



## The Relationship between Nerve Conduction Studies and Electromyography Findings in Patients with Carpal Tunnel Syndrome

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### ABSTRACT

**Background:** Carpal tunnel syndrome is the most common neuropathy in the general population. Nerve conduction studies are among the standard methods for diagnosing carpal tunnel syndrome. Electromyography is painful and unpleasant, and if nerve conduction studies can be used to diagnose axonal injury in carpal tunnel syndrome, electromyography might be replaced.

**Objectives:** This study aimed to evaluate the predictability of electromyography findings by nerve conduction studies.

**Materials and Methods:** This cross-sectional study recruited 47 patients with carpal tunnel syndrome who attended electrodiagnostic unit in teaching hospitals in Isfahan in the spring and summer of 2015, among who both hands of 46 patients and only the left hand of one person were evaluated. Patients were selected by non-probability sampling and the relationship between parameters of nerve conduction studies and electromyography findings were determined based on the information obtained. The data were analyzed by Spearman's test and Mann-Whitney test in SPSS-22.

**Results:** The mean and standard deviation of participants' age was  $47.5 \pm 9.1$  (range: 62-34 years old). According to data analysis, 37.6% of patients were diagnosed with neurogenic MUAP and 32.2% with neurogenic spontaneous activity. Based on the results, among 47 patients with carpal tunnel syndrome, CMAP amplitudes were most relevant to the findings of neurogenic electromyography among parameters of nerve conduction studies (31.2%) ( $p$ -value=0.002).

**Conclusion:** According to the results, axonal damage in carpal tunnel syndrome can be diagnosed by nerve conduction studies, especially in cases where electromyography is not possible (such as coagulation disorders, patient's dissatisfaction, etc.).

**Keywords:** Carpal Tunnel Syndrome; Nerve Conduction Studies; Electromyography

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## Introduction

**C**arpal tunnel syndrome (CTS) is the most common neuropathy in the general population and also the most common occupational disease involving peripheral nerves comprising about 7% of peripheral nerve disorders (1-3). CTS is caused by mechanical pressure and ischemic injury of median nerve as it passes through the carpal tunnel. First, the myelin of the nerve is impaired and finally axons are destroyed (4). The disease is accompanied by a variety of sensory and motor symptoms related to the territory of the median nerve (nonspecific pains and numbness in upper limb) (5-6).

Tests such as Phalen and Tinel and two-point discrimination have proved helpful in physical examination. Methods for the diagnosis of the disease include electromyography (EMG), nerve conduction studies (NCS) and ultrasound (2). Since focal demyelination is the major pathological change in CTS, NCS is used as the standard diagnostic method for diagnosing it. Although NCS cannot determine the severity of this syndrome or the need for surgery (7,8), data on the progress of degeneration and axonal damage can be obtained by EMG of abductor pollicis brevis. EMG can add useful information to nerve studies. Patients with weakness and APB atrophy or in cases there is reduction in CMAP amplitude, EMG greatly contributes to determining axonal damage and in some cases is the only way to diagnose it (9-11). Data can be used to determine treatment strategy and decision on the need for surgery (12).

However, the relationship between the findings of neurogenic EMG and NCS parameters is a subject that is rarely discussed. EMG is painful and unpleasant,

and if NCS can be used to diagnose axonal injury in CTS, EMG might be replaced by NCS (12) to save cost and relieve the patient from pain. Therefore, this study aimed to evaluate the ability of NCS to predict the results obtained from EMG.

## Materials and Methods

This study was approved by the Ethics Committee of Isfahan University of Medical Sciences and all participants signed the consent form after they were briefed about the study.

This cross-sectional study was conducted in the spring and summer of 2015 on patients attending electrodiagnostic unit in Ayatollah Kashani and Al-Zahra Hospitals, affiliated to Isfahan University of Medical Sciences. First, Phalen and Tinel tests were conducted on patients complaining of numbness or tingling in median nerve distribution territory, and those patients suspected of CTS were selected. The criteria for the clinical diagnosis included:

- (1) History of nocturnal or activity induced pain, or numbness in the hands,
- (2) Sensory disturbance in the palmar surface of the thumb, index, middle and the lateral half of the ring finger,
- (3) Weakness or atrophy of the abductor pollicis brevis, and
- (4) Positive Tinel or Phalen test

Then, these patients were examined by electrodiagnostic tests and if they were diagnosed with CTS they were enrolled in the study. Patients who were diagnosed with polyneuropathy, cervical radiculopathy by NCV, who involved by stroke, multiple sclerosis and patients who were not willing to participate in the study were excluded. Finally, patients with CTS confirmed by NCS

were examined by EMG and parameters related to NCS and EMG were recorded.

Electrodiagnostic study was recorded by Electroneuromyography device (Medelec Synergy Company, U.S.). Studies were conducted in a warm room and skin temperature was maintained above 33 °C. In the majority of participants, motor and sensory nerves of four limbs were assessed by NCS, whether healthy or unhealthy, to rule out polyneuropathy.

NCS in two sensory and motor parts was measured and the following parameters were used in the study: SNAP latency and amplitudes, CMAP latency and amplitudes of the median nerve.

According to reports obtained from each patient, abnormal parameters included:

- Values greater than 3.5 milliseconds for SNAP latency
- Values less than 20 mV for SNAP amplitude
- Values greater than 4.4 milliseconds for CMAP latency
- Values less than 4 mV for CMAP amplitude

The absence of waves in the above parameters represents the highest axonal damage among participants.

In EMG, abductor pollicis brevis (APB) muscle was evaluated for the presence or absence of spontaneous activity and configuration of the MUAP. In the early stage, spontaneous activities are revealed and then the MUAP become neurogenic. In other words, spontaneous activity and MUAP denote acute and chronic phases of the disease, respectively. EMG findings are specific and quite different in acute and chronic phases.

The data obtained were analyzed in SPSS-22 by Spearman's and Mann-Whitney tests.  $p < 0.05$  was considered significant, and the relationship between NCS parameters and spontaneous activity in EMG was investigated.

## Results

From a total of 47 patients with CTS, nine patients (19.2%) were male and 38 were female (80.8%). The mean ( $\pm$ standard deviation) of participants' age was 47.59 $\pm$ 9.1 (range: 34 to 62 years). According to data analysis, 37.6% of patients were diagnosed with neurogenic MUAP and 32.2% with neurogenic spontaneous activity.

Table 1 shows the correlation between the components studied in this study suggesting a significant correlation between spontaneous activity and CMAP latency, SNAP amplitude and CMAP amplitude according to Spearman's correlation coefficient ( $p < 0.05$ ).

**Table 1.** Correlation between spontaneous activity and parameters derived from NCS data

	Spontaneous activity	
	r	p-value
SNAP latency	0.056	0.591
CMAP latency	0.248	0.016
SNAP amplitudes	0.488	0.005
CMAP amplitudes	0.381	<0.001

The relationships between the frequency distribution of normal and neurogenic MUAP, and the frequency distribution of normal and abnormal parameters of NCS extracted from the data were estimated by the Mann-Whitney test and are given in table 2. As observed, from the parameters determined in NCS, CMAP amplitude followed by CMAP latency has a significant relationship with MUAP findings obtained from EMG.

**Table 2:** Frequency distribution and MUAP situation of APB according to sensory and motor latency and amplitude

MUAP APB	Normal Frequency (%)	Neurogenic Frequency (%)	<i>p-value</i>
SNAP latency			
Normal	18 (69.2%)	8 (30.8%)	0.209
Increased	39 (61.9%)	24 (38.1%)	
Absence of waves	1 (25%)	3 (75%)	
CMAP latency			
Normal	21 (84%)	4 (16%)	0.009
Increased	37 (54.4%)	31 (45.6%)	
SNAP amplitude			
Normal	35 (68.6%)	16 (31.4%)	0.161
decreased	19 (55.9%)	15 (44.1)	
Absence of waves	4 (50%)	4 (50%)	
CMAP amplitude			
Normal	55 (68.8%)	25 (31.2%)	0.002
Decreased	3 (23.1%)	10 (76.9%)	

## Discussion

The results indicate that NCS is able to somewhat predict the severity of the disease in cases EMG is not possible, especially in cases such as coagulation disorders, patient dissatisfaction, etc. Among NCS results obtained from the patients in this study, the strongest parameter related to spontaneous activity was CMAP amplitude which can predict the severity of axonal damage. More decrease in CMAP amplitude, higher probability of presence and more number of spontaneous activities. Spontaneous activity shows acute phases of axonal injury. Then, SNAP amplitudes and CMAP latency were the second and third predicting parameters. In addition, CMAP amplitude was the strongest predicting factor when MUAP of APB became neurogenic and showed chronic axonal damage.

Standard electrodiagnostic studies for CTS include NCS and EMG. NCS examines parameters such as sensory nerve action potential (SNAP), compound muscle action potential (CMAP), distal motor latency (DML) and distal sensory latency (DSL) (13). In patients with muscle weakness or atrophy of thenar or abnormal findings in the NCS,

needle EMG is useful for the diagnosis of axonal damage and also cervical radiculopathy and proximal neuropathy of median nerve (14). When the median nerve is involved, first, demyelination occurs and then axonal damage progresses. These changes can be assessed by NCS and EMG, respectively. However, mild lesions may not cause any changes in the electrophysiological study (15-16). Information about axonal damage and decision for the treatment strategy can be obtained by EMG; however, few studies have been conducted on its relationship with NCS parameters. According to the results of the present, CMAP amplitude is the most related to EMG parameters. This means that values lower than 4 mV has the most relationship with increasing spontaneous activity or neurogenic MUAP of APB in EMG exam. As a result, neurogenic findings obtained by painful EMG in patients with CTS can be somewhat predicted by CMAP amplitudes.

A study suggested that if NCS is normal, it is less possible to find an abnormal finding in EMG of APB (16). The study by Chang et al. is consistent with the findings of this study, showing that median CMAP amplitude, SNAPS and forearm median nerve conduction velocities (FMCV) have the strongest relationship with spontaneous activity in APB (12). Although the study of Werner and Albers showed the relationship between the spontaneous activity and mean median motor and sensory amplitudes and latencies but this study showed that abnormal NCS cannot predict neurogenic EMG findings because of its low sensitivity estimated in a range of 57% to 68%.(11). Chang considered only acute axonal damage in the form of the presence of APB spontaneous activity, in which the effect of new collateral branches is minimized (The electrophysiological result of forming these

collateral branches is reported in EMG as excessive polyphasic motor unit potentials which are formed in the case of chronic axonal injury) (12). While, in this study, cases with acute and chronic disease were evaluated.

The present study had some limitations, one of which was the low sample size. In addition, velocity parameter in NCS was not examined in this study and thus a wider comparison was not possible. Furthermore, both acute and sub-acute spontaneous activity and chronic neurogenic MUAP were evaluated, which indicated acute and chronic axonal degeneration and the effect of time and possible changes in the results were not addressed in long-term trends.

## Conclusion

The results indicate that CMAP amplitudes is the strongest predictor in NCS for determining the severity of axonal damage and thus its reduction is strongly related to spontaneous activity. However, it seems that needle EMG is an important component in the detection and particularly the degree and severity of carpal tunnel syndrome.

## Conflict of Interest

The authors have no conflict of interest.

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