Suspected carpal tunnel syndrome

Do nerve conduction study results and symptoms match?

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ABSTRACT

OBJECTIVE To evaluate the diagnostic utility of nerve conduction studies (NCSs) by examining a population with a high pretest probability of carpal tunnel syndrome (CTS), including bilaterally and unilaterally symptomatic patients.

DESIGN Comparison of the results of NCSs with the results of prospective, pre-NCS, self-administered questionnaires of patients with clinical diagnoses of CTS referred for confirmatory NCSs.

SETTING A tertiary care hospital neuro-electrophysiology laboratory.

PARTICIPANTS The study population consisted of 211 patients, 156 (73.9%) of whom were female. Population mean (range) age was 46.7 (21 to 88) years. Mean (range) symptom duration was 29.3 (1 to 300) months.

MAIN OUTCOME MEASURES Patient-reported symptom localization and NCS results.

RESULTS Results of NCSs were normal in 83 (39.3%) patients, were consistent with CTS in 121 (57.3%) patients, and suggested non-CTS abnormalities in 7 (3.3%) patients. Bilateral symptoms were reported by 139 (65.9%) patients, and isolated unilateral symptoms were reported by 72 (34.1%) patients. Those reporting bilateral symptoms had the highest agreement with NCS results at 38.8%. Unilateral NCS abnormalities were seen in 18.0% of those reporting bilateral hand symptoms. Discordant findings, either bilateral or opposite-side neuropathies, were seen in 25.6% of those reporting isolated right-sided symptoms, and in 55.2% of those reporting isolated left-sided symptoms. Based on these data the sensitivity of the NCS results was 49.1%, with a specificity of 62.5%. The positive predictive value was 86.4%, and the negative predictive value was 20.2%. Overall accuracy was 51.4%. Likelihood ratios were 1.3 with positive results, and 0.8 with negative results.

CONCLUSION In our study population NCS results did little to alter the pretest probability of CTS. Physicians using NCSs for verification of clinical diagnosis should be aware of potential limitations.

EDITOR'S KEY POINTS

- Although carpal tunnel syndrome is the most common compressive neuropathy, there is no clear-cut consensus on the best diagnostic criteria for it.
- Nerve conduction study results do not substantially modify the pretest probability of carpal tunnel syndrome in patients referred for confirmatory studies.

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Syndrome du tunnel carpien suspecté

Y a-t-il correspondance entre les symptômes et les résultats des études de conduction nerveuse?

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RÉSUMÉ

OBJECTIF Déterminer si les études de conduction nerveuse (ÉCN) sont utiles au diagnostic par l'examen sujets présentant une forte probabilité de syndrome du tunnel carpien (STC), y compris des patients présentant des symptômes uni-et bilatéraux.

TYPE D'ÉTUDE Comparaison des résultats des ÉCN avec ceux d'un questionnaire prospectif auto-administré, antérieur à l'ÉCN pour des patients soumis à cet examen pour confirmer un diagnostic clinique de STC.

CONTEXTE Le laboratoire de neurophysiologie d'un hôpital de soins tertiaires.

PARTICIPANTS La population à l'étude comprenait 211 patients, dont 156 femmes (73,9%). Les sujets avaient entre 21 et 88 ans (moyenne=46,7). La durée moyenne des symptômes était de 29,3 mois (entre 1 et 300).

PRINCIPAUX PARAMÈTRES À LÉTUDE Localisation des symptômes rapportés par les patients et résultats des ÉCN.

RÉSULTATS Les ÉCN étaient normaux chez 83 patients (39,3%), étaient compatibles avec un STC chez 121 patients (57,3%) et suggéraient des anomalies non-STC dans 7 cas (3,3%). Parmi les patients, 139 (65,9%) disaient avoir des problèmes bilatéraux et 72 (34,1%), des symptômes unilatéraux. La plus forte concordance avec les résultats de l'ÉCN (38,8%) était observée chez ceux ayant des symptômes bilatéraux. Des anomalies unilatérales ont été trouvées chez 18,0% de ceux qui mentionnaient des problèmes aux 2 mains. Des résultats discordants, notamment des neuropathies bilatérales ou controlatérales, ont été observées chez 25,6% de ceux disant avoir des symptômes à droite seulement et chez 55,2% de ceux disant en avoir seulement à gauche. D'après ces données, la sensibilité de l'ÉCN était de 49,1% et sa spécificité, de 62,5%. La valeur prédictive positive était de 86,4% et la valeur prédictive négative, de 20,2%. La précision globale était de 51,4%. Le rapport de probabilité était de 1,3 pour les résultats positifs et de 0,8 pour les négatifs.

CONCLUSION Chez les sujets de cette étude, les résultats des ÉCN n'ont pas beaucoup changé la probabilité de STC qui existait avant l'examen. Les médecins qui demandent une ÉCN pour vérifier un diagnostic clinique de STC devraient être conscients de ses limites possibles.

POINTS DE REPÈRE DU RÉDACTEUR

- Même si le syndrome du tunnel carpien est la neuropathie canalaire la plus fréquente, on ne s'entend pas vraiment sur le meilleur critère permettant son diagnostic.
- Les résultats des études de conduction nerveuse ne modifient pas beaucoup les probabilités d'un syndrome du tunnel carpien présentes avant le test chez les patients envoyés pour confirmation de diagnostic.

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Diagnosis of carpal tunnel syndrome (CTS) is based on the patient's history, findings of a physical examination, and often electrodiagnostic testing. Unfortunately, diagnostic confirmation can be a clinical challenge. It is well recognized that physical examination maneuvers have limitations in sensitivity and specificity.[1-6] Comparable sensitivity and specificity have been reported for use of the patient self-reported symptom hand diagram.[7] Nerve conduction studies (NCSs) are often thought to provide desirable objective evidence of median mononeuropathy in the diagnosis of CTS. However, their utility as a diagnostic criterion standard has been called into question by several investigators.[8-11]

In this study, we wished to further evaluate the diagnostic utility of NCSs by examining the relationship between patient symptoms and electrophysiologic data. We studied a population with a high pretest probability of CTS who were referred for NCSs for diagnostic confirmation. This population consisted of both bilaterally symptomatic and unilaterally symptomatic patients. We compared the reported localization of symptoms and symptom-function severity scores with NCS results.

METHODS

This was a single-site, prospective study of patients who had been referred for NCSs during an 11-month period. Our NCS requisition form requires referring physicians to indicate specifically whether CTS is the clinical diagnosis. Patients whose requisitions indicated this to be so were invited to participate in this self-administered survey. Informed consent was obtained from all participants. Patients completed the questionnaire just before their scheduled NCSs. The questionnaire included demographic data, lateralization of symptoms, hand dominance, symptom duration, and the Levine CTS scoring instrument.[12] All NCS results were interpreted by a qualified neurologist. The interpreting neurologist and the electrophysiology technologist conducting the NCSs were blinded to survey responses.

The Levine CTS scoring instrument is a self-administered instrument for measuring symptoms and function in CTS patients.[12] It is a validated tool with excellent reproducibility, responsiveness, and internal consistency. Minimum and maximum cumulative symptom scores are 11 and 55, respectively; minimum and maximum cumulative function scores are 8 and 40, respectively. Higher scores are associated with greater severity of disease.

Our clinical neuro-electrodiagnostic laboratory employed the Nicolet Viking IVP for NCSs. Bilateral studies are the standard in our laboratory, regardless of whether patients report unilateral or bilateral symptoms. A positive NCS result for CTS was defined as demonstrating 1 or more of the following characteristics[13-15]:

- median motor nerve latency greater than 4.2 milliseconds,
- median sensory nerve latency greater than 3.7 milliseconds,
- orthodromic median palmar sensory nerve latency (8 cm) greater than 2.2 milliseconds, or
- antedromic wrist to palm (7 cm) median sensory nerve distal latency (from wrist to digit 3 to palm to digit 3) greater than 2 milliseconds.

Statistical analyses were performed using the Statistical Package for the Social Sciences software (SPSS, version 12.0). Independent 2-tailed *t* tests were employed for 2-group comparisons of continuous data; χ^2 testing was used to evaluate frequency data. Corrections for multiple testing were performed using the Bonferroni method.

The sample size was calculated based on an estimate from pilot data that 30% of patients would have unilateral symptoms. Therefore 15% of hands tested by NCS would be asymptomatic. The proportion of symptomatic hands expected to have positive NCS results was 0.5; the proportion of asymptomatic hands expected to have positive NCS results was 0.2.[16] A 2-sided α was set at .01 and a β at .1. The calculation, allowing for an unequal allocation ratio, required a minimum of 141 patients, 44 with unilateral symptoms, and 97 with bilateral symptoms. A further allowance was added in anticipation of some patients failing to fully complete the questionnaire, resulting a target sample size of 200 patients for this study.[17]

Approval for this study was obtained from the University of Saskatchewan's Behavioural Research Ethics Board.

RESULTS

We identified 240 patients undergoing NCS for assessment of median neuropathy at the carpal tunnel during the recruitment period and invited each of them to participate in the study. A total of 211 patients (156 women and 55 men) completed the questionnaire and gave consent for access to their medical records. Of these 211 patients, 187 (88.6%) had been referred by family physicians, and 24 (11.4%) by other specialists (neurologists, rheumatologists, or hand surgeons). Mean age was 46.4 years (range 21 to 88 years) for women and 44.9 years (range 23 to 83 years) for men. The right hand was dominant in 191 of 211 (90.5%) patients. Bilateral symptoms were reported by 139 (65.9%) patients, isolated right-hand symptoms by 43 (20.4%) patients, and isolated left-hand symptoms by 29 (13.7%) patients. The mean reported duration of symptoms was 29.3 months and the median duration was 14 months (range 1 to 300).

The NCS results were interpreted as normal for 83 (39.3%) patients, confirmed median mononeuropathy in 1 or both wrists for 121 (57.3%) patients, and were

positive for non–median neuropathic abnormalities in 7 (3.3%) patients. For purposes of analysis, the 121 patients with electrophysiologic support for a diagnosis of CTS in 1 or both wrists were regarded as the positive group and the 90 patients with normal results or with non-median neuropathic abnormalities were regarded as the negative group. Comparisons of the characteristics between the groups with positive and negative NCS results are outlined in **Table 1**.

When we compared the lateralization of hand symptoms and NCS results, we saw that regardless of whether hand symptoms were unilateral or bilateral, between 31.0% and 44.2% of the NCS results were negative. The group reporting bilateral symptoms had the highest degree of agreement with the NCS results at 38.8%. Unilateral NCS abnormalities were seen in 18.0% of the patients reporting bilateral hand symptoms. Discordant findings, either bilateral median neuropathies or isolated opposite-side neuropathies were seen in 25.6% of those reporting isolated right-sided symptoms, and in 55.2% of those reporting isolated left-sided symptoms. **Table 2** outlines the NCS results by symptom lateralization category and hand dominance.

Examination of these data by individual hands is outlined in **Table 3**, where again symptoms are compared with NCS results. From these data, we see that the sensitivity of the NCS results was 49.1%, with a specificity of 62.5%. Given the origin of the patient population, we expected a high positive predictive value, which was found to be 86.4%. The negative predictive value was low at 20.2%. The overall accuracy of the NCS results in this population was 51.4%. The likelihood ratios are also close to 1 for both test results, at 1.3 with a positive result, and 0.8 with a negative result.

DISCUSSION

In our study population, we found the overall accuracy of the NCS to be about 50% when comparing symptom lateralization with NCS results, with likelihood ratios close to 1 for both positive and negative results. These findings are consistent with previous population studies by Homan et al and Atroshi et al, and suggest that NCSs do little to alter the pretest probability of CTS in these patients.[9,16] Further comparison between patients with

Table 1. Comparison of groups with positive and negative NCS results

VARIABLE	POSITIVE NCS RESULTS N = 121	NEGATIVE NCS RESULTS N = 90	*P* VALUE (2-TAILED)	95% CI
Mean (SD) age, y	49.08 (12.92)	43.54 (10.45)	.001	-8.81 to -2.26
Male, %	27.3	24.4	.643	NC
Mean (SD) symptom duration, mo	33.07 (49.53)	24.21(25.63)	.095	-19.26 to 1.55
Mean (SD) BMI	30.61 (6.82)	27.45 (5.5)	<.001	-4.89 to -1.43
Mean (SD) Levine symptomatic score*	29.82 (7.46)	27.34 (7.01)	.016†	-4.50 to -0.47
Mean (SD) Levine functional score*	15.40 (5.52)	14.58 (4.87)	.267	-2.27 to 0.63
Missed work, %(n = 29)	55.2	44.8	.855	NC
WCB cases, % (n = 13)	38.5	61.5	.215	NC

BMI—body mass index, CI—confidence interval, NC—not calculated, NCS—nerve conduction study, SD—standard deviation, WCB—Workers' Compensation Board.

*Minimum and maximum cumulative symptom scores on the Levine scoring instrument are 11 and 55, respectively; minimum and maximum cumulative function scores are 8 and 40, respectively. Higher scores are associated with greater severity of disease.

†Not significant when corrected for multiple comparisons.

Table 2. Comparison of patient symptom lateralization and NCS results

	NCS RESULTS				
PATIENT CHARACTERISTICS	BILATERAL POSITIVE N (%)	ISOLATED RIGHT POSITIVE N (%)	ISOLATED LEFT POSITIVE N (%)	BILATERAL NEGATIVE N (%)	OTHER NON-CTS ABNORMALITY N (%)
Lateralization of symptoms					
• Bilateral (n = 139)	54 (38.8)	15 (10.8)	10 (7.2)	55 (39.6)	5 (3.6)
• Isolated right side (n = 43)	11 (25.6)	11 (25.6)	0	19 (44.2)	2 (4.7)
• Isolated left side (n = 29)	13 (44.8)	3 (10.3)	4 (13.8)	9 (31.0)	0
• Total (N = 211)	78 (37.0)	29 (13.7)	14 (6.6)	83 (39.3)	7 (3.3)
Hand dominance					
• Right (n = 191)	69 (36.1)	26 (13.6)	14 (7.3)	75 (39.3)	7 (3.7)
• Left (n = 20)	9 (45.0)	3 (15.0)	0	8 (40.0)	0

CTS—carpal tunnel syndrome, NCS—nerve conduction study.

Table 3. Comparison of symptomatic hand count with NCS results

	SYMPTOMATIC HAND			
NCS RESULTS	YES	NO	TOTAL	LIKELIHOOD RATIOS
Positive	172	27	199	1.3
Negative	178	45	223	0.8
Total	350	72	422	NA

NA—not applicable, NCS—nerve conduction study.

positive and negative NCS results did not reveal any significant differences in symptomatic scores ($P>.016$, not significant when corrected for multiple comparisons), functional scores ($P=.267$), duration of symptoms ($P=.095$), missed work ($P=.855$), or sex ($P=.643$). In keeping with previous studies, those with positive NCS results were older and had higher body mass indexes than those with negative study results.[18,19] What then is the appropriate application of NCS in the process of diagnostic confirmation or exclusion? Nerve conduction studies provide valuable information but should not be viewed as a diagnostic criterion standard, particularly if the clinician's confidence is high for a diagnosis of CTS.

Limitations

This study has several potential limitations. The study population consisted of patients clinically diagnosed with CTS and generally referred by their family physicians for confirmatory NCS. It is possible that patients for whom a clinical diagnosis of CTS was made with a higher degree of confidence were not ever referred for NCS, thereby biasing the study sample, reducing the pretest probability, and limiting the generalizability of the observations. However, the percentage of positive NCS results was 57%, which is consistent with Atroshi's observations from his wider population studies.[16] It could also be argued that using patient symptoms as the standard by which to judge NCS results is problematic. However, these study patients are a select population with clinical diagnoses of CTS referred specifically for confirmatory NCS. Additionally, in the absence of an existing true objective criterion standard, patient symptoms and clinical diagnoses are the means by which medical and surgical treatment choices are made.[20]

Variation in the electrophysiologic criteria for median mononeuropathy might give rise to greater or lesser likelihood ratios. Our criteria were chosen to represent moderate, neither overly permissive nor restrictive, parameters of definition.

Another consideration with any study of a chronic process taken at a single time point is the possibility of future progression. Particularly in the population with unilateral symptoms and bilaterally positive NCS results, a preclinical CTS state could exist. Over time the symptoms might reach concordance with the NCS results in these patients. However, it should be observed that at the time of data collection, the mean symptom duration in our study population was longer than 2 years. Published follow-up studies of populations screened for CTS by Werner et al and Nathan et al have not shown conversion to a symptomatic state in most previously asymptomatic median mononeuropathies.[21,22]

Conclusion

In our study population, the NCS results did little to alter the pretest probability of CTS. These findings are consistent with previously published observations.[11] Physicians using NCS to verify clinical diagnoses should be aware of potential limitations to such testing. Future development of NCSs incorporating a provocative component might improve objective identification of dynamic and functional CTS states.

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Contributors

Drs Taylor-Gjevre, Gjevre, and **Nair** contributed to concept and design of the study; data gathering, analysis, and interpretation; and preparing the manuscript for submission.

Competing interests

None declared

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