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Original Article

Diagnostic Value of Compound Nerve Action Potential in Ulnar Neuropathy at the Elbow

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Keywords
Ulnar neuropathies; Mononeuropathies; Ulnar nerve; Electrodiagnosis

Abstract

Background: Ulnar neuropathy is the second most common neuropathy of the upper extremity. However, routine electrodiagnostic tests may not reveal some cases. To determine the diagnostic value of compound nerve action potential (CNAP) of the ulnar nerve as a complementary test, this study was done.

Methods: In a cross-sectional analytical study, 34 subjects (68 limbs) who had presented with clinical symptoms and signs of the ulnar neuropathy were evaluated with CNAP. Then the subjects were re-evaluated with standard electrodiagnostic tests. Subjects with neuropathy based on standard electrodiagnostic tests were assigned to the patient group and those without it were assigned to the healthy group. Data were analyzed with the use of receiver operating characteristic (ROC) analysis.

Results: The latency and amplitude parameters had diagnostic value given the significance of the area under the ROC curve. In relation to the latency parameter, the two thresholds which had relatively acceptable accuracy were 0.2 ms and 0.7 ms; in patients in whom the difference between the peak latency of the healthy and symptomatic sides was more than 0.7 ms, at likelihood ratio positive (LR^+) = 5.7 and specificity = 95%, the results were in favor of ulnar neuropathy.

Conclusion: CNAP evaluation has diagnostic value and can be used as an adjunct to other diagnostic techniques in suspected cases of ulnar neuropathy in the elbow region.

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Introduction

Ulnar neuropathy is the second most common neuropathy of the upper extremity, which is usually diagnosed according to patient history, clinical examination, and electrodiagnostic tests.[1,2] Previous studies have shown that its incidence is

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approximately 15.8%.[3] The ulnar nerve is formed by C8-T1 and some C7 roots along the lower trunk and medial cord of the brachial plexus.[4,5] The position and course of this nerve predispose its entrapment in some areas, including the elbow and the wrist. Routinely, electrodiagnostic techniques are used to localize and evaluate the severity of nerve entrapment in the elbow region.[6] Previous studies have reported the sensitivity of standard 10 cm nerve conduction studies (NCSs) in the diagnosis of ulnar neuropathy at the elbow (UNE) to be approximately 37-86 percent.[7] In general, the most common factors in false negative finding of ulnar entrapment are the incorrect position of the elbow, displacement of the ulnar nerve, and the early stage or minor involvement of the nerve.[8] Consequently, more sensitive electrodiagnostic techniques are needed for evaluation of ulnar neuropathy.

Compound nerve action potential (CNAP) has been used for evaluation of ulnar neuropathy.[9,10] However, the value of CNAP in the diagnosis of ulnar neuropathy is not clear and validated. In this study, the value of CNAP was evaluated in patients with normal routine electrodiagnostic results despite the presence of clinical symptoms and signs of the entrapment of the ulnar nerve and also in those who had the standard diagnostic criteria.

Methods

The present cross-sectional analytical study was carried out in Firoozgar Medical Center, Iran University of Medical Sciences, Tehran, Iran. The study was approved by the Ethics Committee of Iran University of Medical Sciences (IR.IUMS.FMD.REC.136.9511524006) and was performed in accordance with the Declaration of Helsinki. All the subjects with symptoms and signs of pain, numbness, paresthesia, and tingling in the area of the 4th and 5th fingers of the hand, concomitant with impaired sensory or motor examinations in the territory of ulnar nerve in one upper extremity were included in the study. The sensory tests consisted of pinprick sensation and light touch in the fifth finger in comparison with the third finger, elbow flexion test (induction of symptoms and signs by complete flexion of the elbow and complete supination of the forearm and wrist in the neutral position), pressure provocative test (induction of symptoms and signs by application of pressure on the ulnar nerve for 60 seconds proximal to the cubital canal when the elbow is flexed 20° and the forearm is supinated), and presence of Tinel's sign (induction of electrical shock sensation by percussion of the nerve at medial epicondylar groove). Motor tests consisted of Froment's test [compensatory activity of the flexor pollicis longus (FPL) muscle due to the weakness of adductor pollicis muscle], Wartenberg's sign (abduction of the little finger of the hand due to the weakness of palmar interosseous muscles), and finger flexion test [abnormal over flexion of the interphalangeal (IP) joint and hyperextension at metacarpophalangeal (MCP) joints due to the weakness of interosseous muscles (incomplete claw hand)]. A total of 34 subjects (68 limbs) were selected. An informed written consent was obtained from all the patients and the necessity of the study was explained, then CNAP test was carried out on both upper extremities of all the subjects. In all of the patients, the median and radial nerves of the upper limbs and the sural nerve in the lower limb were evaluated to rule out potential neuropathies. All the tests were carried out by an electromyography (EMG) test machine (Schwarzer Topas, Germany). During the tests, the temperature of the hands of all the subjects were monitored with a digital thermometer and if the temperature dropped to a level below 32 °C, an infrared lamp would be used to increase the temperature. Subsequently, routine standard tests were carried out based on the standards of the American Association of Electrodiagnosis and Neuromuscular Medicine (AAENM) on both hands.[7] Subjects with positive results of standard AANEM tests were assigned to the patient group and

those with normal test results were assigned to the normal electrodiagnosis group.

Patients with history of surgery in the elbow region, bilateral symptoms, induction of symptoms and signs after an acute trauma, presence of brachial plexopathy, polyneuropathy, cervical radiculopathy, systemic conditions such as diabetes, rheumatoid arthritis (RA), chronic renal disease, entrapment of the ulnar nerve in a region other than the elbow, and presence of contraindications for carrying out electrodiagnostic tests were not included. The tests and numeric values of the present study were as follows:

Measurement of the absolute motor nerve conduction velocity (MNCV): The electrodiagnosis equipment was adjusted as follows: amplifier sensitivity = 5000 uv, pulse duration = 250 ms, sweep speed = 5 ms/div, and filter setting = 5 Hz to 2 KHz. In order to measure MNCV, the elbow was placed in 90° flexion, the arm was abducted and externally rotated, and the forearm was supinated. The E1 recording electrode was placed on the middle portion of abductor digiti minimi (ADM) muscle and the E2 recording electrode was placed distal to the fifth MCP joint. Stimulation was carried out at 3 locations of the wrist (8 cm proximal to E1), below the elbow (4-5 cm distal to the medial epicondyle), and above the elbow (at least 10 cm proximal to the excitation location below the elbow) by marking the two latter locations when the elbow was fully flexed. Then the MNCV was calculated based on onset latency of each segment, consisting of wrist to below-the-elbow, across the elbow, and above-the-elbow. Absolute velocity less than 50 m/s at exit from the elbow was considered abnormal. The differences in nerve conduction velocity (NCV) between the segments above the elbow and below the elbow were calculated; a difference of more than 10 m/s between the two segments of the elbow was considered as abnormal. For comparison of the amplitude of the compound muscle action potential (CMAP) above and below the elbow, a decrease of more than 20% in stimulation below the elbow compared to above the elbow was considered abnormal. Based on the AAENM guidelines, if two of the four above parameters were present, UNE would be confirmed.[7,9]

Measurement of CNAP of the ulnar nerve: The electrodiagnostic parameters were adjusted as follows: amplifier sensitivity = 2 ms/div, filter setting = 5 Hz-2 kHz. The patient was in supine position, with the elbow placed at a 90° flexion position, and the forearm was supinated. A bar recording electrode with 4 cm E1-E2 distance was used. The E1 recording electrode was placed at the ulnar sulcus between the two bony prominences of the elbow and the E2 electrode was placed proximal to it. The nerve was stimulated proximal to wrist crease. The distance between E1 and cathode was measured and the same distance was used for recording the CNAP of the other side. The peak latency and amplitude height were calculated in two forms of baseline-to-peak (b-p) and peak-to-peak (p-p).

Needle EMG evaluation: By concentric needle electrode, flexor carpi ulnaris (FCU), ADM, first dorsal interosseous (FDI), and flexor digitorum profundus (FDP) muscles were evaluated.

Data were analyzed by SPSS software (version 21, IBM Corporation, Armonk, NY, USA). Independent t-test was used for analysis of data. Receiver operating characteristic (ROC) analysis was used to determine the diagnostic value (sensitivity and specificity) and logistic regression analysis was used to determine false positive and false negative results.

Results

The tests were carried out on 34 symptomatic individuals (68 limbs), consisting of 15 men and 19 women, with a mean age of 36.0 ± 8.7 years. 14 subjects had ulnar neuropathy in electrodiagnostic tests according to AANEM standards while 20 subjects did not have the neuropathy despite being symptomatic and were assigned to the suspected patients' group.

Table 1. Comparison of the significance of all the three parameters

	Area	SE	Chi-squared	df	P	P (Bonferroni)
P-P	0.5536	0.1013	19.4404	1	< 0.0001	< 0.0001
B-P	0.6786	0.0946	11.5491	1	0.0007	0.0020
Latency	0.6429	0.0991	12.9887	1	0.0003	0.0009

SE: Standard error; df: Degree of freedom; B-P: Baseline-to-peak; P-P: Peak-to-peak

The three diagnostic parameters were the difference in latency between the healthy and symptomatic sides, the difference in the length of p-p amplitude between the healthy and symptomatic sides, and the difference in the length of b-p amplitude between the healthy and symptomatic sides.

As shown in table 1 and based on the analysis of ROC curve, since the surface area under the curve was statistically significant for all the three parameters, it can be concluded that all the three parameters have diagnostic value ($P < 0.05$).

In relation to latency, 0.2 ms and 0.7 ms thresholds had relatively acceptable accuracy, and their calculated likelihood ratios (LRs) were favorable (Table 2).

Table 2. Comparison of specificity and reliability of the difference in latency in the upper and lower cut-off points

	Sensitivity (%)	Specificity (%)	LR^+	LR^-
Latency difference (ms)				
0.2	92.86	25.00	1.2381	0.2857
0.7	28.57	95.00	5.7143	0.7519

LR: Likelihood ratio

Table 2 shows that if the difference in latency between the two sides is less than 0.2 ms, the disease can be ruled out with an acceptable probability and if the difference in latency between the two sides is more than 0.7 ms, the disease will be diagnosed with an acceptable probability: $LR^+ = 5.7$. For the 0.2 ms-0.7 ms interval, the LR was calculated at 0.64, which indicates a high probability of being healthy if the difference between the two sides is between these two values; however, it is not reliable as a negative result.

In relation to differences in p-p and b-p amplitudes between the two sides, none of the thresholds were reliable, which might be attributed to an inadequate number of samples considering the dispersion of data; however, considering the significance of the surface areas under the curves, it might be possible to obtain reliable thresholds for them with the use of a larger sample size. The only reliable threshold for the b-p difference is 12 micV and based on data presented in table 3, if the difference in b-p between the two sides is equal or less than 12 micV, there will be no nerve entrapment.

Table 3. Comparison of sensitivity and specificity of differences in amplitude between the healthy and symptomatic sides

	Sensitivity (%)	Specificity (%)	LR^+	LR^-
B-P diff > 12 micV	100	30.00	1.4286	1.4286

B-P: Baseline-to-peak; LR: Likelihood ratio

Discussion

The results of this study showed that in patients with the clinical symptoms and signs of the ulnar nerve involvement in the elbow region, in whom the routine standard tests are negative, comparison of CNAP in both sides can be a relatively effective and simple method for diagnosis of the neuropathy; when findings of other standard parameters are equivocal, this technique simultaneously evaluates the motor and sensory nerve fibers. Application of latency and amplitude has the greatest diagnostic value while the best parameter in this respect is peak latency when compared between the healthy and symptomatic sides. In this context, a difference of more than 0.7 ms with $LR^+ = 5.7$ and specificity of 95% is in favor of the ulnar nerve entrapment and if this parameter is less than 0.2 ms with $LR^- = 0.2$ ms and sensitivity of 92.8%, it is in favor of an absence of nerve involvement. In relation to the b-p amplitude height, in patients in whom the

difference between the healthy and symptomatic sides is ≥ 12 micV with LR^{-} = 0 and sensitivity of 100%, it is in favor of the ulnar nerve involvement.

By using motor NCSs for the motor segment of ulnar nerve at elbow, there is possibility of errors due to non-linear position of ulnar nerve. Short-segment incremental technique (inching) is probably the most sensitive method for the diagnosis of UNE; however, it is not routinely used.[9] Therefore, other diagnostic techniques, such as CNAP, might be useful. In the present study, application of the latency difference parameter had acceptable diagnostic value, consistent with the results of some previous studies in this respect, including a study reported in 2006 in the American Congress of Rehabilitation Medicine (ACRM)[9] and a study by Merlevede et al.[10]

Since conservative treatment interventions and rehabilitation programs have yielded positive results during the early stages of the ulnar nerve involvement in the elbow region,[11] it is suggested that the CNAP technique be used for early diagnosis of the ulnar nerve involvement, along with other available diagnostic techniques such as ultrasonography,[12] especially in patients suspected of such an involvement, when routine electrodiagnostic tests are normal.

Conclusion

CNAP technique can be used as a complementary technique in diagnosis of the ulnar nerve involvement at the elbow.

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Conflict of Interest

Authors have no conflict of interest.

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