**BACKGROUND**

The electrodiagnosis of ulnar neuropathy at the elbow (UNE) is not easy as that of carpal tunnel syndrome. In 1999 the American Association of Neuromuscular & Electrodiagnostic Medicine (AANEM) suggested electrodiagnostic usefulness of some electrophysiological parameters of the ulnar nerve, including the second order by strength of evidence: 1) reduction of MCV in across elbow segment <50 m/s (C8-T1 slowing); 2) drop of MCV across elbow vs. forearm MCV >10 m/s (C7-T1 drop); 3) drop of CMAP amplitude across the elbow (endurance test - CB) >20%, 4) significant change in CMAP configuration at the above elbow site compared with the below elbow site [1]. They are considered “UNE localizing” electrophysiological parameters.

**AIMS OF THE STUDY**

1) To check optimal cut-off values of the first three AANEM “localizing” and other “non-localizing” neuromuscular parameters of the ulnar nerve (see statistical methods) to identify patients with UNE using receiver-operating characteristic (ROC) curves. The neurographic values were obtained from consecutive subjects enrolled in four EMG labs by a “case-control” study designed for another aim [2].

2) To compare the sensitivity and specificity of the cut-offs obtained with ROC curve with those of AANEM and those of “normative” values of each EMG lab.

**Subjects**

“Case” and “controls” were consecutively recruited among all patients referred to 4 outpatient EMG labs performing electrodiagnostic testing at the upper limbs from June 2014 to April 2015. UNE diagnosis (“cases”) was made according to clinical findings. Mandatory symptoms included numbness, tingling, or burning sensation in the fifth digit of the hand in weakness in an ulnar distribution. “Hand-distribution protocol” proposed by Werner et al. was also used [1]. Guyon’s canal syndrome, C8-T1 radiculopathy, brachial plexopathy, thoracic outlet syndrome were excluded with adequate instrumental tests if necessary.

They were all the other subjects admitted to the same EMG labs without symptoms and neurological findings of peripheral nervous system and muscular diseases. “Case” and “controls” with age <14 and >70 years, polyneuropathy, multifocal motor neuropathy, myasthenic syndrome, dysautonomia, connective and thyroid diseases, renal failure, history of alcoholism and malignancy in the previous 5 years were excluded. Because the “non-localizing” individuals, their neurographic parameters were called “reference values” [4].

**Results**

We prospectively enrolled 523 consecutive UNE “cases” (mean age 49.2 years, 45.8% females, 45.8% blue collar) and 523 normative “controls” (mean age 47.3 years, 51.3% females, 45.3% blue collar). There were no significant differences of age, sex and job.

All parameters had moderate accuracy (AUC=0.6) in the whole sample. The largest AUC was 0.88 (AI, MCV slowing) and 0.87 (MCV drop). The cut-offs of AE MCV slowing (46 m/s) and drop (80 m/s) provided sensitivity of 75.4% and 76.8% and specificity of 87.6% and 85.5%, respectively. Between “localizing” parameters CMAP SAP cut-off (4.40) provided the highest sensitivity and specificity (60.3% and 80%). If we separated the sample in two age groups, the sensitivity and specificity further slightly increased (see figures).

If we considered the cut-offs of AANEM MCV slowing and drop, they had high similar sensitivity and specificity, while the “normative values” had high specificity (92%) but low sensitivity, CB had moderate accuracy only if “reference values” were used.

**Discussion**

Many studies of “normative values” used convenience or feasibility samples composed of hospital personnel, students, and friends. This type of sample has limitation for generalization and might provide false results for the general population [8]. In this study we used an appropriate “reference” cohort belonging to the same cohort of the patients, and theoretically the patients and controls might come from the same population even if they might not represent the general population. In addition our samples are sufficient in size to obtain reliable results.

A normal range may be defined in different ways, the most known were to calculate the percentile values or values within 2 SD of the mean. The latter method depends on a Gaussian distribution. Few electrophysiological parameters show a Gaussian distribution. The number of type I errors can be reduced by using critical values of 2 SD from the mean but it would increase the number of type II errors (“abnormal” considered to be “normal”). The relationship between the true and false positive subjects can best demonstrate using ROC curves [9]. ROC methods were rarely used to obtain the optimal cut-offs of neurographic values not only in the ulnar nerve but in all the nerves. Only a recent paper used ROC curve and Bayesian analyses [10].

**CONCLUSIONS**

Using ROC analysis the discriminative ability of two “localizing” parameters (MCV slowing and drop) to detect UNE patients has high accuracy. The optimal cut-offs of “reference values” with the highest sensitivity and specificity are 47.9 m/s and 8.5 m/s, respectively. The “non-localizing” sensitivity increase if we separate the optimal cut-offs in two age groups.

If we use the cut-offs of AANEM the sensitivity and specificity are similar but slightly lower than our “reference values”. The “normative values” have high specificity but low sensitivity.

Our “reference values” and “normative values” of MCV slowing across the elbow are very similar to those of AANEM and higher than many “normative” ranges of some papers (about i 40 m/s) even if the electrodiagnostic methods are very like to ours [11]. The problem of this difference is the choice of “reference population” and the type of the job of the selected subjects because asymptomatic delay of MCV across the elbow is relatively frequent in subjects with certain jobs.

“Non-localizing” neurographic factors may be useful to confirm UNE diagnosis, especially DUC SAP, they have lower accuracy, but they may help to document axonal degeneration.