Electrodiagnosis of ulnar nerve entrapment at the elbow

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ABSTRACT

الأهداف: دراسة استعمال طرق فسيولوجية كهربائية مختلفة لتشخيص انحشار العصب الزندي في المرفق على وجه الخصوص ومقارنة دراسة القطع الطويلة عند المرفق مقابل القطع الصغيرة.

الطريقة: أُجري تقييم للمرضى الذين تم تحويلهم إلى مستشفى حيدرباشا نومون ومركز التدريب والبحث بقسم المختبر وفسيولوجية الأعصاب – اسطنبول – تركيا، خلال الفترة ما بين 2000م وحتى 2004م، والذين تم تشخيص حالتهم أولياً بانحشار العصب الزندي في المرفق (UNE). قمنا بمقارنة دراسة القطع الطويلة (8–12cm) مقابل القطع القصيرة (3cm)، لتشخيص انحشار العصب الزندي في المرفق (UNE) لـ93 طرف.

النتائج: شملت مجموعة الدراسة 55 أنثى و 31 ذكر. تم تسجيل بطء في (<50m/sn) (CV) نقطة لدى (48.4%) و (73%) من الأطراف مع دراسات القطع الطويلة والقصيرة، على التوالي. تم تسجيل هبوط في (82%) من الحالات (CMAP). كما تم تسجيل نسبة الهبوط (CMAP) بنسبة (30%–10) بين الرسغ والمرفق في 35 أطراف (37.6%). بينما تم تسجيل نسبة هبوط أعلى من (50%) لدى 5 أطراف (5.4%).

خاتمة: كانت دراسة القطع القصيرة حساسة للتشخيص الكهربائي لانحشار العصب الزندي (UNE) في المرفق وحتى عبر تسجيل هبوط (CMAP) لدى معظم المرضى ولكن يعتبر الهبوط المكون من انسداد التوصيل (50%>) نادر.

Objectives: To evaluate the different localizing electrodiagnostic techniques of ulnar nerve entrapment at the elbow (UNE), particularly, comparison of the sensitivities of long segment stimulation across the elbow, versus short segment stimulation.

Methods: Patients who were referred to the Neurophysiology Laboratory of Haydarpaşa Numune Training and Research Hospital, Istanbul, Turkey between 2000-2004 with a preliminary diagnosis of UNE were retrospectively evaluated. We compared the sensitivity of studying long segments (8-12 cm) versus short segments (3 cm) for the diagnosis of UNE in 93 limbs.

Results: The study group consisted of 55 females and 31 males. Slowing of the conduction velocity (<50 m/sn) across the elbow was recorded in 48.4% of the limbs with long segment studies, and 73% of the limbs with short segment studies. In 82% of cases, an amplitude drop of the compound muscle action potential (CMAP) was also recorded. A CMAP amplitude drop of 10-30% between the wrist and elbow was recorded in 35 limbs (37.6%), while a drop of more than 50% was only recorded in 5 limbs (5.4%).

Conclusions: Short segment studies are sensitive for the electrodiagnosis of UNE, and although a CMAP amplitude drop is recorded in most patients, an amplitude drop consistent with a conduction block (>50%) is rare.

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Ulnar neuropathy at the elbow (UNE) is the second most common entrapment neuropathy of the upper extremities, after carpal tunnel syndrome (CTS). The clinical spectrum of UNE ranges from intermittent paresthesias in the fourth and fifth digits to complete sensory loss in the territory of the ulnar nerve, weakness, and atrophy of the first dorsal interosseous and ADM muscles.[1-7] In contrast to CTS, localizing the site of the lesion by electrodiagnostic studies is often more difficult in patients with ulnar neuropathy.[8-12] The UNE usually occurs as a result of chronic mechanical compression or stretch, either at the groove or the cubital tunnel.[5,13] The pathophysiology of UNE is variable with both demyelination and axonal loss. The motor nerve conduction studies do not permit the localization of a pure axonal lesion, which causes reduced compound muscle action potential (CMAP) amplitudes at all stimulation sites.[9] In one study,[14] it was reported with a higher sensitivity for identifying UNE by the detection of absolute slowing of conduction

velocity (CV) in the elbow segment. When CV drops below a reference value such as 50 m/s while recording from the abductor digiti minimi muscle (ADM).[14] In another study,[8] it was noted that to localize an ulnar neuropathy at the elbow, the motor CV across the elbow must be disproportionately slower than the velocity of an adjacent nerve segment.[8] Electrodiagnostic studies may sometimes yield false-negative results, especially in patients with milder lesions, or show nonlocalizing findings in cases of pure axonal injury.[1] In 1999, the American Association of Electrodiagnostic Medicine (AAEM) made several recommendations to optimize the electrodiagnostic protocol for UNE.[1,10] Localization of entrapment of the ulnar nerve can be made by short segment stimulation (SSS), commonly known as 'inching' of the ulnar nerve across the elbow.[5] Precise localization of conduction abnormalities around the elbow is possible with SSS. The purpose of this study was to evaluate the different localizing electrodiagnostic techniques of UNE. In particularly, the sensitivities of long segment stimulation across the elbow (LSS) (8-12 cm), versus SSS (3 cm) were compared.

Methods. Patients who were referred to the Neurophysiology Laboratory of Haydarpaşa Numune Training and Research Hospital, Istanbul, Turkey between 2000-2004 with a preliminary diagnosis of UNE were retrospectively evaluated. Approval of the study protocol was obtained prior to commencing this study. Patients with signs or symptoms of polyneuropathy, systemic or neurological disorders that may affect the peripheral nervous system and patients with a history of elbow trauma or fracture were excluded. A Medelec Sapphire II FO4/00 EMG (Medelec Ltd, Surrey, England) machine was used for all studies. Electrophysiological studies included standard median nerve motor and sensory studies and ulnar nerve conduction studies as described below. Surface recording and stimulating electrodes were used for both motor and sensory nerve conduction studies. The surface active bar electrode was placed over the hypothenar eminence at the ADM with the active electrode on the muscle belly for motor conduction studies. The ulnar nerve sensory studies were obtained orthodromically via a ring electrode placed on the fifth finger and recording from the wrist. The elbow was flexed at 90° and the forearm was supinated as recommended by the AAEM. For LSS the ulnar nerve was stimulated at 3 points, the wrist (W), below the elbow (BE), and above the elbow (AE), with 8-12 cm between the BE-AE stimulation points. For SSS, first a point "P" was localized over the course of the ulnar nerve on a line passing through the prominent point of the medial epicondyle perpendicular to the medial border of the ulna. Then 5 stimulation points 3 cm apart were used; 3 cm and 6 cm distal (D3 and D6) to the point P, the point P, and 3 cm and 6 cm proximal (P3 and P6) to the point P. The ulnar nerve sensory nerve latency (SNL), sensory nerve action potential (SNAP) amplitude, and sensory nerve conduction velocity (SNCV) were recorded. The ulnar nerve motor latency (ML), CMAP amplitudes, and motor nerve conduction velocities (MNCV) were evaluated with both methods. An MNCV lower than 50 m/sn across the elbow was accepted as UNE. The MNCV for the wrist-elbow segment (WES) and across elbow segments (AE-BE) were compared with the amplitude changes between the different stimulation points to compare the sensitivities of SSS and LSS.

Student's T-test was used for statistical analysis and comparisons between the 2 groups with $p<0.05$ accepted as significance. Pearson's correlation was used for correlational analysis.

Results. One hundred and fifty patients (163 extremities) with a preliminary diagnosis of UNE were found. The mean age was 41.23±13.8 (16-76), with 99 (66%) female and 51 (34%) male patients. The most common presenting symptom was paresthesias in the fourth and fifth digits (**Table 1**). Of the 163 arms tested, 116 (71.2%) arms were diagnosed with UNE with a slow MNCV across the elbow (<50 m/sn). Only 93 arms, in which both SSS and LSS studies were available were included in this study. In 93 arms, LSS and SSS were compared. With LSS, the MNCV AE-BE was lower than <50 m/s in 45 (48.4%) arms; with a mean MNCV of 42.2 m/s (range of 22-49 m/s). In all of these arms, the D3-P CV was slower more than 10 m/s compared to the WES. In 92% of the arms, the CV in the P-P3 segment was at least 10 m/s slower than the WES. The most significant MNCV slowing was in the D3-P segments (cubital tunnel) and P-P3 segments (retro epicondylar) using the SSS method (**Table 2**). The UNE was confirmed in 68 (73.1%) arms using the

Table 1 - Presenting symptoms of patients (N=163).

Symptoms	Cases n (%)
Paresthesia of the fourth and fifth digits	104 (63.8)
Pain at the elbow	14 (8.6)
Paresthesia of the fourth and fifth digits and atrophy of the first dorsal interosseous muscle	4 (2.5)
Paresthesia of the fourth and fifth digits and weakness of the ulnar muscles	8 (4.9)
Paresthesia of the fourth and fifth digits and pain at the elbow	31 (19.0)
Pain at the elbow + weakness of the ulnar muscles	2 (1.2)

Table 2 - Short segment study results (N=93).

MNCV	D6-D3	D3-P	P-P3	P3-P6
		n (%)		
<50 m/s	11 (11.8)	45 (48.4) (Mean 33.22 m/s)	41 (44.1) (Mean 32.02 m/s)	4 (4.3)
>50 m/s	82 (88.2)	48 (51.6)	52 (55.9)	89 (95.7)

MNCV - Motor nerve conduction velocity, m/s - meter/second, D3 - 3 cm distal to the elbow, D6 - 6 cm distal to the elbow, P - elbow, P3 - 3 cm proximal to the elbow, P6 - 6 cm proximal to the elbow, AE - above elbow, BE - below elbow,
D6-D3 mean MNCV = 60.68±15.43 m/s, D3-P mean MNCV = 48.71±17.88 m/s, P=P3 mean MNCV = 48.47±19.31 m/s, P3-P6 mean MNCV = 64.87±12.79 m/s

Table 3 - Motor nerve conduction velocity across elbow (N=93).

MNCV at the elbow with SSS	MNCV at the AE-BE segment with LSS	
	<50 m/s	>50 m/s
D3-P		
<50 m/s	29	16
>50 m/s	16	32
P-P3		
< 50 m/s	25	16
> 50 m/s	20	32

MNCV - Motor nerve conduction velocity, m/s - meter/second, D3 - 3 cm distal to the elbow, D6 - 6 cm distal to the elbow, P - elbow, P3 - 3 cm proximal to the elbow, P6 - 6 cm proximal to the elbow, AE - above elbow, BE - below elbow

Table 4 - Motor nerve conduction velocity and motor nerve action potential at the elbow in ulnar nerve neuropathy at the elbow (N=93).

Ulnar nerve	D3-P		P-P3	
	MNCV <50 m/s (n=45)	MNCV >50 m/s (n=48)	MNCV <50 m/s (n=41)	MNCV >50 m/s (n=52)
MNDL at the wrist	2.70±0.49 (*p*=0.179)	2.57±0.39	2.70±0.45 (*p*=0.245)	2.57±0.43
CMAP amplitude (mV) at the wrist	7.72±2.61 (*p*=0.339)	7.73±2.53	7.05±2.80 (*p*=0.150)	7.83±2.36
MNL at D3	6.39±0.87 (*p*=0.103)	6.08±0.82	6.34±0.74 (*p*=0.228)	6.13±0.93
CMAP amplitude at D3	6.21±2.33 (*p*=0.103)	7.00±2.35	6.29±2.44 (*p*=0.236)	6.88±2.30
MNL at the elbow (P)	7.27±0.94 (*p*=0.000)	6.57±0.81	6.99±0.77 (*p*=0.438)	6.84±1.05
CMAP amplitude at the elbow (P)	6.07±2.44 (*p*=0.079)	6.93±2.23	6.17±2.27 (*p*=0.219)	6.78±2.42
MNL at P3	7.93±1.04 (*p*=0.012)	7.39±1.00	8.06±0.90 (*p*=0.001)	7.32±1.06
CMAP amplitude at P3	5.99±2.47 (*p*=0.261)	6.58±2.49	5.56±2.52 (*p*=0.010)	6.88±2.32

MNDL - motor nerve latency, CMAP - compound muscle action potential, MNCV - motor nerve conduction velocity, D3 - 3 cm distal to the elbow, D6 - 6 cm distal to the elbow, P - elbow, P3 - 3 cm proximal to the elbow, P6 - 6 cm proximal to the elbow, AE - above elbow, BE - below elbow

Table 5 - The sensory nerve conduction studies in ulnar nerve entrapment of the elbow (N=93).

Sensory nerve	D3-P		P-P3	
	MNCV <50 m/s (n=45)	MNCV >50 m/s (n=48)	MNCV <50 m/s (n=41)	MNCV >50 m/s (n=52)
SNL (ms)	1.98±0.82 (p=0.760)	1.03±0.66	1.86±0.83 (p=0.325)	2.01±0.66
SNAP amplitude (μV)	14.36±12.24 (p=0.545)	16.23±16.92	11.17±10.43 (p=0.015)	18.60±16.87
SNCV (m/s)	44.48±16.79 (p=0.386)	47.37±15.19	42.70±18.42 (p=0.078)	4.56±13.34

SNL - Sensory nerve latency, SNAP - Sensory nerve action potential, SNCV - Sensory nerve conduction velocity, MNCV - Motor nerve conduction velocity, D3 - 3 cm distal to the elbow, D6 - 6 cm distal to the elbow, P - elbow, P3 - 3 cm proximal to the elbow, P6 - 6 cm proximal to the elbow, AE - above elbow, BE - below elbow

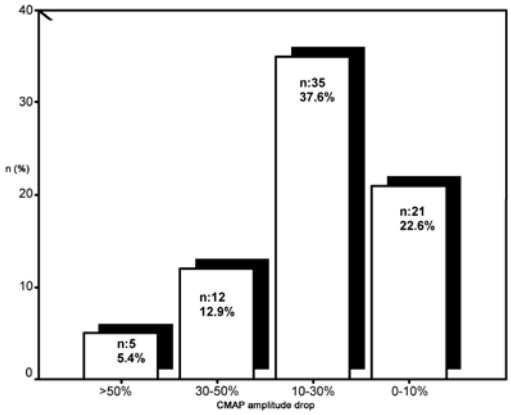

Figure 1 - The amplitude changes between wrist and elbow segments in ulnar nerve entrapment at the elbow.

SSS and also the LSS method. Out of the 48 arms with normal LSS study, 16 (33.3%) were diagnosed with UNE with slowing across the D3-P or P-P3 during SSS (**Table 3**). The distal latency and CMAP amplitudes by wrist stimulation were significantly abnormal in arms with UNE. This finding was also present at the elbow, especially with P3 stimulation (**Table 4**). The SNAP amplitudes and SNCV's were lower in the arms with UNE. In arms with a MNCV lower than 50 m/sn in P-P3 segments, the SNAP amplitude was significantly lower with a positive correlation of 19.6% (**Table 5**). In 9 (9.7%) arms with UNE, the ulnar sensory nerve was inexcitable. Although a real conduction block (CB) between wrist and elbow segments with an amplitude drop of more than 50% was detected in only 5 (5.4%) cases, an amplitude drop of a lesser degree was found in 78-82% of the cases (**Figure 1**).

Discussion. The clinical symptoms of UNE are well known and easy to recognize, but the pathophysiological mechanisms involved in the 2 most common types; cubital tunnel syndrome and retro epicondylar compression are different.[12] Some previous reports mentioned slowing of the ulnar nerve motor CV across the elbow in a patient with chronic traumatic UNE.[15-20]

Lesions of the ulnar nerve in the cubital tunnel and retro epicondylar region cannot always be differentiated clinically.[15] The term 'cubital tunnel syndrome' is often used to mean compression of the nerve anywhere around the elbow.[5,20] The goals of electrodiagnosis in UNE are to confirm the disturbance of the ulnar nerve, to pinpoint the exact site of the nerve lesion, and to assess the severity of ulnar nerve dysfunction. Awareness of anatomical variations in structural anatomy, anomalous innervation, and fascicular arrangement of ulnar nerve fibers are required to interpret electrodiagnostic studies accurately.[10,11] The most common localizing electrophysiological sign is slowing of the motor CV across the elbow with preserved CV in the forearm. Additional techniques, such as relative slowing in different ulnar nerve segments, the use of alternative muscles for recording motor, sensory, and mixed nerve techniques provide complementary information.[1]

In the present study, we accepted a slow CV lower than 50 m/s across the elbow to be our diagnostic criteria for UNE. This finding was present in 73% of the extremities. In all cases, the CV was at least 10 m/s slower around the elbow (D3-P or P-P3) than the WES. A CB or dispersion has been reported to be less common than slowing, occurring in only 5-15% of patients with UNE.[2,4,20] A drop of >20% in amplitude or area of the CMAP between a distal and a more proximal site is considered abnormal, although a >50% drop in an area between a proximal and a distal stimulating site required before CB can be diagnosed.[9] In our study, a true CB (amplitude drop more than 50%) was detected in only 5 (5.4%) of our patients, while a 10-20% amplitude drop was seen in 35 (37.6%) of the patients. With these

findings, we believe the slowing of the NCV at the AE-BE segment is a more sensitive finding for UNE.

Recent studies have focused the electromyographer's attention on the use of shorter across-elbow segments (SSS) (2-5 cm).[20] The SSS of the median nerve at the wrist has proven to be a valuable method in the diagnosis of CTS.[21] A similar method in another study applied to the UNE concentrated on localizing the lesion only in the presence of the abrupt change of shape and amplitude of CMAP in the across-elbow segment.[15]

The SSS technique, which has become a standard method of testing for UNE can pinpoint a lesion to the exact site of compression and can distinguish cubital tunnel syndrome from tardy ulnar nerve palsy (retro condylar compression). If the lesion is localized to more than 2 cm distal to the medial epicondyle, the diagnosis of cubital tunnel syndrome can be made. On the other hand, if the lesion is localized to the medial epicondyle or proximal to it, retro condylar compression syndrome can be diagnosed.[15] With the SSS method, we used 5 different stimulation points 3 cm's apart across the elbow and found CV slowing (<50 m/s) in 16 extremities, in which the LSS study was normal. This finding demonstrates a 33.3% gain for UNE localization. Cubital tunnel syndrome was diagnosed in 45 (48.4%) and similarly retro epicondylar UNE was detected in 41 (44.1%) of our patients.

The sensitivity of electrodiagnostic studies ranges from 37-86% in UNE. There are also technical problems including the elbow position and length of the across-elbow segment during nerve conduction studies. Distal ulnar nerve sensory conduction studies are relatively sensitive for identifying an ulnar neuropathy, but the findings are nonspecific, and nonlocalizing.[8,17] We had similar findings with sensory nerve conduction studies being less sensitive than the motor nerve conduction studies. The retrospective nature of this study is a limitation of this study, and although the AAEM standards were used during electrophysiological studies, the multiple personnel might have affected the results.

In conclusion, we found both cubital tunnel and retro epicondylar ulnar nerve lesions an equally common cause of UNE. The motor nerve conduction studies are sensitive, and the most reliable electrophysiological finding is local slowing of NCV across the elbow. A 10 m/s drop of the CV across the elbow compared to the WES is a sensitive marker for UNE. An amplitude drop is usually an accompanying feature, but a real conduction block is present in only 5% of the cases. In this respect, the conventional LSS ulnar nerve conduction studies are the first step in the diagnosis of UNE, but SSS is more sensitive for localizing the pathology.

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