Observational Study

Medicine®

OPEN

Estimation of ultrasound reference values for the upper limb peripheral nerves in adults

A cross-sectional study

Mohamed Abdelmohsen Bedewi, MD[a,*], Ahmed Abodonya, MD[a], Mamdouh Kotb, MD[a], Gehan Mahmoud, MD[a], Sanaa Kamal, MD[a], Abdullah Alqabbani, MD[a], Bader Alhariqi, MD[a], Mohammed H. Alanazy, MD[b], Khaled Aldossari, MD[a], Sherine Swify, MD[c], Fahad Al-Bader, MD[d]

Abstract

The objective of this study is to estimate the reference values for the upper limb peripheral nerves in adults.

The demographics and physical characteristics of 69 adult healthy volunteers were evaluated and recorded. In addition, the side to side differences of the estimated reference values and their correlations with the age, weight, height, and body mass index (BMI) were evaluated.

Cross-sectional area reference values of the upper limb nerves did not correlate with height; however, they correlated with age, weight, and BMI in some scanned sites.

The data obtained in this study could be helpful in future diagnosis of peripheral nerve disorders of the upper limb.

Abbreviations: BMI = body mass index, CSA = cross-sectional area.

Keywords: peripheral nerve, reference values, ultrasound, upper limb

1. Introduction

During the past decade, high-resolution ultrasound gained more popularity, as a promising imaging modality in the diagnosis of the different peripheral nerve disorders. Several studies reported the cross-sectional area reference values for different peripheral nerves.[1–5] Some of these studies involved local population,[1–8] others involved extremes of age,[9] or even single peripheral nerves, either in a single site, or several sites for a single nerve along its course.[10–13] One of the important studies for evaluation of normal cross-sectional area values, is that of Cartwright et al[1]; however, another important study conducted by Kerasnoudis et al,[2] obtained clear difference in different values, which mandated further studies in different population groups for the standardization of the CSA reference values, especially, those which sex-matched, and others correlating different demographic factors with the obtained CSA reference values.

2. Methods

1.1. Participants

The local institutional review board committee approved the study protocol and all participants provided an informed consent before enrollment. Sixty-nine healthy adult volunteers, 20 to 70 years' old, were recruited from November 2015 to April 2016, at a university Hospital. For each participant, the age, height, weight, and body mass index (BMI) were recorded before ultrasound scanning. The participants were free of any neuromuscular disease as indicated by clinical examination and history. Subjects who accepted electrophysiological studies, were enrolled to rule out the possibility of sub-clinical neuropathy. Electrodiagnostic studies were performed by an investigator blinded to the results of the clinical evaluation.

1.2. Technique

The ultrasound scanning of the upper nerves was carried out using Philips ultrasound diagnostic scanner, (Epic 7 version 1.5, Ultrasound system: Philips, Bothell) using a L18–5 MHZ linear transducer. All studies were performed by a radiologist (MB) with 10 years' experience in neuromuscular ultrasound, and were results reviewed by another sonologist (AA), with 3-year experience in neuromuscular ultrasound. Each examination was performed bilaterally and for 3 times to assess for intrarater reliability. To minimize anisotropy, the probe was positioned in a perpendicular position to the nerve. In each subject, 8 sites were scanned bilaterally. The median nerve was scanned at 3 predetermined sites, with the elbow in a flexed position, examination was done in the palmar aspect, first site was at the mid-carpal tunnel level, then the probe was moved proximally

Editor: Marco Onofrj.

The authors report no conflicts of interest.

[a] College of Medicine, Prince Sattam bin Abdulaziz University, Alkharj, KSA, [b] Department of Internal Medicine, King Saud University Medical City, King Saud University, Riyadh, Saudi Arabia, [c] Ministry of Health, Alexandria, Egypt, [d] King Saud University Medical City, King Saud University, Riyadh, Saudi Arabia.

[*] Correspondence: Mohamed Abdelmohsen Bedewi, College of Medicine, Prince Sattam bin Abdulaziz University, P.O. Box 173, Al-kharj 11942, Kingdom of Saudi Arabia (e-mail: mohamedbedewi@yahoo.com).

Medicine (2017) 96:50(e9306)

Received: 19 September 2017 / Received in final form: 23 November 2017 / Accepted: 27 November 2017

http://dx.doi.org/10.1097/MD.0000000000009306

Figure 1. Short axis scan of the median nerve in the carpal tunnel.

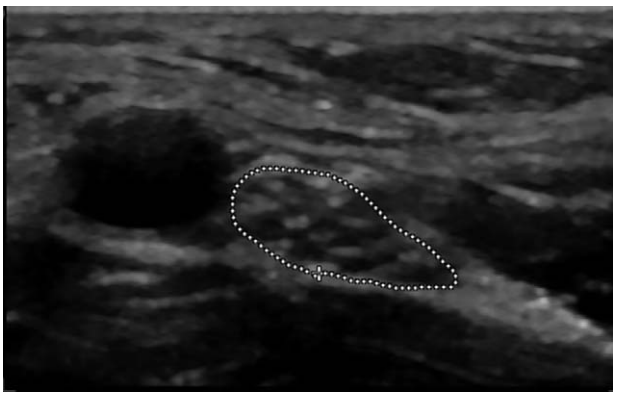

Figure 4. Short axis scan of the median nerve at the level of the elbow.

10 cm in the forearm, the third site was at the elbow level, at the level of the brachial artery. The ulnar nerve was scanned at 4 sites, with the elbow in a flexed position, and the forearm supinated; first the ulnar nerve was identified between the pisiform bone and the ulnar artery, then the probe was moved upwards in the forearm, 10 cm above the Guyon canal, the third position was at the level of the medial epicondyle; the fourth position was 1 inch above the medial epicondyle. The radial nerve was scanned at the level of the mid arm. The cross-sectional area at each scanned site was measured by circumferential tracing inside the hyperechoic rim of each nerve (Figs. 1–5), and the identification of each nerve was made by identifying its anatomical site as mentioned above and by identification of the peculiar fascicular pattern. Images and results were saved electronically and analyzed.

1.3. Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 21 software (SPSS Inc, Chicago, IL). All data were presented as mean ± standard deviation (SD) and range. The mean CSA were compared between both sides using Wilcoxon signed rank test. The correlations between the CSA of the scanned nerves, age, weight, height, and BMI were evaluated using Pearson's correlation coefficient (r). A P value of $<.05$ was considered significant.

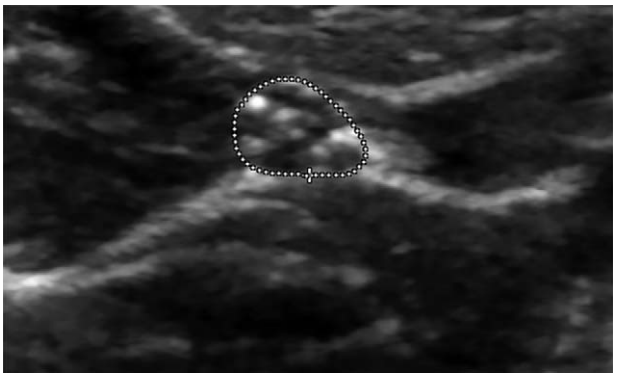

Figure 2. Short axis scan of the median nerve Mid forearm.

3. Results

During the recruitment period, we studied 69 healthy adult volunteers with a mean age of 38.33 ± 12.13 years (range: 20–73). The mean height was 161.48 ± 9.8 (range 144–183) and weight 77.14 ± 18.4 (range 44–128). Table 1 showed different descriptive statistics, mean reference values of the scanned nerves together with their reference range. Table 2 showed correlation of our results with different demographic factors. The intraobserver reliability calculations resulted in an overall intraclass correlation coefficient of 0.80.

We compared the cross-sectional area values of the 8 scanned sites at the right and left sides, no significant differences were noted. Significant statistical difference between both sexes (towards the male side) was noted for the median nerve at the forearm, median nerve at the elbow, and the ulnar nerve at the medial epicondyle. Significant positive statistical correlation with age was found for the median nerve at the carpal tunnel in addition for the all scanned sites for the ulnar nerve.

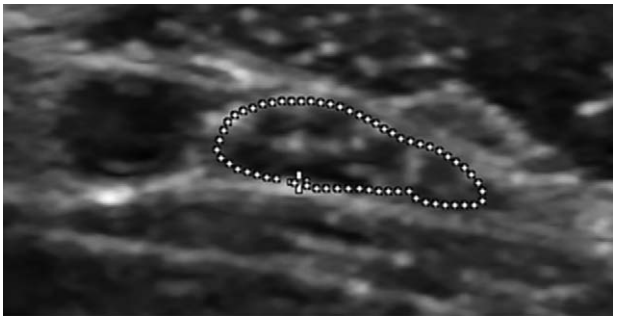

Figure 3. Short axis scan of the ulnar nerve in the Mid forearm.

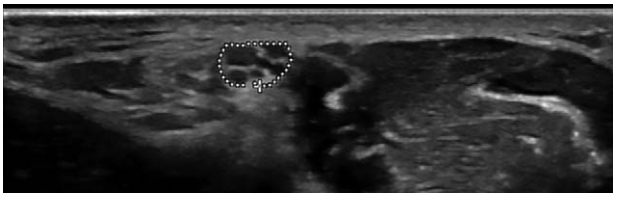

Figure 5. Short axis scan of the ulnar nerve at the level of the level of the elbow.

Table 1

Descriptive statistics, mean reference values of the scanned upper limb nerves together with their reference range.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	69	20.00	73.00	38.3333	12.13123
Weight	69	44.00	128.00	77.1449	18.38276
Height	69	144.00	183.00	161.48	9.88495
BMI	69	15.91	45.54	29.3132	6.64041
Median nerve CT	138	5.00	19.00	9.7710	2.88677
Median nerve FA	138	1.00	14.60	6.4645	2.04960
Median nerve elbow	138	4.00	24.90	11.1261	3.94760
Ulnar nerve Guyon canal	138	1.40	12.00	4.0732	1.56986
Ulnar nerve FA	138	2.00	14.00	5.5232	1.90892
Ulnar nerve elbow	138	3.00	15.00	7.4993	2.35550
Ulnar nerve arm	138	3.00	15.00	7.5543	2.60113
Radial nerve arm	138	1.00	11.00	5.7065	1.93821

BMI = body mass index, CT = carpal tunnel, FA = forearm.

Significant positive statistical correlation with weight and BMI was found for the median nerve at the carpal tunnel in addition for the all scanned sites for the ulnar nerve except for the Guyon canal. No significant statistical correlation was noted in relation to height.

4. Discussion

In our study, we scanned 8 sites for 3 important upper limb peripheral nerves. Statistical difference was observed toward the male side in 3 sites. Significantly positive statistical correlation of the CSA reference values with age in four out of eight sites. No correlation was noted in relation to height. Five of 8 sites showed correlation with weight and BMI. Our results, in general, were comparable to the studies especially those of Kerasnoudis et al and Won et al. For example, the study conducted by Kerasnoudis et al correlated well with our study, except for the radial nerve which was measured at the spiral groove, whereas we measured it at the midarm. Sex differences and age correlation with age were also found in Kerasnoudis study. Comparing our results with those of Kerasnoudis et al, the mean median nerve CSA was (8.75 mm^2 at the carpal tunnel), (6.7 mm^2 at the forearm), and at our study, the median nerve showed the following values (9.8 mm^2 at the carpal tunnel), and (6.5 mm^2 at the forearm). The ulnar nerve in Kerasnoudis et al study was (4.8 mm^2 at Guyon canal); (5.1 mm^2 at the forearm); (6.2 mm^2 at the elbow), whereas in our study (4 mm^2 at Guyon canal); (5.5 mm^2 at the forearm); (7.5 mm^2 at the elbow). The second study was that for Won et al, which correlated well with our results except for the median nerve at the elbow, and the ulnar nerve at the arm, which showed some difference, for example, showed the following values: median nerve, (8.32 mm^2 at the carpal tunnel), (6.45 mm^2 at the forearm), (8.1 mm^2 at the antecubital fossa), compared to (9.8 mm^2 at the carpal tunnel), (6.5 mm^2 at the forearm), (11.1 mm^2 at the elbow). While the ulnar nerve with Won et al showed the following results (4.93 mm^2 at the wrist), (6.3 mm^2 at the forearm), (7.2 mm^2 at the cubital tunnel inlet), (5.8 mm^2 at the midhumerus), in our study while in our study (4 mm^2 at Guyon's canal); (5.5 mm^2 at the forearm); (7.5 mm^2 at the elbow), (7.6 mm^2 at the arm). Won et al study showed correlation with height, weight, and BMI; no correlation was found with height in his study. The third study was that for Qrimli et al, which showed very near values to our study, including the radial nerve at the mid arm (Table 3 for comparative data). Our results were also comparable to Boehm et al, with slight differences. Two studies showed different values from our study, those by, the first one is the study by Tagliafico et al, which showed difference in the results for the ulnar nerve at Guyon canal and the elbow.

Table 2

Correlations between age, weight height, and BMI, and CSA reference values of the upper limb nerves.

		Median nerve CT	Median nerve FA	Median nerve elbow	Ulnar nerve Guyon Canal	Ulnar nerve forearm	Ulnar nerve elbow	Ulnar nerve arm	Radial nerve arm
Age	Pearson correlation	.361**	.191*	.126	.339**	.327**	.238**	.200*	.144
	Sig. (2-tailed)	.000	.025	.141	.000	.000	.005	.019	.092
	N	138	138	138	138	138	138	138	138
Weight	Pearson correlation	.296**	.102	.005	.005	.281**	.355**	.319**	.081
	Sig. (2-tailed)	.000	.234	.951	.956	.001	.000	.000	.346
	N	138	138	138	138	138	138	138	138
Height	Pearson correlation	−.037–	−.037–	.104	−.061–	−.013–	−.044–	.000	−.062–
	Sig. (2-tailed)	.664	.665	.225	.477	.883	.612	.996	.467
	N	138	138	138	138	138	138	138	138
BMI	Pearson correlation	.375**	.088	-.011-	.033	.284**	.303**	.301**	.096
	Sig. (2-tailed)	.000	.307	.903	.699	.001	.000	.000	.262
	N	138	138	138	138	138	138	138	138

BMI = body mass index, CSA = cross-sectional area, CT = carpal tunnel, FA = forearm.
* Significant at .05.
** Significant at .01.

Table 3

Correlations between our data, with other studies in literaturel, CSA measured in square millimeters at 8 scanning sites.

	Median nerve CTI	Median Nerve FA	Median nerve elbow	Ulnar nerve Guyon canal	Ulnar nerve forearm	Ulnar nerve elbow	Ulnar nerve arm	Radial nerve arm
Our study	9.8	6.5	11.1	4	5.5*	7.5	7.6.	5.7
Kerasnoudis et al	8.75	6.7	NA	4.8	5.1	6.1	NA	NA
Won et al	8.3	6.3	7.2	4.9	6.3	7.2	5.8	NA
Qrimli et al	10	7.1	10.3	5	6.2	6.9	6.9	6.5

CSA = cross-sectional area, CT = Carpal tunnel, NA = not applicable.

Whereas Cartwright et al showed similar results for the median nerve at the carpal tunnel, and clear difference for the radial nerve. Our results were also compatible with the results of Bedewi et al, considering the ulnar nerve at the elbow. The discrepancy in the results of some nerves may be attributed to difference in the local population done for each study; also the probe resolution has improved in the last few years. In conclusion, the CSA reference values of the scanned upper limb peripheral nerves were reported, and correlated with some of the scanned locations with sex, age, weight, and BMI, and did not correlate with height. The data obtained in this study, could be helpful in future diagnosis of peripheral nerve disorders of the upper limb.

1.4. Study limitations

The present study has some limitations. It did not include intranerve CSA variability, or side-to-side difference ratio CSA variability. Also the study did not include some relatively important nerves, like musculocutaneous and axillary nerves.

Acknowledgments

The authors are grateful to the Deanship of Scientific Research at Prince Sattam bin Abdulaziz University.

References

[1] Cartwright MS, Passmore LV, Yoon JS, et al. Cross-sectional area reference values for nerve ultrasonography. Muscle Nerve 2008;37:566–71.

[2] Kerasnoudis A, Pitarokoili K, Behrendt V, et al. Cross sectional area reference values for sonography of peripheral nerves and brachial plexus. Clin Neurophysiol 2013;124:1881–8.

[3] Heinemeyer O, Reimers CD. Ultrasound of radial, ulnar, median, and sciatic nerves in healthy subjects and patients with hereditary motor and sensory neuropathies. Ultrasound Med Biol 1999;25:481–5.

[4] Won SJ, Kim BJ, Park KS, et al. Reference values for nerve ultrasonography in the upper extremity. Muscle Nerve 2013;47:864–71.

[5] Boehm J, Scheidl E, Bereczki D, et al. High-resolution ultrasonography of peripheral nerves: measurements on 14 nerve segments in 56 healthy subjects and reliability assessments. Ultraschall Med 2014;35:459–67.

[6] Qrimli M, Ebadi H, Breiner A, et al. Reference values for ultrasonograpy of peripheral nerves. Muscle Nerve 2016;53:538–44.

[7] Rasenack M, Décard BF, Schädelin S, et al. Ultrasonographic reference values for peripheral nerves and nerve roots in the normal population of children and adolescents: study protocol for an observational-prospective trial. BMJ Open 2016;6:e014662.

[8] Tagliafico A, Martinoli C. Reliability of side-to-side sonographic cross-sectional area measurements of upper extremity nerves in healthy volunteers. J Ultrasound Med 2013;32:457–62.

[9] Cartwright MS1, Mayans DR, Gillson NA, et al. Nerve cross-sectional area in extremes of age. Muscle Nerve 2013;47:890–3.

[10] Bedewi MA, Yousef AM, Abd-Elghany AA, et al. Estimation of ultrasound reference values for the ulnar nerve fascicular number and cross-sectional area in young males: A cross-sectional study. Medicine (Baltimore) 2017;96(10.):

[11] Chen J, Wu S, Ren J. Ultrasonographic reference values for assessing normal radial nerve ultrasonography in the normal population. Neural Regen Res 2014;9:1844–9.

[12] Gonzalez-Suarez CB, Dones VC3rd, Grimmer K, et al. Radial nerve measurements in nonsymptomatic upper extremities of Filipinos: a cross-sectional study. Muscle Nerve 2015;52:568–75.

[13] Sugimoto T, Ochi K, Hosomi N, et al. Ultrasonographic reference sizes of the median and ulnar nerves and the cervical nerve roots in healthy Japanese adults. Ultrasound Med Biol 2013;39:1560–70.