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Normative Data of Nerve Conduction Studies in the Upper Limb in Kuwait: Are They Different from the Western Data?

Key Words

Electromyography
Median nerve
Ulnar nerve
Radial nerve
Neural conduction
Action potential

Abstract

Objective: To establish the normal electrophysiological data for the median, ulnar and radial nerves and to compare our results with the Western data published in the literature. **Methods:** Nerve conduction studies were performed prospectively in the upper limbs of 50 carefully screened healthy individuals between the ages of 16 and 56 years using standardized technique. **Results:** The median motor distal latency (DL) was 3.1 (0.3) ms, amplitude 11.01 (2.8) mV, conduction velocity (CV) 56.5 (3.5) m/s. The ulnar motor studies gave DL of 2.4 (0.3) ms, amplitude 9.2 (2.2) mV, CV 60.4 (5.0) m/s. Sensory studies for the median nerve were: DL of 2.3 (0.3) ms, amplitude 63.3 (18.9) μ V for men and 79.3 (28.8) μ V for women and CV 56.6 (7.6) m/s. For the ulnar nerve (DL) 2.0 (0.23) ms, amplitude 54.5 (18.4) μ V for men and 63.9 (16.8) μ V for women and CV 51.7 (5.3) m/s. The radial sensory studies were DL 1.95 (0.3) ms, amplitude 18.7 (5.5) μ V and CV 52.3 ms. Only gender showed a statistically significant effect on the sensory nerve action potential for the median ($p = 0.04$) and ulnar nerves ($p = 0.07$). **Conclusion:** Normative conduction parameters of commonly tested nerves in the upper limb were established in our EMG lab in Kuwait. The mean motor nerve conduction parameters for the median and ulnar nerves compare favourably with the existing literature data. However, for the sensory nerves, higher value for the nerve action potential amplitude was demonstrated in the study. Gender was shown to have a significant effect on the sensory amplitude of the median and ulnar nerves.

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Introduction

Nerve conduction studies are routinely performed in electrodiagnostic medicine as an important method to evaluate peripheral nerve function. They help in the diagnosis, prognosis, extent and distribution of peripheral nerve injury. Many studies have been published from the Western countries regarding normative data for the nerves of the upper and lower limbs [1–6]. To the best of our knowledge no study has been performed in the Middle East.

For the last two decades, the electrophysiology laboratory has been using standard values used by the US, Canada and Europe to diagnose different neurological problems. We were therefore interested to obtain a set of data in healthy adults in order to establish reference values for our EMG laboratory and to compare our values with other published data in the literature.

For the upper limb, the median ulnar and radial nerves are the three most commonly tested nerves with published normative data. A number of factors need to be considered when establishing normative electrophysiological data. These are standardized measurements, temperature control, height, and age of normal healthy individuals. Some studies considered one or more of these factors, while Hennessey et al. [1] have looked at all these factors in their study of the median and ulnar nerves.

This paper provides normative electrophysiological data for the median, ulnar and radial nerves in carefully screened healthy adult individuals using standard distances and temperature control.

Subjects and Methods

Fifty healthy individuals, aged 16–56 years ($\bar{x}$ = 34.9), were included in the study. These included 32 women ($\bar{x}$ = 32.6) and 18 men ($\bar{x}$ = 39). All individuals

were screened, and inclusion criteria were young adults with no history of systemic or neuromuscular diseases, normal neurological examination and normal laboratory findings including blood sugar level, electrolytes and renal function. A standardized questionnaire was used to exclude those with a history of systemic or neuromuscular diseases. The following individuals were excluded: those individuals above age 60, those with a history of alcohol abuse or medications that might affect the results, and those with a history of diabetes, hypothyroidism and systemic diseases. None of the individuals were taking any medication at the time of the study. A simple neurological examination was performed including muscle power testing, muscle stretch reflexes and sensation including superficial and deep sensory testing. Room temperature was 25 °C and skin temperature at the palm of the individual was recorded immediately before the study using temperature probe No. 92E 46515 for the Nicolet Viking II machine. The study was performed when the temperature of the skin was between 32 and 35 °C as was suggested by Denys [7]. The study was performed with the subject sitting comfortably in the upright position. A standardized technique was used to obtain and record action potentials for motor and sensory studies [2, 6, 8].

Motor and sensory studies were performed on the ulnar and median nerves, both proximally and distally along the forearm. The radial sensory nerve was examined distally along the forearm. The ground electrode was placed on the dorsum of the hand between stimulating and active electrodes. Standardized techniques were used to obtain and record action potentials. For sensory studies, the radial, median and ulnar nerves were examined antidromically. The active ring electrode was placed over the 1st, 3rd and 5th digit to record responses along the radial, median and ulnar nerves, respectively. The reference electrode was placed about 4 cm distal to the active electrode. Median nerve stimulation was performed at 13 cm proximal to the active electrode and medial to the flexor carpi radialis tendon. For the ulnar sensory nerve stimulation was performed 10 cm proximal to the active electrode and posterior to the flexor carpi ulnaris tendon. Radial nerve stimulation was performed 10 cm proximal to the active electrode along the lateral border of the radius. For motor studies, ulnar and median nerves were examined orthodromically. The active electrodes were placed over the motor point of the abductor pollicis brevis for the median nerve, and over the abductor digiti minimi for the ulnar nerve. The reference electrode was placed 4 cm distally over the 1st metacarpophalangeal joint for the median nerve and over the 5th metacarpophalangeal joint for the ulnar nerve. Distal

stimulations were performed 8 cm proximal to the active electrode and medial to the flexor carpi radialis tendon for the median nerve and posterior to the flexor carpi ulnaris for the ulnar nerve. Proximal median nerve stimulation was performed medial to the biceps tendon at the elbow crease, whereas for the ulnar nerve, proximal stimulation was just distal to the medial epicondyle with the elbow in 70° of flexion. Hennessey et al. [1] found that sidedness did not affect conduction variables. The dominant side was therefore chosen for the study, and the majority of the individuals were right-handed.

A Nicolet Viking II EMG instrument was used in the study. Filters were set at 2 Hz and 5 kHz for motor studies and at 20 Hz and 2 kHz for sensory studies. The sweep speed was set at 2 ms/division, 1-cm disc recording electrodes were used for motor studies and ring recording electrodes were used for sensory studies. Supramaximal stimuli were delivered in order to get adequate responses. Data were collected for the following parameters: onset latency, conduction velocity and action potential amplitude measured from the peak of

the negative potential to the peak of the positive potential. The Student t test was used to assess the significance between the means of males and females. The value $p < 0.05$ was used as cut-off level for statistical significance.

Results

Fifty individuals aged 16–56 years ($\bar{x} = 34.9$) including 32 women (age $\bar{x} = 32.6$) and 18 men (age $\bar{x} = 39$) participated in the study. Data from the upper limb of all the individuals were keyed in the computer using the Statistical Package for Social Sciences (SPSS) for data processing. Descriptive statistics for continuous variables included the mean and the standard deviation. Arm lengths ranged from 65 to 86 cm with a mean value of 77.6 cm for males and 73.6 cm for females. The majority of the individuals were right-handed.

The mean and standard deviation for the median and ulnar motor nerves and for the median, ulnar and radial sensory nerves are summarized in tables 1 and 2. Data are separately analysed for males and females. There was no statistically significant difference in median and ulnar motor parameters, as well as distal latency, conduction velocity of the median, ulnar and radial sensory nerves. Only the sensory action potential amplitude was found to be significantly influenced by gender for the median and ulnar nerves.

Table 1. Motor nerve parameters (mean, SD)

Nerve	DL, ms ^a	NCV, m/s	CmaPA, mV ^b
Median	3.1 (0.3)	56.5 (3.5)	11.07 (2.8)
Ulnar	2.4 (0.3)	60.4 (5.0)	9.2 (2.2)

DL = Distal motor latency measured from the onset of action potential; NCV = nerve conduction velocity; CmaPA = compound muscle action potential amplitude measured from peak to peak.

Table 2. Sensory nerve parameters (mean, SD)

Nerve	DL, ms*	NCV, m/s	SNAPA, μV^{**}	
			male	female
Median	2.3 (0.3)	56.6 (7.6)	63.3 (18.9)*	79.3 (28.8)*
Ulnar	2.0 (0.2)	52.3 (5.3)	54.5 (18.4)**	63.9 (16.8)**
Radial	1.95 (0.3)	52.3 (7.5)		18.6 (5.5)

DL = Distal latency; NCV = nerve conduction velocity; SNAPA = sensory nerve action potential amplitude. * $p < 0.04$, ** $p < 0.07$.

Table 3. Comparison of nerve conduction parameters of median and ulnar nerves between the present study and those reported by others

Nerve conduction parameters	Present study (n = 50)		Hennessey et al. [1] (n = 44)		Robinson et al. [9] (n = 44)		Falco et al. [2] (n = 51)	
	mean (SD)	95% CI	mean (SD)	95% CI	mean (SD)	95% CI	mean (SD)	95% CI
<i>Motor</i>								
<i>Ulnar nerve</i>								
DL	2.4 (0.3)	2.4– 2.6	2.6 (0.3)	2.5– 2.6	2.9 (0.4)	2.7– 3.0	2.7 (0.3)	2.6– 2.8
CMAPA	9.2 (2.2)	8.6–10.1	12.6 (2.3)	11.9–13.3	8.4 (2.1)	7.7– 9.0	9.9 (1.8)	9.3–10.4
CV	60.4 (5.2)	59.5–62.4	63 (4.8)	61.5–64.4	56.3 (6.2)	54.4–58.1	61.6 (4.1)	60.4–62.1
<i>Median nerve</i>								
DL	3.1 (0.3)	3.0– 3.26	3.2 (0.4)	3.0– 3.3	3.6 (0.4)	2.7– 3.0	3.5 (0.5)	2.3– 2.6
CMAPA	11.1 (2.8)	10.1–13.0	12.1 (3.8)	10.9–13.2	9.5 (2.9)	7.7– 9.0	9.2 (3.1)	8.3–10.0
CV	56.5 (3.5)	55.5–57.5	59.5 (4.40)	58.1–60.8	54.4 (3.8)	54.4–58.1	54.4 (5.4)	52.8–55.9
<i>Sensory nerve</i>								
<i>Ulnar</i>								
DL	2.0 (0.2)	1.8– 2.0	2.4 (0.2)	2.3– 2.4	3.6 (0.3)	3.5– 3.7	2.6 (0.3)	2.5– 2.6
SNAP	54.5 (18.4) ^a	45.4–63.7	52.4 (14.3) ^a	48.0–56.7	32.3 (13.1) ^a	28.3–36.2		
	63.9 (16.8) ^b	62.1–81.2	52.9 (13.9) ^b	48.6–57.1	36.5 (16.2) ^b	31.5–41.4	27.1 (11.5)	23.8–30.3
CV	52.1 (7.5)	51.6–55.4	64.0 (6.9)	61.9–66.1	57.7 (5.6)	56.0–59.4	60.0 (7.5)	57.8–62.1
<i>Median</i>								
DL	2.3 (0.3)	2.2– 2.4	2.5 (0.2)	2.4– 2.5	3.7 (0.3)	3.6– 3.8	2.8 (0.4)	2.6– 2.9
SNAP	63.3 (18.9) ^a	53.8–72.7	31.4 (8.2) ^a	28.7–34.0	35.6 (11.8) ^a	32.0–39.1	27.1 (11.2)	23.9–30.2
	79.3 (28.8) ^b	68.9–89.7	27.0 (7.8) ^b	24.6–29.3	41.8 (15.4) ^b	37.1–46.4		
CV	56.6 (7.6)	54.4–58.8	61.2 (4.3)	59.8–62.5	54.6 (3.7)	53.4–55.7	56.0 (4.5)	54.7–57.2

n = Number of cases; 95% CI = 95% confidence interval; DL = distal latency; CMAPA = compound muscle action potential amplitude; CV = conduction velocity; SNAP = sensory nerve action potential.

^a Sensory nerve amplitude for males.

^b Sensory nerve amplitude for females.

Discussion

This study examined the nerve conduction parameters of the most commonly tested nerves in the upper limb of a healthy adult population in Kuwait to provide normative and reference values in our EMG lab. A comparison was made between this study and other studies published in the literature, and since numerous studies have been published, the few that used standardized techniques and recorded limb temperature and age of the subjects [1, 2, 6, 9] were chosen. The results of this study for the motor parameters of the ulnar and median nerves agree generally with Hennessey et al. [1] and Falco et al. [2] (table 3).

For the sensory parameter, we have demonstrated that gender affects sensory nerve amplitude for the median and ulnar nerves, as was demonstrated by others [3, 10]. Arm length has no effect on nerve conduction velocity, in contrast to the influence of leg length and height on nerve conduction study of the leg [14–16]. The effect of gender on the sensory nerve action potential amplitude was studied before. Hennessey et al. [3] found that there is no influence of gender for nerve conduction velocity and distal latency but the effect of gender is only significant and affects the sensory nerve potential amplitude [3, 15]. This difference of sensory potential amplitude in males and females has been explained

Table 4. Sensory radial nerve parameters

Author	Cases, n	Distance, cm	DL, ms	Amplitude ^b , μ V	NCV, m/s
Present study	50	10	1.95 (0.3)	18.6 (5.5)	53.1 (8.7)
Hoffmann et al. [17]	33	14	2.2 (0.3)	32.0 (18)	–
Shirali et al. [18]	32	4	1.3 (0.2)	54.3	65.0 (3.97)
Johnson et al. [6]	78	10	2.4 ^a (0.2)	12.0 (1.0)	–
Falco et al. [2]	51	10	2.0 (0.2)	16.5 (13.8)	–

DL = Onset distal latency; NCV = nerve conduction velocity.

^a DL measured as a peak latency.

^b Amplitude, base to peak.

by Bolton and Carter [10], because of varying finger circumferences between men and women, rather than as a direct gender influence. Stetson et al. [14] have elaborated on this fact, since thicker subcutaneous tissue in a finger of greater diameter may diminish the amplitude by providing greater distance between digital nerves and the surface ring electrode. The sensory nerve action potential amplitude for median and ulnar nerves were higher than the data published in the literature. We have measured the amplitude from the peak of the negative potential to the peak of positive potential rather than from the baseline to the peak of the negative potential, which could be the reason for the difference. For the radial sensory nerve our results were similar to those of Falco et al. [2] at 1.95 ± 0.3 ms compared to 2.0 ± 0.2 ms (table 4) and the amplitude was 18.6 ± 5.5 compared to 16.5 (13.8).

Conclusion

Normative conduction parameters of commonly tested peripheral nerves in the upper limb were established for our EMG lab in Kuwait. The overall mean motor nerve conduction parameters for the median and ulnar

nerves compared favourably with the existing literature data [1, 2, 8, 9, 11–13] while for the sensory nerves, higher values for potential amplitudes were demonstrated in this study, possibly because of the different methods of measurement. Also, gender has been shown to have an effect on the sensory potential amplitudes for median and ulnar nerves, as was shown by studies.

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