, with $X^2_{(1)}= 36.2$, $p < 0.000$. Since all the individuals had been classified according to age into under or over 35, an X^2 analysis allowed us to conclude that in the three groups there was a predominance of individuals of over 35 years of age (group 1: 80%, $X^2_{(1)}= 121.5$, $p < 0.000$; group 2: 82%, $X^2_{(1)}= 57.9$, $p < 0.000$; healthy group: 70%, $X^2_{(1)}= 20.4$, $p < 0.000$). By carrying out an ANOVA to compare the mean age values of the three groups we obtained a Fisher statistical result F of 1.71, with a p=0.18, not finding any significant differences in the mean age values. There was a pathological elevation of the CSI in more than 50% of the patients in both groups, with mean values of 1.91 and 1.8 ms, respectively; the mean CSI value in the healthy group was 0.59 ms.
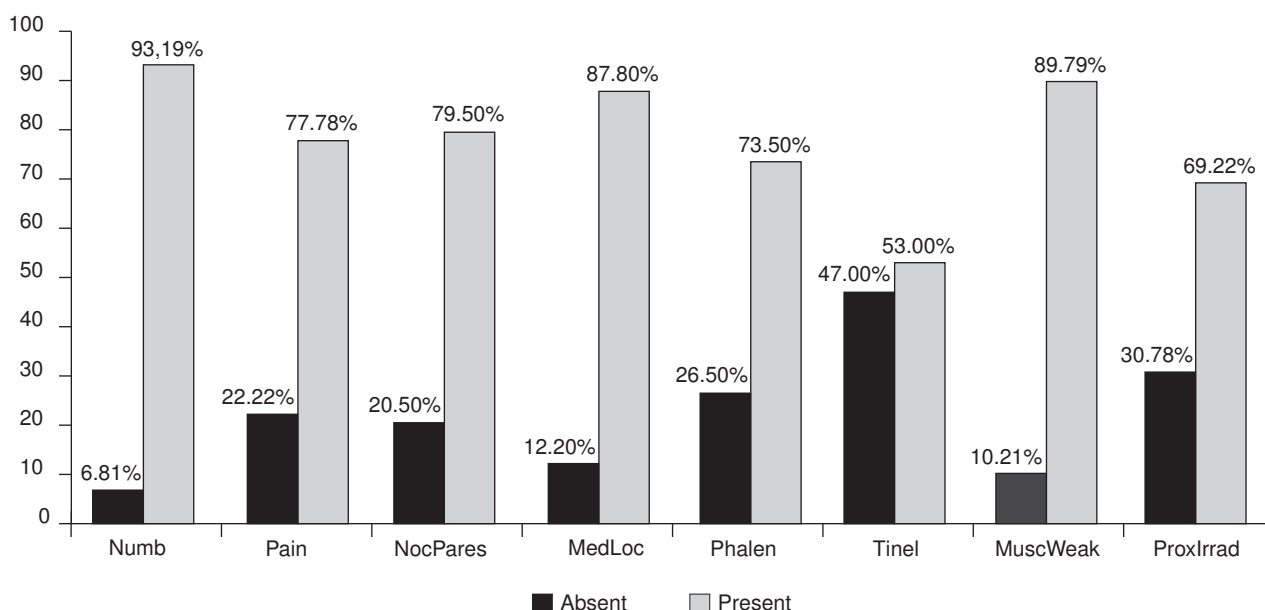

Figure 1. *Presence of clinical features in cases with positive combined sensory index; note that the highest percentages correspond to the features numbness, muscular weakness and localization. Numb: numbness; MuscWeak: muscular weakness on thumb abduction during physical examination; ProxIrrad: proximal irradiation; MedLoc: localization in areas innervated by median nerve; NocPares: nocturnal paresthesia.*

Table 1. Diagnostic efficiency of the different clinical features according to profile

Sensitive profile	Sensitivity %	Specificity %	Diagnostic accuract %
Numbness and previous			
Med-Loc	85.7	71.1	77.1
and NocPares	73.0	76.6	75.1
Pain and previous	69.8	80	75.8
Previous			
and Prox Irrad	53.9	85.5	73.1
Motor profile			
SubjWeak &	66.6	77.7	73.2
MuscWeak*			
Subj Weak or			
Musc Weak**	88.8	62.2	73.2
Sensitive and Motor			
Phalen Maneuver	68.2	83.5	77.5
Sensitive and Motor			
Tinel's Sign	52.3	88.6	74.3
Sociodemographic			
Age > 35 years	74.6	42.2	55
Female gender	93	79	85
Evolution time			
Over 3 months	84.2	67.7	74
Over 6 months	75.4	74.1	74.6
Over 1 year	54.3	80.6	70.6
Bilateral involvement	90	70	78

Subj Weak: subjective weakness; Musc Weak: muscular weakness on thumb abduction during physical test; Prox Irrad: proximal irradiation; Med-Loc: localization in areas innervated by median nerve; NocPares: nocturnal paresthesia. *Considered positive if both features are present.**Considered positive when one of the features is present.

The following data arose from the evaluation of the 50 patients in the second group and of the 30 healthy individuals. We found sensitivity values over 70% for numbness (93.6%), pain (84.1%), nocturnal paresthesia (77.7%), localization of sensitive symptoms in the innervations areas of the median nerve (85.7%), as well as for muscular weakness on thumb abduction (85.7%), and Phalen maneuver (77.7%). Specificity was over 70% only for localization (71.2%), pain (72.6%), Phalen maneuver (75.7%) and Tinel's sign (85.1%), for which sensitivity was 60.3%. Although the remaining features (proximal irradiation, hypoesthesia, continuous paresthesia and thenar atrophy) had specificity values over 70%, they presented a notably inferior sensitivity as a result of which they were considered to be less useful for the diagnosis of the disease in the early stages. Figure 1 shows the percentages for the various clinical features in patients with a positive CSI; numbness, muscular weakness and the localization of symptoms in the areas innervated by the median nerve were found in more than 80% of the hands that were evaluated, which were later found to be electrophysiologically positive.

Clinical features were grouped according to sensitive and motor profile, clinical maneuvers and sociodemographic factors with the aim of estimating their relative value in the PAT quantification (Table 1). The profile of the sensitive symptoms of numbness, nocturnal paresthesia and localization in median nerve area was the one that presented the highest diagnostic efficiency; the proximal irradiation feature reduces the sensitivity and diagnostic precision of the group when it is included. Phalen maneuver and Tinel's sign had a diagnostic precision over 70%, with a higher sensitivity for the former and higher specificity for the latter.

In Table 2 we suggest the criteria for estimating PAT in cases presenting the disease, according to assignation and eventual adding up of values. In order to obtain the optimal limit that defines a patient as clinically positive for CTS, we worked out sensitivity, specificity and the diagnostic precision of each one of the PAT values obtained in the first group of patients. Results suggest considering positive the values over 0.6.

When these criteria were applied to the second group of patients, 72 out of 90 symptomatic hands (80%) were identified as positive; we found a sensitivity value of 88%, a specificity value of 72% and a diagnostic precision of 79% for the suggested clinical model and with respect to CSI. In the second group of patients we found a coincidence between clinical and electrophysiological affection

Table 2. Suggested criteria for estimating clinical probability prior to electrodiagnostic test

Clinical Factors	Score
Presence of dysesthesia (numbness, nocturnal paresthesia or pain) localized in the area innervated by the median nerve. Whole	0.4
hand may be affected	0.4
Subjective muscular weakness or muscular weakness on thumb abduction	0.2
Phalen maneuver or Tinel's sign, or both positive	0.2
Sociodemographic factors	
Referred bilateral affection, may be asymmetric	0.1
Female gender	0.05
Six-month or longer evolution	0.05
Discordance factors	
Possibility of alternative diagnoses (peripheric polyneuropathy, cervical radiculopathy, thoracic outlet syndrome)	–0.25
Exclusive location of symptoms in area innervated by ulnar nerve (only fourth and fifth fingers)	–0.25

in 67.3% of the cases. None of the healthy individuals was positive.

The lineal regression analysis of the PAT and CSI variables showed a significant lineal association between the two $(F(1,148) = 49.7; p < 0.000;$ fig. 2).

DISCUSSION

Our observations regarding sociodemographic characteristics coincide with those of other authors who refer a higher incidence of CTS in the female gender and in individuals of over 40 years of age[9,10,20].

These results prove the hypothesis of bilateral involvement occurring in most patients, an assumption that was undefined in previous studies[10,11,20,21]. Our results confirm the hypothesis suggested by Bland[2] to the effect that idiopathic CTS is predominantly bilateral, though it may appear with unequal severity in both hands[9].

Other authors have described the presence of sensitive and nocturnal symptoms in 76.8% of their cases[10,11,12]. The symptomatic triad numbness-pain-nocturnal paresthesia, localized in the areas innervated by the median nerve, could be considered to be critical in the clinical diagnosis of CTS. The topographic pattern is especially significant due to its clearly neuropathic character, since the musculo-skeletal symptoms appear more diffusely distributed over the whole of the upper limb[11]. The features that are suggestive of a dysfunction of the motor fibres showed a diagnostic precision of 73.2%, and were therefore regarded as useful diagnostic items. The diagnostic efficiency of the Phalen and Tinel signs has been studied previously[10,16,22]. Sensitivity has been reported to range between 42 and 85% for the former and between 38 and 100% for the latter. Specificity varies between 54 and 98%, and between 55 and 100%, respectively[10,16,22].

In this study we find sensitivity and specificity values of 73 and 75.7% for the Phalen maneuver, and of 60.3 and 85.1% for Tinel's sign, the latter, then, being found to be less sensitive but more specific. Both signs are, therefore, deemed useful in the clinical diagnosis of CTS. Proximal irradiation is a feature that is also found in other affections of the upper limbs and, as such, is not considered critical for our diagnosis.

The significance of clinical features and of sociodemographic factors in CTS has been widely studied[9,11]. We do not know of any other clinical approach that may have attempted to quantify the significance of the various symptoms and signs and to group them together with sociodemographic factors. The values we observed for sensitivity(88%), specificity (66.6%) and diagnostic precision (75.8%), though far from being ideal, are slightly above the values referred by other authors[9,12] and might be influenced by the use of electrophysiological results as reference crite-
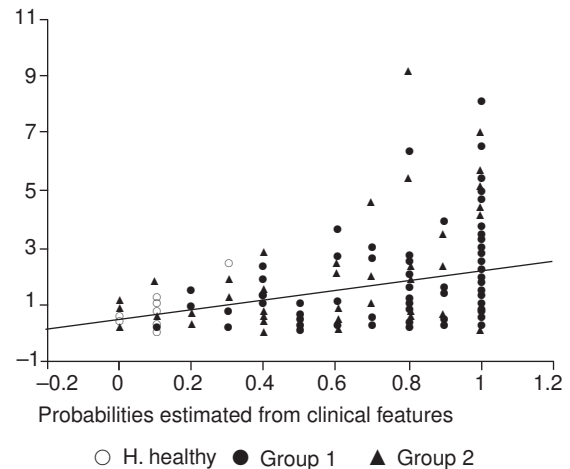

Figure 2. Lewis-dot diagram showing relationship between clinical probability prior to diagnostic test (PAT) and combined sensory index (CSI) in the total number of individuals studied. Note that the tendency is not completely lineal, there being several cases with high PAT's and low CSI's, which is related to the low sensitivity of the nervous conduction studies (NCS). I: individuals.

rion. One of its drawbacks is the fact that it is specific for the diagnosis of CTS and it does not take into account as risk factors anthropomorphic characteristics such as body mass or carpal anatomy, both of which have also been identified as relevant[21,23].

In conclusion, the identification of a pattern of critical features, allowed us to estimate the clinical probability of CTS, which is significantly associated with electrophysiological alterations.

The pattern includes the presence of numbness, pain, nocturnal paresthesia, localization of these symptoms in the median nerve territory, muscular weakness on thumb abduction, and positive Phalen maneuver or Tinel's sign. We additionally identified such significant risk factors as female gender, evolution time of 6 months or more and bilateral involvement. Further research is necessary so that the diagnostic range of the clinical measure suggested here can be both validated and improved.

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Conflict of interests

The authors have declared that they have no conflict of interests.