Electrophysiological study of the ulnar palmar cutaneous nerve in normal individuals

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Introduction
The electrophysiological assessment of the ulnar palmar cutaneous nerve (UPCN) is clinically essential to assess the integrity of this nerve in some clinical situations that involve compression or injury of this nerve.
Aim
This study proposed to assess the electrophysiological antidromic technique of the UPCN
and to obtain normal reference values for the electrophysiological parameters of this nerve.
Settings and design
It is a single-center public hospital-based electromyography laboratory. It is a cross-sectional study of consecutive apparently healthy volunteers.
Patients and methods
The study included 70 apparently healthy volunteers. Antidromic sensory nerve conduction study of the UPCN was carried out.
Statistical analysis
Quantitative data were analyzed using Student's *t*-test and paired *t*-test. Correlation was tested using the Pearson correlation test.
Results
The present study included 119 hands of 70 healthy individuals [36 (51.43%) women]. Their mean age was 41.91±13.21 years. The UPCN was elicited in 116 (97.48%) hands. The estimated reference values (mean±2 standard deviations) for the UPCN sensory nerve action potential were determined for onset latency (≤2.1 ms), peak latency (≤2.8 ms), conduction velocity (≥46.4 m/s), amplitude (≥6.9 μV), and interside sensory nerve action potential amplitude ratio (≥0.50).
Conclusion
This study provided a feasible electrophysiological antidromic technique and normal reference values for sensory conduction study of the UPCN.

Keywords:
antidromic technique, palmar cutaneous nerve, sensory nerve conduction study, ulnar nerve, ulnar palmar cutaneous nerve

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Introduction

The ulnar palmar cutaneous nerve (UPCN), also known as the palmar cutaneous branch of the ulnar nerve, is a branch of the ulnar nerve [1–6]. The electrophysiological assessment of the UPCN is clinically essential to assess the integrity of this nerve, as well as the ulnar nerve, in some clinical situations that involve compression or injury to these nerves [7–9]. There is only one study that assessed the sensory conduction of this nerve orthodromically [10].

This study proposed to assess the electrophysiological antidromic technique of the UPCN and to obtain normal reference values for the electrophysiological parameters of this nerve.

Patients and methods

The present cross-sectional study included 119 hands of 70 apparently healthy volunteers. The volunteers included medical staff, their relatives, and the relatives of patients attending the outpatient clinic of Department of Physical Medicine, Rheumatology and Rehabilitation, Main University Hospital, Alexandria Faculty of Medicine. All of them had no risk factors for neuropathy, such as diabetes mellitus, rheumatologic disorders, endocrine disorders, and metabolic disorders, and had normal neurological examination results. The study was explained to the participants and informed consent was obtained from each participant. The study had been approved by the Ethical Committee of the Faculty of Medicine, Alexandria University, Egypt.

Demographic data were taken and height was measured. Sensory nerve conduction study of the UPCN was carried out using the antidromic technique (similar to Stowell and Gnatz orthodromic technique with modification) [10,11]. The electrophysiological study was performed using a Nihon Kohden Neuropack MEB-7102 mobile unit with a two-channel evoked potential/EMG measuring system (Nihon Kohden Corporation, Tokyo, Japan). Skin temperature at the site of the recording electrodes was maintained around 32–34°C with hot packs. The skin surface was cleansed adequately before placing the recording surface disc electrodes. The active recording surface disc electrode was attached to the palmar aspect of the hypothenar eminence over the fifth metacarpal bone halfway between the pisiform bone and midcrease of the fifth metacarpophalangeal joint. The reference surface disc electrode was placed 3 cm distal to the active surface disc electrode distal to the fifth metacarpophalangeal joint on the fifth digit. Electrical stimulation was applied proximal to the proximal wrist crease just lateral to the flexor carpi ulnaris tendon 10 cm proximal to the active recording surface disc electrode using a bipolar stimulator. The ground electrode was placed between the recording electrodes distally and the bipolar stimulator proximally. Conduction distance was measured with a measuring tape with a precision of 1 mm. The sweep speed was 2 ms/division and the sensitivity was 5–10 μV/division. The filter bandwidth was 20 Hz–2 kHz. The bipolar stimulator had a production current ability of 50 mA. The pulse duration was 0.1–0.2 ms. Supramaximal stimulation was ensured. Signal averaging was applied. Responses were recorded twice and were superimposed to ensure reproducibility. Measurements of sensory nerve action potential (SNAP) included the following parameters: latency (onset and peak), amplitude, and conduction velocity (CV). The onset latency was measured from the onset of stimulus artifact to the onset of initial negative deflection of SNAP expressed in milliseconds. The peak latency was measured from the stimulus artifact onset to the peak of the negative deflection of SNAP expressed in milliseconds. The amplitude was measured from the baseline to the negative peak expressed in microvolt. The CV was measured in meter per second using onset latency [12]. In addition, side-to-side differences in the onset latency, peak latency, and CV, and interside amplitude ratio (smaller amplitude/larger amplitude) were calculated among individuals who had UPCN SNAP recorded bilaterally.

Statistical analysis of data was performed using the statistical package for the social sciences (SPSS, version 17) software [13]. Descriptive measures [count, frequency, minimum, maximum, mean, and standard deviation (SD)] and analytic measures (Student's *t*-test and paired *t*-test) were used. Student's *t*-test was used to compare the numerical variables, including age, height, UPCN SNAP onset latency, peak latency, CV, and amplitude between male and female participants. The paired *t*-test was used to compare the numerical variables, including UPCN SNAP onset latency, peak latency, CV, and amplitude between the right and left hands of the same individual among the individuals who had UPCN SNAP recorded bilaterally. Correlation was tested using the Pearson correlation test. Statistical significance was assigned to any *P* value at less than 0.05. The reference cutoff values of the electrophysiological parameters were calculated by rounding the mean±2 SD to the nearest 10th to measure the upper limit of normal or the lower limit of normal, respectively.

Results

The present study included 119 hands of 70 healthy volunteers [34 (48.57%) men and 36 (51.43%) women]. Their mean age was 41.91±13.21 years (range: 19–71 years). Their mean height was 161.71±5.93 cm (range: 149–175 cm). There was no statistically significant difference between men and women as regards age (t=–1.029; P=0.305) and height (t=–1.780; P=0.078). Bilateral study was conducted on 46 (65.71%) healthy volunteers [20 (43.48%) men and 26 (56.52%) women]. Unilateral study was conducted for 24 (34.29%) healthy volunteers [14 (58.33%) men and 10 (41.67%) women].

In 116 (97.48%) hands, UPCN SNAP was obtained. There were three healthy volunteers (one man and two women) with unobtainable UPCN response on one hand each [three (2.52%) hands] and obtainable UPCN response on the other hand. These three hands with unobtainable response were excluded from the results. All participants tolerated the study well. Reference values for the different parameters of the UPCN SNAP are shown in Table 1. An example of a typical UPCN SNAP is illustrated in Fig. 1. It is noted that the volume-conducted motor potential that immediately follows the UPCN SNAP is a finding that was present in most of the studied hands.

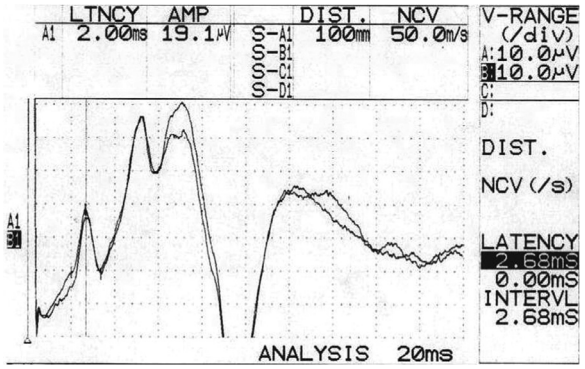
There were no statistically significant differences between UPCN SNAP parameters between the right and left hands of the same individual among the 46 individuals who had UPCN SNAP recorded bilaterally (onset latency, t=0.422 and P=0.674; peak

Table 1 Reference values of the ulnar palmar cutaneous nerve sensory conduction study

UPCN SNAP parameters	Mean±SD	Range	NL	Rounded NL
Onset latency (ms)	1.72±0.17	1.36–2.10	2.06	2.1
Peak latency (ms)	2.41±0.20	2.00–2.92	2.81	2.8
CV (m/s)	58.52±6.07	47.60–73.50	46.38	46.4
SNAP amplitude (μV)	19.03±6.09	7.56–44.00	6.85	6.9

CV, conduction velocity; NL, upper (latency) or lower (conduction velocity and amplitude) limit of normal; SD, standard deviation; SNAP, sensory nerve action potential; UPCN, ulnar palmar cutaneous nerve.

Figure 1



This is an illustration of two sensory nerve action potentials of the right ulnar palmar cutaneous nerve of a healthy man. Each sensory nerve action potential is followed by volume-conducted motor potential of the hypothenar muscles.

latency, t=0.298 and P=0.766; CV, t=−0.402 and P=0.689; SNAP amplitude, t=0.716 and P=0.476). The intrasubject side-to-side differences of the UPCN SNAP parameters are tabulated in Table 2.

There were no statistically significant differences between UPCN SNAP onset latency, peak latency, and SNAP amplitude between men and women (onset latency, t=0.706 and P=0.482; peak latency, t=1.040 and P=0.301; CV, t=−0.756 and P=0.451). However, there was a statistically significant difference between men and women as regards UPCN SNAP amplitude (t=−2.221 and P=0.028): the UPCN SNAP amplitude was larger among men in comparison to women (UPCN SNAP amplitude among men was 20.67±6.98 versus 18.10±5.35 μV among women). There was no statistically significant correlation between the participant's age and the UPCN SNAP peak latency and CV (r=−0.013 and P=0.886; r=0.050 and P=0.592, respectively), as well as the amplitude (r=0.092 and P=0.632). In addition, there was no statistically significant correlation between participant's height and UPCN SNAP peak latency and CV (r=−0.038 and P=0.683; r=−0.061 and P=0.519, respectively).

Table 2 Intrasubject side-to-side differences in the ulnar palmar cutaneous nerve sensory nerve action potential parameters (46 pairs of hands had obtainable sensory nerve action potentials bilaterally)

UPCN SNAP parameters	S-S Δ (mean±SD)	NL	Rounded NL
Onset latency (ms)	0.17±0.09	0.35	0.4
Peak latency (ms)	0.17±0.13	0.43	0.4
CV (m/s)	5.72±3.26	12.24	12.2
Interside amplitude ratio	0.75±0.14	0.47	0.5

CV, conduction velocity; NL, upper (latency and conduction velocity) or lower (interside amplitude ratio) limit of normal for side-to-side difference; SD, standard deviation; SNAP, sensory nerve action potential; S-S Δ, intrasubject side-to-side difference; UPCN, ulnar palmar cutaneous nerve.

Discussion

The UPCN is a branch of the ulnar nerve. Its nerve roots are the seventh and eighth cervical nerve roots. It arises from the ulnar nerve in the distal forearm segment. It arises proximal to the exit of the dorsal cutaneous branch of the ulnar nerve. It travels on the lateral aspect of the ulnar artery [1,2]. It usually perforates the fascia of the anterior forearm just proximal to the distal wrist crease, and then it passes superficial to the transverse carpal ligament [3]. The UPCN lies lateral to the flexor carpi ulnaris tendon and medial to the palmaris longus tendon at the level of the wrist. It provides sensation to the medial one-third of the palm of the hand. UPCN is a pure sensory nerve. Sometimes it carries motor nerve supply to the palmaris brevis muscle [1–5]. It does not pass through Guyon's canal, and hence the UPCN is not involved in ulnar neuropathy at the wrist [6].

There are various available electrophysiological methods that evaluate conduction of the sensory and motor fibers of the ulnar nerve, as well as other branches of the ulnar nerve, such as the dorsal cutaneous branch and the deep palmar motor branch [4]. However, there is no well-assessed electrophysiological technique for directly assessing the conduction along UPCN antidromically. This study was conducted aiming to assess an antidromic sensory nerve conduction study for the UPCN and to obtain normal reference values for the electrophysiological parameters of this nerve.

The UPCN SNAP was recorded in 97.48% of studied hands. Its antidromic technique was not difficult to perform. This antidromic technique allows eliciting UPCN SNAP of higher amplitude [4]. Because of

the small innervated area of UPCN at the hypothenar eminence, the electrophysiological study of this nerve should be conducted with caution. The recorded SNAP waveform had appeared in most of the studied volunteers followed by volume-conducted motor potential. This volume-conducted motor potential is secondary to the orthodromic spread of excitation along the ulnar nerve motor fibers, resulting in depolarization of the hypothenar muscles that immediately follow the UPCN SNAP and can obscure it. This finding was present in most of the studied hands, especially with the use of high stimulus intensity. It was important to increase the stimulation intensity slowly during the recording of UPCN SNAP. This aimed to record the potential at a low level of stimulation intensity inadequate to stimulate ulnar motor fibers, to prevent the appearance of the volume-conducted motor potential [4].

The explanation of the unobtainable response in 2.52% of studied hands can be due to three causes. First, the point of stimulation is located at the course of the ulnar nerve in the wrist where the ulnar nerve is inadvertently stimulated, causing a volume-conducted motor potential that interferes with the recording of the UPCN SNAP. Second, the congenital absence of the UPCN with the presence of a variant, which arises as a branch of the dorsal branch of the ulnar nerve. Third, an anomalous innervation in which the palmar cutaneous branch of the median nerve innervates the entire palm (i.e. its territory in association with the territory of UPCN). This situation can present as apparently absent UPCN response during nerve conduction study [5,7].

There were little intrasubject side-to-side differences as regards UPCN SNAP onset latency, peak latency, and CV measurement. The obtained interside amplitude ratio of UPCN SNAP was 0.75±0.14 (estimated rounded lower limit of normal was 0.5). Thus, it was suggested that, when the amplitude of the affected side is less than 50% of the normal healthy contralateral side, it can be used as an indication of axonal nerve lesion affecting the UPCN [4].

In the current study, there was no significant difference between men and women as regards UPCN SNAP onset latency, peak latency, and CV, but men had significantly larger UPCN SNAP amplitude compared to women. The current study is in agreement with that of Garg *et al*. [14] in which there was no influence of sex on the nerve CVs. However, the present study is not in accordance with that reported in the literature, in which women had larger SNAP amplitude [14–17] and faster sensory CV compared with men [15,18,19]. The differences between the results of the current study and the results published in the literature could be due to a variety of causes. First, it could be due to differences in the mean age and height of the studied participants in the current study in comparison with other studies [15,19]. In the studies of Karnain *et al.* [15] and Balasubramaniam *et al*. [19], the mean age of the studied participants was younger and men were taller than that reported in the current study. Second, it could be due to the absence of homogeneity between men and women as regards their height [15,19]. In the current study, there was no statistically significant difference between men and women as regards age and height. Third, it could be due to racial differences between the studied participants in different studies and the current study. Different studies were conducted on different racial and ethnic groups [14–20]. It was reported that racial factor had an effect on nerve conduction study parameters [20]. Fourth, previous studies assessed the effect of sex on the median and ulnar SNAPs using the antidromic technique and recorded from the fingers [15,17,19]. However, in the present study the UPCN SNAP was recorded from the palm and there were no previous studies on the UPCN that could be used for comparison assessed this issue. Finally, the diversity of the methods and techniques, which includes differences in the maneuvering, setting used in recording of the electrical responses, as well as the type of electrodes and the equipment that were used, could be a source of this variation [14]. However, it was reported that, although sex is known to affect nerve conduction values, it is not quantitatively sufficient to require individual correction [21].

There was no significant correlation between participant's age and UPCN peak latency, CV, and UPCN SNAP amplitude. During adulthood, the effect of age is minimal. Age has influence at extremes of age. The effect was obscured by the wide range of normal values [4,21]. There was no significant correlation between participant's height and UPCN SNAP peak latency and CV. This is in agreement with the findings of Soundman *et al.* [22] and Rivner *et al.* [23]. The effect of height on CV is apparent in nerve conduction studies of the lower limbs [21].

There was a single study that described an orthodromic method for recording SNAP of the UPCN. Stowell and Gnatz [10] recorded UPCN SNAP in a sample of 20 healthy volunteers. Their ages ranged from 22 to 58

years (mean: 35.2 years). They reported that UPCN SNAP peak latency was 2.19±0.17 ms and amplitude recorded at wrist was 12.7±6.9 μV [10]. The current study is in agreement with that of Stowell and Gnatz [10] as regards the peak latency. The current study is not in accordance with that of Stowell and Gnatz [10] as regards their SNAP amplitude, which was smaller than that obtained in the current study. The larger SNAP amplitude in the present study can be attributed to the use of the antidromic technique. The antidromic technique is better than the orthodromic technique for eliciting a SNAP of higher amplitude because the thickness of tissues between the recorded nerve and the recording surface electrodes is less when compared with the orthodromic technique in which the nerve is relatively deep in the wrist [4].

The electrophysiological assessment of the UPCN is clinically essential to assess the integrity of this nerve in many clinical situations involving it. Thus, this UPCN sensory conduction study will increase the awareness of UPCN injuries. This can be represented in the following conditions. Compression of the UPCN can occur by subcutaneous cystic lesions such as ganglion that occurs along its course in the forearm and wrist. Traumatic injury of the UPCN can take place secondary to cut wounds and laceration along its course. Iatrogenic injury of the UPCN can occur during surgical procedures in the wrist region, such as carpal tunnel decompression surgery [7,8]. The application of self-retainer retractors during wrist and forearm surgery applied close to the nerve with undue tension can apply high pressure and unfortunately cause a traction or pressure neuropathy, which is usually a sort of neuropraxia [8]. Ulnar neuropathy at the elbow can be presented with paresthesia and hypoesthesia along the sensory territory of the UPCN [9]. The UPCN has potential clinical value in the evaluation of peripheral neuropathy in upper limbs by determining the proximal extension of peripheral neuropathy among patients with finger amputation and in those with severe swelling of the fingers rendering routine nerve conduction study of the ulnar and median sensory nerves recording digits technically difficult to perform. UPCN has a role in the localization of ulnar neuropathy at the wrist [24]. In this situation, the presence of normal UPCN is a localizing sign.

The UPCN SNAP recorded over the hypothenar area could be a volume-conducted SNAP from the superficial sensory branch of the ulnar nerve supplying the medial one and half digits recorded on the palm. However, Stowell and Gnatz [10] reported a case with injury of the superficial sensory branch of the ulnar nerve. This case was associated with sparing of the UPCN, which was recorded electrophysiologically [10]. Further studies are needed to explore this point of conflict.

This technique for electrophysiological assessment of UPCN is an addition that allows the assessment of the UPCN directly. This antidromic technique for recording UPCN SNAP makes electrophysiological assessment of all branches of the ulnar nerve to be reachable.

Conclusion

This study provided a feasible electrophysiological antidromic technique and normal reference values for sensory nerve conduction study of the UPCN. This is useful for evaluation of patients with suspected UPCN lesion.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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