High Resolution Sonography Of The Median Nerve: Normal Values In Healthy Bosnian Individuals

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***Abstract*—Introduction: High resolution ultrasound (US) is one of the most commonly used method for visualing the median nerve. One of the most important US features of the MN pathology is change of nerve size. Therefore it is crucial to have normal values of the MN routinelly assessed. The purpose of this study was to determinate the reference values for the cross sectional area (CSA) of the MN in a healthy Bosnian population.**

Participants and methods: One hundred healthy individuals were investigated with high resolution US at the Department of Neurology University Clinical Centre in Tuzla from January 2016 to June 2019. Participants were recruited from the hospital staff and medical students. Demographic data such as age, gender, height and body weight were recorded. Results: Average age of participants was 41.4± 6.1 years; weight 66.0± 3.1 kg and height 168 ± 3 cm. The 3 CSA measurements of the MN were carried out: MN at the mid-upper arm; MN at the distal third of the forearm and MN at the proximal entrance of the carpal tunnel. Mean CSA measures of MN ranged from to 5.6 to 8.9 mm^2.

Discussion: CSA measurements of the MN were dependent of age but independent of weight and height. Regarding gender, males had thicker nerves in the arm and carpal area. Several reports have been published on reference values for the CSA of the MN. The US is important as a diagnostic tool in pathology of NM due to dynamic examination, assesment of long median nerve segments in a short time, bed-side-availibility, non-invasive and low cost.

Keywords—nervus medianus, cross sectional area, ultrasound

Introduction

The median nerve (MN) originates from the medial and lateral cords of the brachial plexus (BP). The MN enters the arm from the axilla at the inferior margin of the teres major muscle and then passes vertically down and courses lateral to the brachial artery (BA) between musculus biceps brachii and musculus brachialis. At first, the MN position is lateral to the BA, lying anterior to the elbow joint and then crosses anteriorly to run medial to the BA in the distal arm and into the cubital fossa. Inside the cubital fossa, the MN passes medial to the BA and passes between the two heads of the pronator teres. It crosses the ulnar artery while being separated by the deep head of the pronator teres. It then travels between the flexor digitorum superficialis and flexor digitorum profundus. The MN is accompanied by the median artery. Then, about 5 cm above the flexor retinaculum (wrist), it emerges between the flexor digitorum superficialis and the flexor carpi radialis into the hand. The MN enters the hand through the carpal tunnel, deep to the flexor retinaculum along with the tendons of flexor digitorum superficialis, flexor digitorum profundus, and flexor pollicis longus. From there, it is divided into recurrent muscular branch and digital cutaneous branch (1).

High resolution ultrasound (HRUS) is one of the most commonly used method for visualing the MN (2). It is a relatively new imaging field. First studies date back to the mid-1980s. In 1988, Fornage published the sonographic features of the median nerve in the carpal tunnel (3). In normal-weigh people the MN can be visualized in his course in the extremities. The cross sectional area (CSA) is one of the most important value which we use to measure the nerve size (4). Normally, the cross sectional appearance of the NM is round to oval and looks like a honey comb. Visualization of the MN abnormalities by HRUS include changes in nerve CSA, echogenity, continuity and vascularisation. With HRUS, we can identify pathological changes of the NM such as tumors, traumatic lesions, inflammations, polyneuropathies and compressive neuropathies of the NM. The examination of the MN is usually started with transverse sections. Once found, the MN can be simply traced upwards and downwards in cross-sections (5). The site of underlying pathology of the NM should be examined on longitudinal scans as well. US allows precise structural analyses and quantitative measurements of the MN. Nerve width (medial to lateral diameter), thickness (anterior to posterior diameter) and cross-sectional area (CSA) mesured on transverse scans, and anterior-posterior diameter

(LAPD) measured on longitudinal scans are the most frequently used quantitative parametars for the US investigation of MN (6). Ratio of CSA between different segments of the MN have also been used (7). One of the most important US features of the MN pathology is change of nerve size. Therefore it is crucial to have normal values of the MN routinelly assessed. Several reports have been published on reference values for the CSA of the MN. This resulted in an evidence-based guideline stating that US may be used as a diagnostic method for carpal tunnel syndrome (8,9). The purpose of this study was to determinate the reference values for the CSA of the MN in a healthy Bosnian population.

Methods and patients

One hundred healthy individuals were investigated with high resolution ultrasound at the Department of Neurology University Clinical Centre in Tuzla from January 2016 to June 2019. Participants were recruited from the hospital staff and medical students. None of the study participants had simptoms or signs suggesting polyneuropathy, entrapment syndomes, systemic disease potentionally associated with polyneuropathy, nor any history of neuromuscular disease. Demographic data such as age, gender, height and body weight were recorded. Informed consent was signed by all participants. For ultrasound examination, a Phillips ultrasound device with a 12 MHz linear array transducer was used. The 3 CSA measurements on the median nerve (MN) were carried out: MN at the mid-upper arm; MN at the distal third of the forearm and MN at the proximal entrance of the carpal tunnel. The measurements were time-consuming (aproximately 30 minutes) and therefore they have been performed only of the left side. The MN was identified on transverse scans using the same typical anatomical landmarks (10). On the upper arm, the MN was identified adjacent to the brachial artery between the biceps and triceps muscles at the midpoint of the line connecting the axilla and the median epicondyle. On the distal forearm, the MN is measured first at the level of the proximal third of the pronator quadratus muscle: after the pronator quadratus muscle was visualized, the MN was identified between the tendons of the flexor pollicis longus and flexor digitorum superficialis muscles. At the wrist, the MN was examined at the proximal entrance of the carpal tunnel using the pisiform bone as an anatomical landmark. The CSA of each MN segment was measured three times and the three measurements were averaged and the mean value was used for analysis.

Statistical analysis

The following parameters were calculated and presented for normal values of the 3 MN segments: mean, median, standard deviation (SD), 95% confidence intervals of the mean, and the coefficient of variation. Correlation of CSA measurements with age, gender, height and body weight was tested using the Spearman correlation coefficients.

Results

One hundred healty Bosnian medical workers were examined with high resolution ultrasound from January 2016 to June 2019 at the Department for Neurology University Clinical Centre in Tuzla due to assess the values of the median nerve. Demographic features such as age, gender, weight and heiht are given in table 1.

Table 1.Demographic data of the healthy medical individuals

Parametar	Bosnian healthy individuals
Age (years)	41.4± 6.1
Gender (M:F)	58:42
Weight (kg)	66.0± 3.1
Height (cm)	168 ± 3

CSA measurements of all 3 medianus nerve segments for all subjects are presented in the table 2. Mean CSA measures of MN ranged from to 5.6 to 8.9 mm^2.

Table 2. CSA values (mm^2) of the median nerve

Site of median Nerve	MeanMedian (mm^2)	SD (mm^2)	95% CI for the mean (mm^2)	
Median arm	8.2	8.0	0.7	8.1-8.4
Median forearm	5.9	5.9	0.3	5.8-6.0
Median carpal	7.8	8.0	0.7	7.7-7.9

CSA=cross-sectional area; SD=standard deviation; CI=coinfidence interval

Univariate Spearman correlations between CSA of the MN with age, body, weight, height and Kruskal-Wallis ANOVA test for gender are presented in table 3.

Table 3. Correlation between CSA of the median nerve with age, body, height and gender

Site of MN	Age Spearman R p	Weight Spearman R p	Height Spearman R p	Gender p
Median arm	-0.54 **<0.0001**	0.40 0.1	-0.2 0.06	**<0.0001**
Median forearm	0.26 **0.007**	-0.24 0.1	0.02 0.77	0.26
Median carpal	0.19 **0.05**	-0.35 0.06	0.03 0.70	**<0.0001**

MN=median nerve

CSA measurements of the MN were dependent of age but independent of weight and height. Regarding gender, males had thicker nerves in the arm and carpal area

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Discussion

High resolution ultrasound is an effective tool for the investigation of the median nerve (MN) disorders. The pathology of the MN results in changes of nerve size as well as changes of echostructure and echogenity (2). The measurement of the cross-sectional (CSA) is the most common method used to qualify size of the MN. The increase of CSA of the MN allows precise localization in entrapment neuropathies and peripheral nerve tumors. Therefore, it is essential to compare MN parameters measured in patients to reference values. So far, in our country we do not have reference values for NM. The aim of our study was to contribute a reference values of the CSA of the MN in the forearm, arm and carpal. Heinmeyer et al. (11) found no correlation between CSA and age, height and body weight but reported that males has a thicker nerves in the upper limbs. On the other hand, Cartwright et al. (12) that nerve size correlated with wight and that females had smaller nerves than males. They did not find any difference in CSA when dominant and non-dominant sides were compared. According to Zaidman et al., CSAs of the MN are larger with increasing height, but they are independent of age (13). Kerasnoudis et al. (14) found no dependence to weight and height in the size of NM. In a Japanese study, age-based differerence in nerve size was found in arm for NM while height-based difference was found in all 3 CSA of the MN. The CSA of the NM in our study, ranges from 5.6 to 8.9 mm2. We found consistent correlation between CSA values and age and no correlation with weight and height. In our study, males had significantly larger values than females for MN segments in the upper arm and carpal area. Regarding the age dependent, our study had some limitations. Due to only 100 examined mostly young subjects, the correlation could not be investigated in sufficient number of middle-aged and old subjects.

The possibility of dynamic examination, assesment of long median nerve segments in a short time, bed-side-availibility, non-invasive and low cost, make ultrasound the ideal imaging tool in the MN pathology.

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