

MEDIAN NERVE IMAGING USING HIGH-RESOLUTION ULTRASOUND IN HEALTHY SUBJECTS

Dražen Ažman, Jelena Bošnjak, Maja Strineka, Raphael Béné, Mislav Budišić, Arijana Lovrenčić-Huzjan and Vida Demarin

University Department of Neurology, Reference Center for Neurovascular Disorders and Reference Center for Headache of the Ministry of Health and Social Welfare of Republic of Croatia, Sestre milosrdnice University Hospital, Zagreb, Croatia

SUMMARY – Although electroneuro- and electromyography are still the leading diagnostic methods for investigation of peripheral nerve function, they do not provide information on their morphology. This study was conducted to evaluate the suitability of ultrasonography in visualization of median nerve in healthy volunteers. Twenty-five asymptomatic volunteers (17 women and 8 men), age range 21-47 years, participated in the study. Body height was measured and handedness ascertained, as well as average time spent daily working on a computer. The device used was Aloka Prosond Alpha10 Premier with a 13-MHz probe, using custom preset for musculoskeletal sonography. The following dimensions of median nerve at the pisiform bone level were measured bilaterally: cross-sectional area (CSA), circumference, and longer and shorter diameter. Using the latter values, the flattening ratio (FR) was calculated. Median nerve and the surrounding soft tissue structures were easily depicted in all study subjects. The mean median nerve CSA was 9.70 mm² (range 5-15 mm², SD 2.25 mm²), mean FR (longer/shorter diameter) 4.04 (range 2.16-6.08), and median height 172.72 cm. Only one subject was left-handed. The mean time spent daily working on a computer (overall mean of 3.2 h/day) did not correlate with either CSA or FR for the dominant hand. In four subjects, an aberrant artery accompanying median nerve was visualized. High-resolution sonographic imaging is a fast and noninvasive method for assessment of various morphological properties of median nerve and can be used to enhance diagnostic efficiency.

Key words: *Median nerve – physiopathology; Median nerve – ultrasonography; Carpal tunnel syndrome – diagnosis; Carpal tunnel syndrome – physiopathology*

Introduction

In daily neurologic clinical routine, electroneurophysiological methods such as electroneuromyography and nerve conduction studies are still the leading diagnostic approaches to evaluate median nerve and other peripheral nerve pathology. However, these methods offer only evaluation of peripheral nerve function, while providing no data on their morphol-

ogy or the possible visible pathomorphology of the surrounding structures and tissues.

Ultrasonography is generally considered a convenient diagnostic method, due to its wide availability, dynamic approach, mobility, rapid performance, noninvasiveness, and relatively low price as compared to magnetic resonance and similar radiologic procedures. Foundations of the ultrasound imaging technology and its wide range of application in medicine are already well-known^{1,2}.

This brings forward the usage of ultrasonography in visualizing and evaluating the morphology of median nerve and other peripheral nerves. Several studies

Correspondence to: Dražen Ažman, MD, University Department of Neurology, Sestre milosrdnice University Hospital, Vinogradska c. 29, HR-10000 Zagreb, Croatia

E-mail: drazen.azman@sb.t-com.hr

have previously reported the possibility of peripheral nerve imaging with ultrasonography³⁻⁹, and only most recent ones^{10,11} used high-resolution ultrasonography. Only a few studies found in most relevant literature on ultrasonography used high-resolution imaging of median nerve in healthy subjects. Data on median nerve dimensions in healthy subjects are therefore limited.

Progress of ultrasound technology has increasingly enabled detailed and informative study of peripheral nerve morphology and its possible pathologic conditions. Using high-resolution ultrasonography, an experienced sonographer is able to examine median nerve along its course in the arm, from axillary region all the way to its ramification in the hand, and to evaluate its shape, size and echoic structure.

The aim of this study was to assess the suitability of high-resolution ultrasonography in visualization of median nerve in the carpal tunnel region, to describe its appearance on sonogram, and to obtain values of several morphological median nerve dimensions. The latter can serve as reference values for comparison with values measured in different pathologic conditions in future studies. Additionally, we wanted to compare our results with data found in the abovementioned reports.

Subjects and Methods

Sonographic evaluation of median nerve was performed in 50 wrists of 25 asymptomatic volunteers, 17 women and 8 men. Study subjects were members of medical personnel from our clinical ward and students without symptoms of carpal tunnel syndrome or any medical condition that could affect peripheral nerves. Their mean age was 31.08 (range 21-47) years and mean height 172.72 (range 160-195) cm. Right hand was dominant in 24 subjects, and only one subject was left-handed. Additional demographic data referred to the mean time spent daily working on a computer or typewriter (PCt). The mean PCt was 3.2 h/day.

The device used in the study was Aloka Prosound Alpha10 Premier with a 13-MHz linear probe, using custom preset for musculoskeletal sonography. A sufficient amount of gel was used to increase transmission of ultrasound and care was taken not to compress the anatomic structures to be examined. Ultrasound images were also printed on thermal paper. The following median nerve dimensions were measured bi-

laterally at the pisiform bone level of carpal tunnel: cross-sectional area (CSA), circumference, and longer (Dl) and shorter (Ds) diameter. The CSA and diameters were automatically calculated by using the built-in elliptical selection and/or caliper selection tool. In this study, no measures were taken on median nerve longitudinal scans. Using the latter values, the flattening ratio (FR) was calculated by the following formula: $FR = Dl/Ds$.

On statistical analysis, linear correlation was used to determine the possible association between personal computer/typewriter usage and size of CSA and FR on median nerve in dominant hand. Two-tailed T-test was employed to determine statistical significance in median nerve dimensions between dominant and non-dominant hand.

Results

Median nerve and surrounding structures and tissue were easily depicted in all subjects. Located in the carpal tunnel and viewed at the level of pisiform bone, median nerve is situated under the transverse carpal ligament and on top of flexor tendons of the hand (Fig. 1). On transverse section, it presents with a variably echogenic inner structure and consistently hyperechoic sheath. Longitudinal section shows median nerve as an elongated structure with hyperechoic borders and hypoechogenic inside with slightly hyperechogenic longitudinal fibers (Fig. 2). At the men-



Fig. 1. Transverse section of median nerve in carpal tunnel.



Fig. 2. Longitudinal section of median nerve.

tioned level, median nerve is usually compressed in dorso-palmar direction with longer diameter in radio-ulnar direction. On finger movements, the shape of the nerve varies due to changes in the anatomic relationships within the carpal tunnel, indicating softer consistency compared to tendons. However, the position of the nerve does not change, as reported in previous studies^{3,4}.

The mean CSA was 9.70 mm², range 5–15 mm² and standard deviation of 2.25 mm². The mean FR was 4.04, range 2.16–6.08. The mean FR of median nerve was slightly higher in dominant hand than in non-dominant one, but the difference was not statistically significant ($P > 0.05$). There was no correlation



Fig. 3. Bifid median nerve (elliptic selections).



Fig. 4. Anomalous median artery (arrow) located between two parts of bifid median nerve.

between the mean PCt and either CSA or FR for dominant hand.

In one subject, a bifid median nerve and in four subjects anomalous median artery was visualized (Figs. 3 and 4), the latter commonly being a branch of radial artery that sonographically appears as a pulsatile vessel coursing with the median nerve.

Discussion and Conclusion

Our results indicated great inter-individual variability in the median nerve CSA as visualized in carpal tunnel. Comparison of our values with those of control groups in other studies^{6,12,13} showed some disparity regarding CSA values. The ones obtained in this study (mean CSA of 9.7 mm²) were somewhat higher than those reported elsewhere (Buchberger *et al.* 7.9 mm², Nakamichi *et al.* 5.2–5.4 mm², and Wiesler *et al.* 9 mm²)^{6,12,13}. This could be attributed to the small sample size. On the other hand, it may, at least partially, be ascribed to higher resolution of the image acquired and therefore greater detail provided in our study compared to previous studies. The more so, a recent study using high-resolution linear-array (11 MHz), reported by Yucel *et al.*, showed values (9.1 mm²) closer to ours¹⁰.

Furthermore, we wanted to assess the possible correlation between the mean PCt and median nerve CSA or FR in dominant hand, since it has been suspected to be an occupational risk factor for developing carpal tunnel syndrome. There was no correlation be-

tween PCt and median nerve CSA or FR, which is in line with some recent reports on the issue^{14,15} claiming the association between computer work and carpal tunnel syndrome (marked by compression of median nerve and, thus, probable change in its CSA or even more likely in FR)^{6,13,16-18}, to be at least controversial.

The present study was limited by the small sample size and similar working conditions of the many subjects included. Furthermore, control subjects, although without any neuromuscular symptoms, did not undergo electroneurophysiological evaluation for the possible carpal tunnel syndrome, hereditary or metabolic neuropathies or other subclinical pathologic conditions that could be accompanied with enlarged or atrophied peripheral nerves.

As mentioned above, we could not find any large systematic study using high-resolution ultrasound to define reference values for normal median nerve CSA and/or FR. Further extensive studies should be conducted to provide baseline for future research into median nerve pathology such as carpal tunnel syndrome, since there is already an increasing number of sonographic studies on this topic^{6,7,13,16-21}.

In conclusion, high-resolution ultrasonography proved to be very convenient and easily applicable method to image and evaluate various morphological properties of median nerve, and can therefore be used to enhance diagnostic efficiency.

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Sažetak

PRIKAZ MEDIJANOG ŽIVCA ULTRAZVUKOM VISOKE REZOLUCIJE U ZDRAVIH ISPITANIKA

D. Ažman, J. Bošnjak, M. Strineka, R. Béné, M. Budišić, A. Lovrenčić-Huzjan i V. Demarin

Iako su elektroneuro- i elektromiografija još uvijek vodeće dijagnostičke metode u ispitivanju funkcije perifernih živaca, one ne pružaju informacije o njihovoj morfologiji. Cilj studije bio je procijeniti prikladnost visokorezolucijske ultrasonografije u slikovnom prikazivanju medijanog živca u asimptomatskih dobrovoljaca. U studiji je sudjelovalo 25 asimptomatskih dobrovoljaca u dobi od 21 do 47 godina. Na uređaju Aloka Prosound Alpha10 Premier (sonda 13 MHz) izmjerene su obostrano slijedeće dimenzije medijanog živca (razina os pisiforme): površina presjeka (CSA, *cross-sectional area*), opseg, duži i kraći promjer, te je izračunat omjer stješnjenja (FR, *flattening ratio*). Izmjerena je visina ispitanika, utvrđena dominantnost ruke, kao i prosječno vrijeme koje ispitanici provedu na dan radeći za računalom (mogući čimbenik za kompresiju živca u dominantnoj ruci). Prosječna CSA medijanog živca bila je 9.70 mm² (raspon 5-15 mm², standardna devijacija od 2.25 mm²). Srednji omjer stješnjenja (duži promjer/kraći promjer) bio je 4.04, raspona od 2.16 do 6.08. Srednja visina ispitanika bila je 172.72 cm i samo je jedan ispitanik bio ljevak, dok je ostalima (96%) desna ruka bila dominantna. Prosječno vrijeme rada za računalom na dan (ukupni prosjek 3,2 h/dan) nije koreliralo s CSA ili FR dominantne ruke. Nadalje, u jednog je ispitanika nađen podvojeni medijani živac (*n. medianus bifidus*), dok se u dvoje ispitanika prikazala anomalna arterija koja prati medijani živac (*a. mediana*). Sonografski prikaz visoke rezolucije omogućuje utvrđivanje različitih morfoloških karakteristika medijanog živca, uključujući njegove različite dimenzije i eho arhitekturu. Uz to, ultrazvučni prikaz je izrazito prikladan (dostupan, brz, relativno jeftin i neinvazivan) kao metoda procjene morfologije perifernog živčevlja i može se stoga rabiti u svrhu povećanja dijagnostičke sigurnosti.

Ključne riječi: *Medijani živac – patofiziologija; Medijani živac – ultrazvuk; Sindrom karpalnog kanala – dijagnostika; Sindrom karpalnog kanala – patofiziologija*