Medical Science

25(116), October, 2021

Anatomical and radiological study of the brachial plexus using ultrasonography

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To Cite:
Ali AHA, Bedewi MA, Aldosari NS, Almalki AM, Alhajri RA, Aldawsari AM, Alharbi MNM, Alghuwainem MA, Alharbi FSF, Hijan EAA. Anatomical and radiological study of the brachial plexus using ultrasonography. Medical Science, 2021, 25(116), 2652-2659

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Peer-Review History
Received: 11 September 2021
Reviewed & Revised: 12/September/2021 to 09/October/2021
Accepted: 12 October 2021
Published: October 2021

Peer-review Method
External peer-review was done through double-blind method.

ABSTRACT

The ultrasonography is able to reveal in-depth anatomical components of brachial plexus and to locate any lesions have been demonstrated. This study aimed to evaluate the normal cross-sectional area (CSA) of the brachial plexus nerves in the interscalene groove. Also, to correlate the anatomical specimen's with image the brachial plexus nerves. Lateral photographs of twenty plastinated sections of head and neck specimen to study the brachial plexus roots in the groove between middle and anterior scalene muscles. On the same time, fifty-five healthy volunteers of different age groups were included in our study. Ultrasound of roots of the cervical nerves was performed on both sides. The average cross-sectional area of the roots was estimated. There was a positive statistical association between the CSA of cervical nerves. These data may be beneficial in future studies designed to assess the brachial plexus injures.

Keywords: Ultrasound, Anatomy, Brachial plexus, Cross-sectional area, Nerve roots.

1. INTRODUCTION

The evaluation of the brachial plexus is more difficult for the radiologist and the clinician and leads to difficulties in patient management, investigation, as well as surgical indications (Abul-Kasim et al., 2010). Ultrasound is currently a useful method for diagnosing disorders of peripheral nerve. Measurements of cross-sectional area (CSA) in the cervical nerve roots and peripheral nerves have already shown high diagnostic specificity and sensitivity in mononeuropathies (Drake-Pérez et al., 2021; Hobson-Webb and Padua, 2009; Zaidman et al., 2013; Padua et al., 2013; Abdulmunem et al. 2021). In the interscalene gutter between the middle and anterior scalene muscles, the brachial plexus roots emerge. This groove is detected on the lateral side scalenus anterior muscle and under the cover of sternomastoid muscle. This plexus is created by the ventral rami of the lower four (fifth, sixth, seventh and eighth) cervical nerves. Also, the upper part of the first thoracic nerve participates in the formation of the plexus (Demondion et al., 2003).

In the posterior triangle of the neck, three trunks were formed by union of the roots. The upper trunk is formed by roots of C5 and C6, the root of C7 singly creates the middle trunk. The C8 and T1 roots of unite to form the lower trunk (Atasoy, 1996). The area between scalenus medius and anterior is easily affected by both traumatic and nontraumatic injuries. Three of the roots of brachial plexus are clearly seen by ultrasound in the interscalene groove (Haun et al., 2009; Haun et al., 2010; Orebaugh and Williams, 2009; Johnson et al., 2010; Lapegue et al., 2014; Mattox et al., 2016; Bedewi and Kotb, 2021). Ultrasound with high-resolution permits evaluation of numerous parts of the brachial plexus and neighboring soft tissues with high accuracy; detailed information on topographic anatomy and common variations is needed to achieve appropriate examination by ultrasound. Ultrasonography is especially useful in many neurological disorders. In addition, ultrasound is inexpensive, most patients can afford it. Ultrasound has the possibility of examination of both sides at the same setting. On the other hand, the limitation of ultrasound is in cases of trauma which can assess by MRI (Bedewi et al., 2018; Griffith, 2018; Griffith and Lalam, 2019).

Our study aimed to characterize the normal CSA and cervical nerve roots appearance on ultrasound, and correlate them to anatomical specimens with an image of the brachial plexus nerves.

2. MATERIALS, METHODS AND PARTICIPANTS

In this research, twenty plastinated sections of head and neck specimen were used anatomy department. Lateral photographs of all samples were taken to find out the brachial plexus roots in the interscalene area on the posterior triangle of the neck. Meanwhile; Fifty-five healthy volunteers (25 males, 30 females) were involved in the study at the outpatient clinic of the hospital of our university in Al Kharj, KSA. Study participants were enrolled in the period between January 2021 and June 2021, and consent has been completed. Participants, who had clinical symptoms related to neurovascular ailments of the upper extremity, were excluded. The age, sex and BMI for each volunteer, data including were acquired.

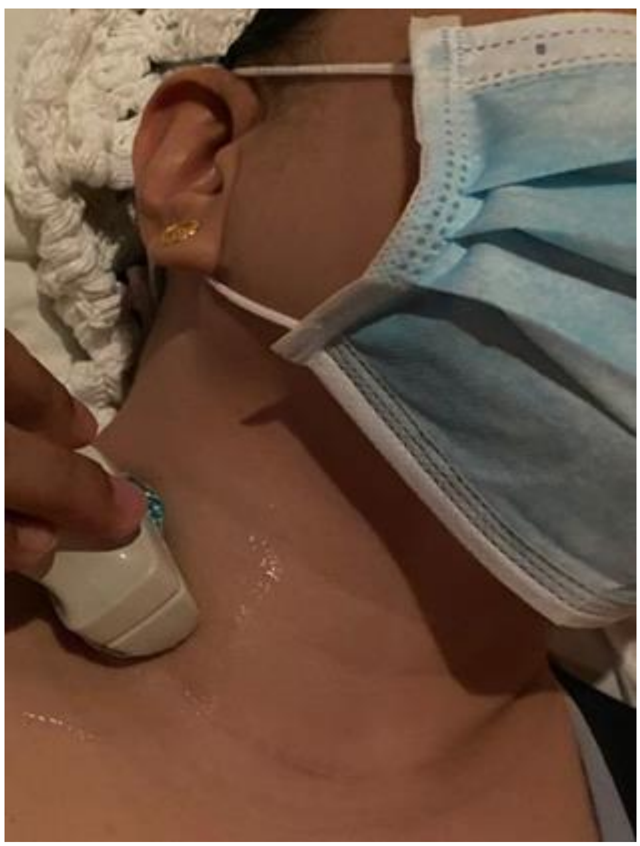

Figure 1 A 35 yeaes old female volunteer during an ultrasound examination

The brachial plexus roots were scanned on both sides in short axis at the posterior triangle of the neck using an L17–5 MHz linear probe (version 1.5, Philips,). An experienced radiologist performed all ultrasound scans. Each subject was placed on his back in a supine position, and the probe was placed on the thyroid gland lobe (fig, 1). The roots of brachial plexus were shown as oval dark grey (hypoechoic) structures the interscalene groove. The roots of fifth and sixth cervical nerves were found between the posterior and anterior tubercles. On the other hand, the seventh cervical root was shown at lower level than sixth cervical nerve, with the tubercles of the seventh cervical vertebra.

Statistical analysis

Standard errors and means of CSA of cervical nerves (fifth, sixth and seventh) were calculated. It was done by SPSS software. After collection, all data were displayed. The Pearson's correlation coefficient was used to assess the association among the CSA of the scanned nerves, age, and BMI. The results were significant, when the p-value was less than .05.

3. RESULTS

The brachial plexus trunks specially the upper one (fifth and sixth cervical) was clearly shown in the images taken from real anatomic sections. These trunks found passing through the interscalene groove (fig. 2, 3). These results were similar to those of ultrasound images obtained in the outpatient. The resulting images allow precise identification of anatomical structures identified by ultrasonography. It also allows the identification ofstructures that are too small to be seen by ultrasound images. These sections allow accurate identification of connective tissue surrounding the brachial plexus (fig. 4, 5, 6). On the other hand, the results of fifty-five healthy volunteers the mean age was 36.3 ± 14.7 (range: 20–65), and BMI mean was 26.2 ± 4.8 (15.3–30).

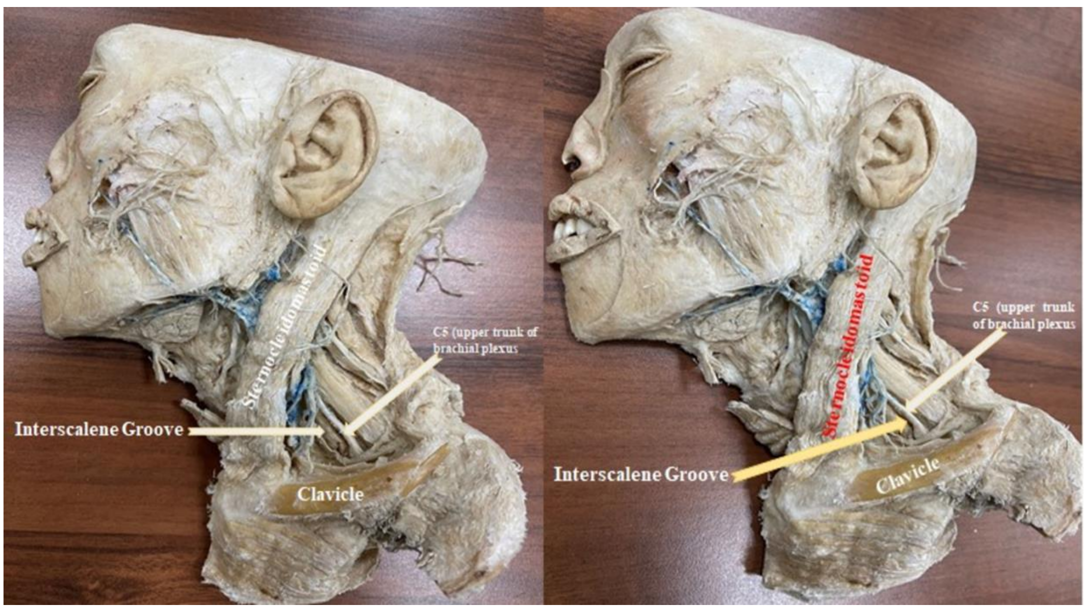

Figure 2 A & B Lateral view image of plastinated specimen shows the trunks of brachial plexus pass through the posterior triangle of the neck.

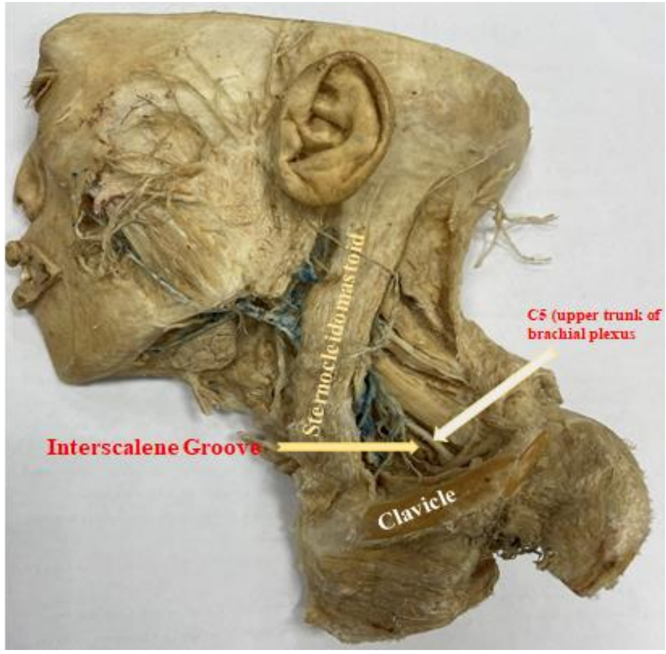

Figure 3 Lateral view image shows that the upper trunk of brachial plexus trunks passes through the interscalene groove.

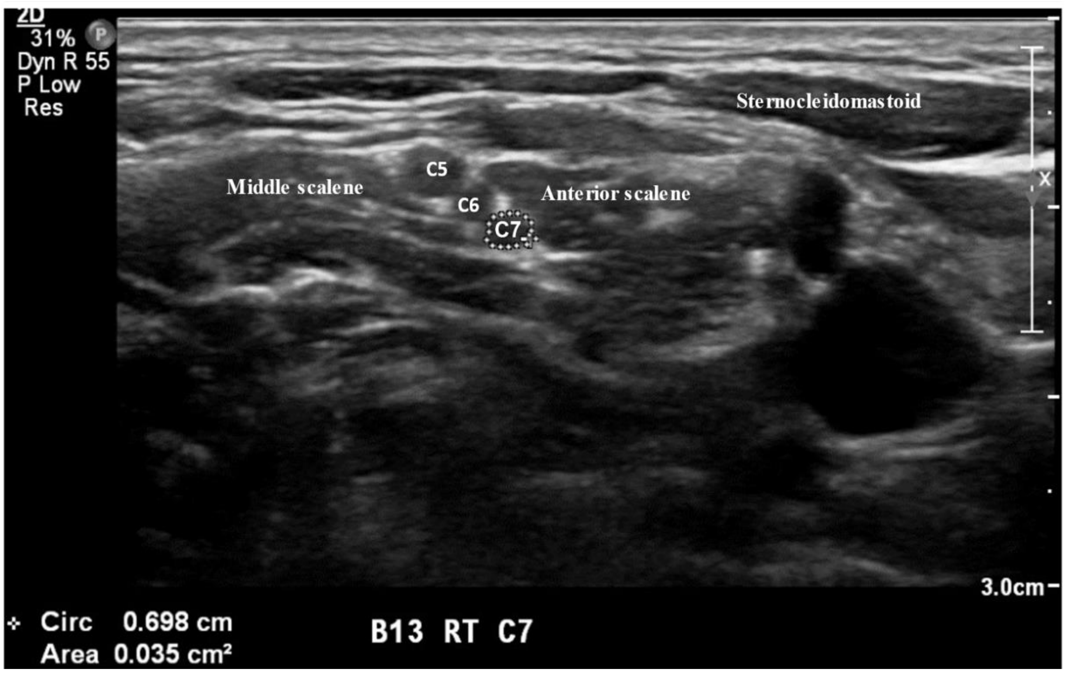

Figure 4 Ultrasound image shows the brachial plexus nerves located between the scalenus medius and anterior muscles.

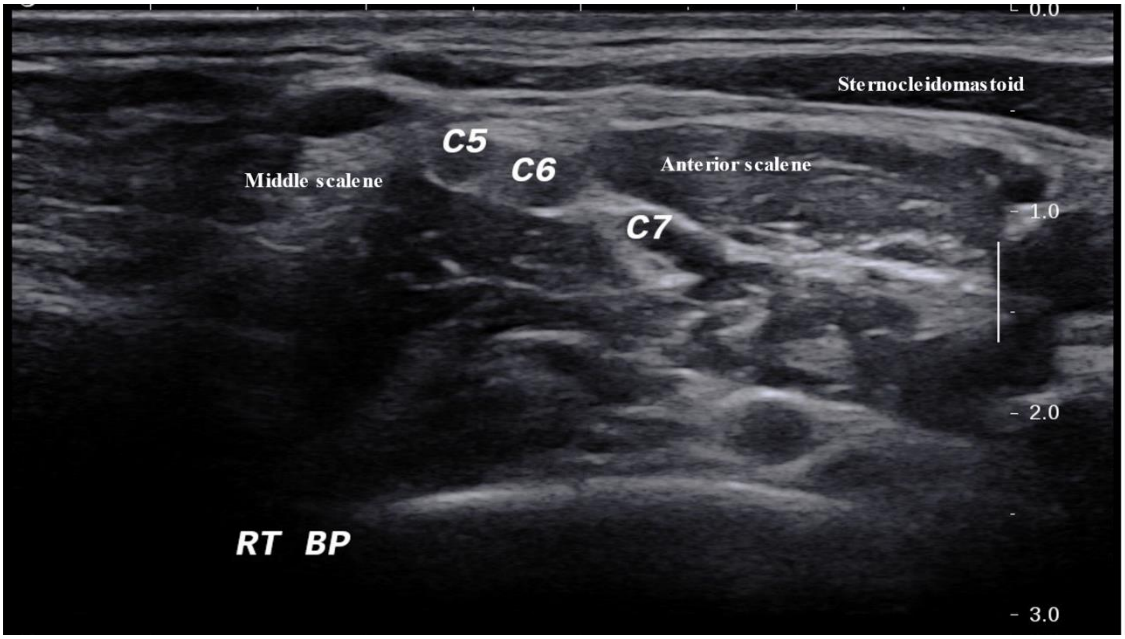

Figure 5 Ultrasound image illustrating nerve roots between scalene muscles.

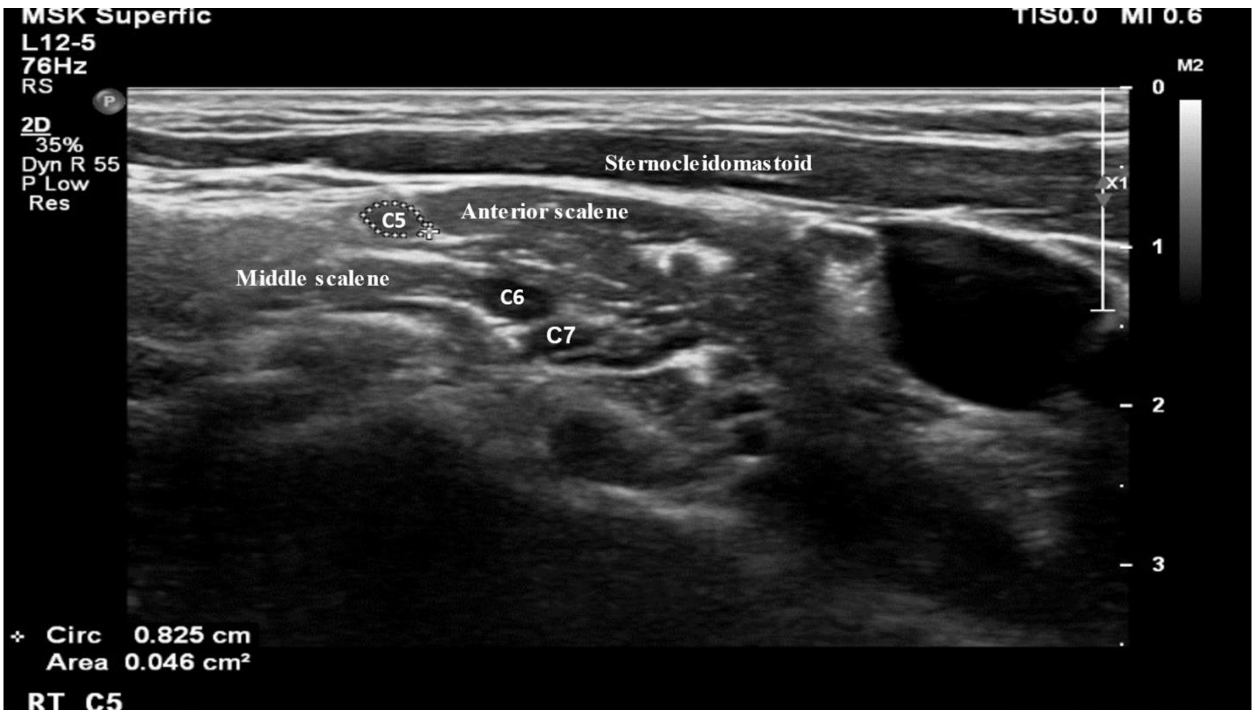

Figure 6 Ultrasound image shows the brachial plexus nerves located between the scalenus medius and anterior muscles.

Table 1 explained the mean Cross Sectional Area values of the fifth sixth and seventh cervical nerve roots. In addition, the association between age, BMI, of the cervical nerve roots is presented in table 2. The average Cross-Sectional Area of the brachial plexus roots was: fifth cervical nerve root was 4.10 mm2 (ranging from 1.5 to 10.10 ± 1.80 Standard Deviation), sixth root was 4.80 mm2 (ranging from 1.6 to 12 ± 2.5 Standard Deviation), and the seventh one was 5.30 (ranging from1.5 to 17.60 ± 3.3 Standard Deviation). Regarding BMI and age, there is no significant statistical correlation was observed. A positive statistical relationship was observed between the nerve roots and Cross-Sectional Area ($p < 0.01$).

Table 1 Shows the statistics and means CSA for cervical nerves.

	Number of participants	Maximum	Minimum	Mean	Std. Deviation
Age	55	65	20	36.3	14.7
BMI	55	30	15.3	26.2	4.8
C5	55	10.1	1.5	4.1	1.8
C6	55	12	1.6	4.8	2.5
C7	55	17.6	1.5	5.3	3.3

Table 2 Association between Body Mass Index (BMI), age and normal values of cervical nerves

		Age	BMI	C5	C6	C7
Age	P. Correlation	1	0.227 0.072	.001 .891	.186 .137	.232 .77
BMI	P. Correlation	.227 .072	1	.121 .366	-056 .667	-023 .854
C5	P. Correlation	.001 .981	.121 .367	1	.342 .007	.345 .006
C6	P. Correlation	.186 .137	-056 .667	.342 .007	1	.773 .000
C7	P. Correlation	.232 .077	-023 .855	.345 .007	.773 .000	1

4. DISCUSSION

In the current study, sections of head and neck were taken to detect the brachial plexus roots in the posterior triangle of the neck between the scalenus medius and anterior muscles. At the same time, fifty-five healthy volunteers undergo examination cervical nerve roots (fifth, sixth and seventh) by ultrasound. When comparing our results with a previous one, only slight differences in the CSA were showed regarding C5 root compared to current study (Won et al., 2012). The results of Won's study (2012) found higher measurements compared to our study. In addition, other research also found higher measurements for Cross-Sectional Area of the roots of cervical nerves, than those attained by our study, especially the roots of sixth and seventh cervical nerves (Haun et al., 2010). Other researches get significantly lower CSA dimensions than all other previous studies, in all the three mentioned roots (Sugimoto et al., 2013). However, the fifth cervical nerve root studied in current research was the smallest size, and the seventh one was the largest size which is in agreement with previous studies.

Some of the paper's results were not comparable with ours because they measured the entire cervical nerve roots simultaneously at the interscalene groove (Kerasnoudis et al., 2013). In addition, some other studies were performed on the brachial plexus trunks quite distal to the roots consistent with our values (Cartwright et al., 2008). The limitation was that we did not include the last cervical nerve, (eighth) and the first thoracicone because its imaging was difficult to measure across all subjects. Finally, our study did not include abnormal conditions to compare the normal values with different pathological conditions.

5. CONCLUSION

We conclude that, normal reference range for the roots of cervical nerve can promote a better diagnosis of various brachial plexus diseases. A prospective study comparing a high medical imaging modality as Magnetic Resonance Imaging and ultrasound in brachial plexus assessment is highly recommended.

Acknowledgments

This publication was supported by the Deanship of Scientific Research at Prince Sattam bin Abdulaziz University, Alkharj, Saudi Arabia. In addition, we thank those who participated and contributed to the study.

Authors' Contributions

All authors contributed to the research and/or preparation of the manuscript. Ali Hassan A. Ali, Mohamed A. Bedewi, Nasser S. Aldosari, Abdulrahman M. Almalkiand Rasheed A. Alhajri participated in the study design and wrote the first draft of the manuscript. Abdulrahman M. Aldawsari, Mohammed N. M. Alharbi, Muath A. Alghuwainem, and Faisal S. F. Alharbi (https://orcid.org/0000-0002-8351-022X) collected and processed the samples. Eyad A. A. Hijan (https://orcid.org/0000-0003-1056-8102) participated in the study design and performed the statistical analyses. All of the authors read and approved the final manuscript.

Ethics Approval

All series of steps that were implemented in this study that included animal models were in compliance with Ethics Committee of Prince Sattam bin Abdulaziz University Institutional Review Board (PSAU-2020 ANT 4/43PI).

Funding

This study has not received any external funding.

Conflicts of interest

The authors declare that they have no conflict of interest.

Data and materials availability

All data associated with this study are present in the paper.

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