Location of Brachial Plexus Terminal Branches Determined by Ultrasound and Cadaver Examination

Trey Henderson M.S., Zach Anderson OMS III, Dr. Stacy Chelf PhD, Dr. Jeffrey Chestnut D.O
Lincoln Memorial Debusk College of Osteopathic Medicine

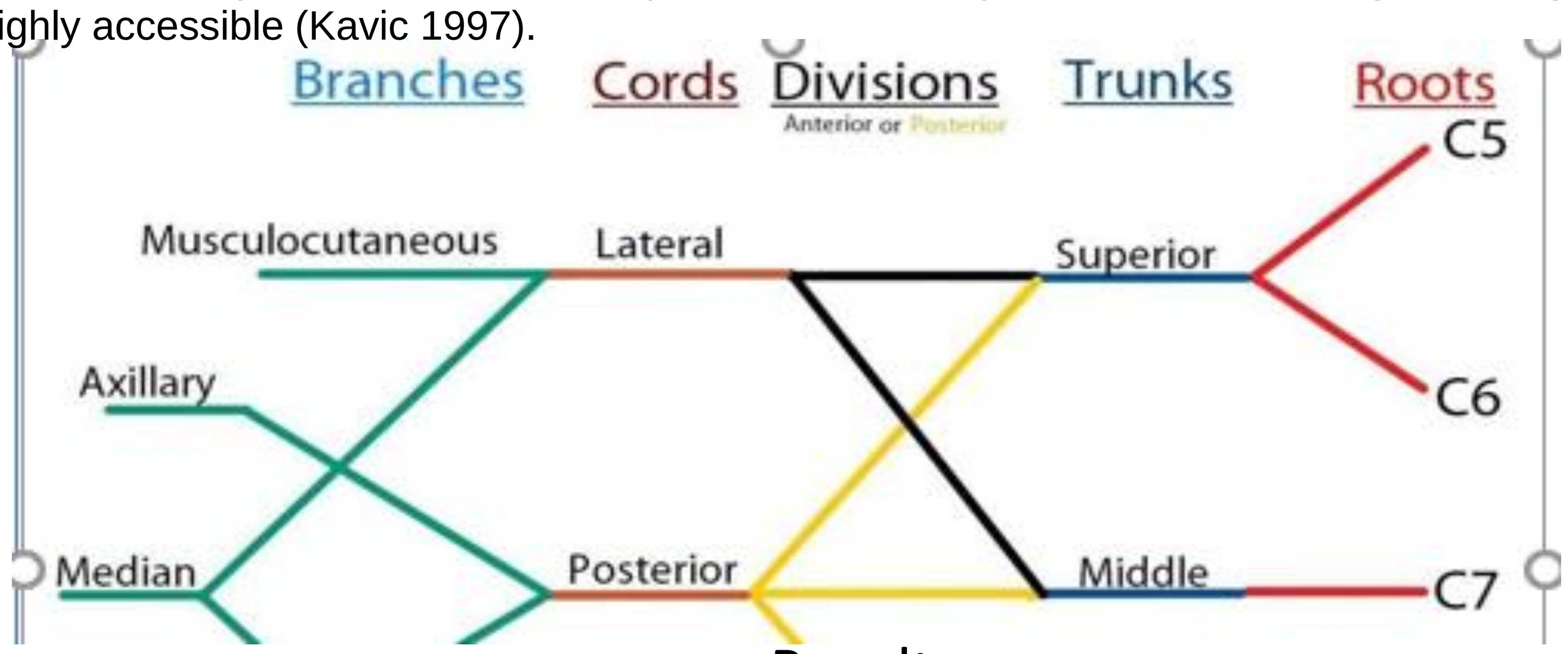
Abstract

The utilization of ultrasound studies to identify the musculocutaneous and axillary nerve could provide great benefits to Doctors of Osteopathic Medicine as it will expand their ability to efficiently locate and treat in a clinical setting. There is significant interest in new techniques to properly diagnose and treat injuries, impingements, and neuropathies, as well as administering local anesthetic nerve blocks, as the brachial plexus contains large variation in structure from patient to patient. Ultrasound nerve studies provide a pathway to effectively locate peripheral nerves during a procedure, provide local anesthetic or steroid injections, and diagnose impingements in the musculocutaneous and axillary nerves. There exists a limited dataset to validate these methods. This research provides a case study on the efficacy and utilization of ultrasound technology by the demonstration of how to locate the nerve. A normalized, baseline database of axillary and musculocutaneous nerve localization techniques, along with minor changes to established techniques, in both cadaveric and human participants has been explored and provided within this paper. The human population (N = 21) consisted of eleven males and ten females, ranging from 24-39 years old with a mean age of 26 and was supplemented with a cadaveric donor population (N=24) consisting of thirteen females and eleven males. Participants filled out a questionnaire and their whole arm length measurement was obtained prior to ultrasound imaging. Cadaveric measurements were taken based on the distance of the nerves from different clinically relevant bony landmarks. The case study obtained significant results with positive correlations between the different variables both in the cadaveric study as well as the ultrasound portion. In the cadaveric study, significant positive correlation ($p \leq .05$) between the coracoid process to where musculocutaneous nerve pierces coracobrachialis and the length between coracoid process and medial epicondyle was found in males (rp= 0.58, p=.006) A one-unit increase of the distance between medial epicondyle and coracoid process will increase the distance of coracoid process to musculocutaneous nerve pierces coracobrachialis by 0.40 units (p=.006). Statistical significance was denoted by $p \leq .05$. The data and techniques outlined in this research aim to provide the foundation for larger clinical studies in the realm of Osteopathic medicine.

Introduction

The terminal branches of interest in this study are the axillary nerve (AN) and the musculocutaneous nerve (MCN) due to their clinical relevance. The AN exits the posterior cord, courses posterolateral through the quadrangular space and runs alongside the posterior circumflex humeral artery. It provides motor innervation to the deltoid and teres minor, as well as sensory innervation to the skin over the shoulder (Moore). The MCN exits the lateral cord, pierces the coracobrachialis (CB), then courses between the biceps brachii (BB) and brachialis before emerging lateral to the BB tendon as the lateral cutaneous nerve of the forearm (Moore). It provides motor innervation to coracobrachialis, biceps brachii and brachialis, as well as sensory innervation to the lateral forearm (Moore).

Ultrasound provides the ability to acquire cross-sectional imaging that allows clinicians to measure the cross-sectional area (CSA) of a nerve, which may be used as an additional diagnostic criteria when assessing brachial plexopathies (Bedewi 2018). US machines are portable and commonly found in a variety of healthcare settings, making it highly accessible (Kavic 1997).



Results

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We found that the distance between the coracoid process and the location of nerve penetration into CB was 7.88±3.09 cm in males, 6.83±2.09 cm in females. In patients with the typical MCN course, the penetration point of MCN may be found at 25% of the brachium, distal from the CP. One study describes a dangerous zone for the MCN as greater than 5 cm from the CP (Apaydin et al). Our study suggests a more expansive danger zone should be considered, with the CP to penetration point of MCN distance being as short as 3.5 cm (range=3.5-14 cm). Results of the correlation analyses showed that among women, there was a significant, positive correlation of origin of AN to ME with CP to ME (r=0.86, p<.001) and whole arm length (r=0.75, p<.001). among men, there was a significant, positive correlation of origin of the AN to ME with CP to ME (r= 0.88, p<.001) and whole arm length (r=0.47, p=.026).

Results Continued

Two-tailed independent t-test showed a significant difference in average anterior AN CSA between male and females (p=.028), while showing no gender differences for posterior AN (p=.077) or MCN CSA (p=.506). There was a significant, positive correlation of MCN CSA with arm length (r=0.37, p=.021). There was also significant, positive correlations of posterior AN CSA with height (r=0.41, p=.011) and arm length (r=0.40, p=.013).

Variable	Mean ± SD	N
MCN CSA (F)	0.11 ± 0.02 mm^2	8
MCN CSA (M)	0.13 ± 0.02 mm^2	10
Ant. AN CSA (F)	0.13 ± 0.04 mm^2	9
Ant. AN CSA (M)	0.18 ± 0.04 mm^2	9
Post. AN CSA (F)	0.19 ± 0.06 mm^2	9
Post. AN CSA (M)	0.24 ± 0.09 mm^2	9
Age	26.14 ± 4.76	21
Height	67.45 ± 3.92 in	21
Weight	176.88 ± 41.68 lb	20
BMI	26.77 ± 4.96 kg/m^2	20

Variables	r_p	p-value
MCN CSA- BMI	0.10	.544
MCN CSA- Height	0.31	.056
MCN CSA- Weight	0.18	.281
MCN CSA- Arm Length	0.37	.021
Ant. AN CSA- BMI	0.09	.587
Ant. AN CSA- Height	0.13	.434
Ant. AN CSA- Weight	0.12	.468
Ant. AN CSA- Arm Length	0.18	.272
Post. AN CSA- BMI	0.14	.402
Post. AN CSA- Height	0.41	.011
Post. AN CSA- Weight	0.30	.068
Post. AN CSA- Arm Length	0.40	.013

Conclusions

The MCN variation was the most significant find because it has the higher degree of variation when compared to the AN. The posterior view of the AN within the quadrangular space was difficult in both US and cadaveric measurements because of the thick layer of fascia and overlying thickness of the deltoid muscle. US machine probe used at the lowest wavelength could still not easily identify the CSA in posterior view of the AN. In conclusion, the two brachial plexus nerves studied in this paper should serve as a pilot study into future explorations of the localization techniques used in specific procedures provided by the CSA measurements from this study to test whether the data is actually functional in clinical practice. Additionally, certain brachial plexopathies, such as entrapment syndrome, may be able to be treated with Osteopathic Manipulative Treatment (OMT). Future studies could be performed that compare the advantages and disadvantages of US versus MRI imaging diagnostic capabilities. US is a non-invasive, high resolution imaging technique that does not administer ionizing radiation, it makes for a safe option for pregnant patients, trauma cases, patients with pacemakers, and patients with claustrophobia (Kavic 1997, Suk 2013, Torloni 2009, Strakowski 2016, Pinzon 2011, Demondion 2003). US normalized data of the sural nerve could be another potential future study. AN and MCN healthy normalized baseline data provided in this study will allow the clinician to have a quick reference for diagnosis and treatment of neuropathies. The healthy levels of CSA could be eventually built in to the machine, and appear on the live image. A deeper understanding of nerve pathways and variations by cadaveric exploration can give the user and developer to provide precision care for the patient. The osteopathic physician will benefit from this data when locating anatomical bony landmark and subsequently a nerve or other structure. The tenants of osteopathy are: the person is a unit, the body is self-healing, structure and function are interrelated, and a rational approach to treatment. Our study compliments osteopathic physicians by approximating the location of the musculocutaneous and axillary nerves from palpable anatomic landmarks.