International Journal Dental and Medical Sciences Research
Volume 5, Issue 5, Sep-Oct 2023 pp 637-646 www.ijdmsrjournal.com ISSN: 2582-6018

Anatomical Variations in Origin, Course, and Distribution of Mainterminal Branches of Brachial Plexus in Morphology among Black African Population; Cadaveric Study in Western Kenya.

Omuga, Philip Charles Alinyo,[1] Marera, Dominic, & Ng'wena, Gideon, [2] Omondi, Calvin,[3] Otieno, Olga[4], Waswa Kennedy,[5] Khisa Allan,[6] Oluma Edwin,[7] Oyale Warren[8]&Owuocha Dorice. [9]

Correspondence: *Omuga, Philip Charles Alinyo,(Postgraduate student), Maseno University, Kisumu, Kenya,*
[2] Marera, Dominic, Department of Anatomy, School of Medicine, Maseno University, Kisumu, Kenya. P.O Box333-40105 private bag Maseno.
[2]Ng'wena, Gideon, Department of Physiology, School of Medicine, Maseno University, Kisumu, Kenya. P.O. Box 333-40105 private bag Maseno. Email: ngideo@maseno.ac.ke Phone: 0720804606
[3]Omondi, Ochieng Calvin, (Postgraduate student), Maseno University, Kisumu, Kenya.
[4]Otieno, Olgah Anyango (Postgraduate student), Maseno University, Kisumu, Kenya,
[5]Waswa, Kennedy Wanyonyi (Postgraduate student), Maseno University, Kisumu, Kenya,
[6]Khisa, Allan Wanjala, (Postgraduate student), Maseno University, Kisumu, Kenya,
[7]Oluma Wanjala,Edwin (Postgraduate student), Maseno University, Kisumu, Kenya,
[8]Oyale, Warren Ayonga (Postgraduate student), Maseno University, Kisumu, Kenya,
[9]Owuocha, Dorice Akoth (PhD student), Masinde Muliro University Kakamega, Kenya,

Date of Submission: 01-11-2023 Date of Acceptance: 11-11-2023

ABSTRACT
The brachial plexus (Bp) has many variations, anda greater understanding of these differences is essential for achieving good surgical outcomes. The current study's objective was toinvestigate anatomical variations in the origin, course, and distribution of the terminal branches of Bp.The anatomical laboratory departments at Maseno, Masinde Muliro, and Uzima Universities undertook a descriptive, cross-sectional study. Using the Yamane Taro formula, a sample size of 70 (35 males and 35 females) cadavers was used from a total of 86. Ethical consideration was undertaken. X^2 test was applied. The P-value for significance was set at0.05. Data was entered into a Microsoft Office Excel spreadsheet, and statistical analysis was performed using SPSS version 26. Descriptive statistics was used to determine the mean, mode, median, and standard deviation of the variations. Study findings recorded no statistical significance in variation of the axillary, ulnar, musculocutaneous, medial,and radial nerve.This study found Bp variations at the root at38 (27.1%), on the trunks at 11(7.9%), at the divisions 3(2.2%), and the cords at 4(2.9%). The highest variation was at the prefixed root, while the least was at the division. Both anatomists and clinicians are interested in learning about these anatomical variances. These variances must be understood by surgeons who perform procedures involving neoplastic or reparativetraumasurgeries.Anestheticregional blocks atthe axilla brachial plexus nerves and surgical procedures may become disorientedbecause of median nerve variations.

Keywords: Anatomical variations; Brachial plexus; cadaver;course; distribution; length;origin.

I. INTRODUCTION

Brachial plexus (Bp) is a complex interaction of nerves of the spinal cord at the brachium (humerus region) and neck region (Rasulic et al., 2020). It conveysmotor and sensory innervation to extrinsic thoracic muscles and the sympathetic impulses from the spinal cord into the arms. It connects via inter-scalene muscle between the anterior scalene muscle and middle scalene, then through the posterior neck triangle Vaid and Vaid (2015). The union of C5, C6, C7, C8 and T1 forms it. There are different segments, thus the roots, trunks, divisions, and cords (Emamhadi et al., 2016).

Studies stipulated that it is located in the upper limbs of the human body, with embryological originbeing the initial differentiation of mesenchymeoccurringin the fourth week of embryologyStandring (2016). Primordial dorsal nerves reach the length of the distal outstretch of the humerus innermost the sheath at the growing primordial arm muscle nerves originate from C5 to

T1 that commence extending on day 32 of human life, whereby the nerves merge and form Bp(Bala, Sinha, Tamang, & Sarda, 2014; Rasulic et al., 2020).

The interconnection of nerves conducts signalsfrom the spine into the shoulder, arm, and hands. Bp injuries are caused by the destruction of those nervesSachar, Ray, Landau, Dy, and Brogan (2020). Commonly, injuries are caused by trauma to the neck and shoulderregion. These symptoms might include a limp, paralyzed arm, inadequacy of muscle control in the arm, hand, or wrist, and absence of sensational feeling in the arms and or hand(Emamhadi et al., 2016).

Pizzo and others (2019) established that it's essential for neurosurgeons, anesthesiologists, and anatomists to grasp the technical recognition of the anatomy of the human neuron complex network, leading to efficient outcomes in the critical and emergency patient comfort anda better prognosis. The most significant vital challenges in human anatomy arefound in the nerve variations, particularly in extreme casesin the upper limb Pizzo, Yoon, Adams, Lynch, and Liporace (2019). This could bedue to sports injuries, car or motorcycle accidents, falls, medical conditions like autoimmune, and surgery around the upper limbs, which are vulnerable to trauma.(Hardcastle, Texakalidis, Tora, Nagarajan, & Boulis, 2020; Verma, Vora, Thatte, & Yardi, 2020). It's important to note that Bp anatomical variations are so common. Most of the cadaveric anatomical studies of the human nerve connection are reported to erupt from the Bp(Pizzo et al., 2019).

Professor Ogeng'o (2013) and others indicated thatBp injuries may occur during the delivery of newborns.After head delivery, the anterior shoulder of an infant may not pass below the pubic symphysis minus manipulation (Bahm, Bouslama, Hagert, & Andersson, 2020; El Falougy, Selmeciova, Kubikova, Stenova, & Haviarova, 2013). This manipulation may cause the baby's shoulder to overstretch, damaging the Bp to varying degrees (Feigl, Litz, & Marhofer, 2020; Singh, Das, Deora, Jaiswal, & Behari, 2020). This type of injury is often alluded to as shoulder dystocia. Shoulder dystocia can result in obstetric brachial plexus palsy (OBPP), the actual injury to the BpTay et al. (2021). The incidence of OBPP in the USA is 1.5 per 1000 births, while lower in the UK and the Republic of Ireland (0.42 per 1000 births). While there are unknown risk factors for OBPP, if any newborn is involved in shoulder dystocia, this increases their risk for the OBPP 100-fold (Menticoglou, 2018). Nerve damage has been interconnected to birth weight, with bigger babies being more susceptible to injury, but it may also involve the delivery methods. Although very difficult to prevent during live birth, clinicians must be able to deliver newborns with precise and tender movements to minimize the chances of injuring the nerve(Fakoya et al., 2019; Tay et al., 2021).

The most frequent variations of the Bp may lead to a lack of success amid infiltration of local anesthesia Yee et al. (2019). Following invasive surgical therapy of lesions of the brachial plexus variations could lead to inadvertent injury of the nervesLam, Fufa, Chang, and Chuang (2015). The variations in the emergence of trunks of Bp have effectively been described. Other studies foundthe upper trunk not being formed in a smaller percentage of cases, lower trunk of Bp being created by the T1 plus T2 roots while a formation of superior trunk of the Bp by C5, C6 plus C7 roots is quite rare, which always unite minus the middle trunk where by surgeon defend this kind of scenario as the act of anatomical fusion of the middle with superior trunkLeonel et al. (2021). A case was documented in regard to a fusion of the superior plus middle trunk established to be bilateral Martin, Senders, DiRisio, Smith, and Broekman (2018).

Martin et al. (2018) extensively observed a female cadaver with a bilateral variation in the Bp. The musculocutaneous nerve arising from the median nerve instead of lateral code of Bp on the left part at a distance of 75mm while the right side at a distance of 66mm away from the coracoid processSharma et al. (2016). On both sides, the musculocutaneous nerve penetrates coracobrachialis muscles at a distance of 128mm away from the coracoid processEllabban, Sadek, Galhom, Hafez, and Ramadan (2021). In both limbs, the Bp nerve cell projection fibers of musculocutaneous run along with a projection of the median nerves for 21mm along their pathwayRusso et al. (2020). The median nerve was established on the left side at 54mm, while the right part was at a distance of 45 mm away from the coracoid process. No other variations were identified in the pathway of the median nerves on both sides.

Studies done by Kuhn and others (2015) indicated that the median nerve was established at different distances away from the coracoid process, and the musculocutaneous nerve pierced the coracobrachialis at different distances away from the coracoid process. This type of study is essential and valuable to orthopedicians, anatomists, neurosurgeons, radiologists, anesthetists, surgeons, nurses, and other carders. In invasive surgical

procedures around the humerus and shoulder region, nerve blocking, plastic surgical operations, diagnosis, and managing of traumatic peripheral neuropathies in which these structures must be recognized and protected for probable injuries; therefore, collecting information regarding these structures plus their variations in the different populations is very essentialKuhn, Lebus, and Bible (2015). In comparison, some studies on Bp variations have been documented by several authors who identified variations in47.1% of their series and 53.5% of human females on the right side. This indicates the variations; therefore, it explains clinical syndromes with effect resolution in post-traumasurgical procedures. It is important to note that selective therapeutic failures and lack of success of the brachial plexus tumors reparative surgery are directly interconnected to variations Leaper, Tanner, Kiernan, Assadian, and Edmiston (2015). Different anomalies of long thoracic nerves were united at other parameters, though they couldn't outline a long thoracic having a course from C3 specifically encountered in that research Kuhn et al. (2015). The surgeons operating should, on the back oftheir minds, be bound to understand the feasibility of the proximal and or distal superior with inferior root joining. Surgeons with classical technical skills of nerve fibers may cause destruction. The suprascapular nerve is moreoften prone to a variable; it may begin at C4 or C5 from the posterior or anterior division of the upper trunk plus from the posterior cord Leonel et al. (2021).

Emamhadi and associates (2016) established that most cadavers had inconsistency in the infraclavicular part; the medial cutaneous nerve was found disconnected from the medial cord in a big branch, whereas five cadavers displayed a cross-connection between the nerve above and the T1 spinal root. A medial antebrachial cutaneous nerve originating from a medial cord in thirty-seven plexuses (57.81%). Nevertheless, the rest derived from the inferior trunk, in the totality of male cadavers. The suprascapular nerve was straightly established by the C5spinal root of six brachial plexuses. Often, the subscapular nerve arises at the posterior cord. A variation was noted at the beginning of the upper subscapular nerve, appearing at the superior trunk. The medial pectoral nerve abnormally shot up from the anterior division at a medial trunk into two plexuses. The lateral pectoral nerve had no variations at all. Final dissection revealed that the thoracodorsal was found to vary in a sixty-year-old lady inone of the two arms, emerging from the axillary nerve.

In some cases, the thoracodorsal nerve usually arises from the posterior cord, as in totality, spinal roots begin at the C5 to T1, forming the nerve. Brachial Plexus terminal branches that are ulnar nerve which arises from C8 to T1 roots. Rasulic et al. (2020) found that three cadavers (2 females and one male) had apparent variations on the ulnar nerve. These cases illustrated that the ulnar nerve got a connecting branch from the lateral cord. The median nerve had variations in the twenty-two plexuses. The median nerve in some cadavers was established by only two lateral roots originating from the lateral cord. And others with one medial rootbeginning from the medial line in six cadavers. The other five cases of significance are that either the musculocutaneous nerve generated an interconnecting branch into the median nerve or the median nerve drew abranch from theposterior cord of the plexus above Rasulic et al. (2020).

It was well-established that lateral roots from the lateral cord were exemplarily united to emerge from the musculocutaneous nerve. Some nerve fibers at C7roots infiltrated in three females and five males. We revealed that the majority of cases of radial nerves were established by the posterior cord (C5 to T1 roots). In contrast, themain part united with the division of the middle cord a long with inferior trunks (C7to T1 roots)andstraight away communicated to produce radial nerve of the remainder in the bilateral plexus in 1 male cadaverEmamhadi et al. (2016)This kind of knowledge might also help in the treatment on-neural tumors like lipoma Leijnse, de Bakker, and D'Herde (2020). Most ofthe orthopedic therapy oncervical spine injuries requires technical skills along with theatypical emergence of Bp, even though the reported variations may rarely alter the physiological function of an individual's upper limbs. All these are vital for general and orthopedic surgeries.

II. MATERIAL STUDIED

The study population is represented by 70 cadavers of both genders, female n=35 and male n=35 in theanalyzed number. This research was conducted at the Maseno University School of Medicine based in Kisumu County, Western Kenya. Adescriptive cross-sectional study designwas employed for measurements and descriptionof brachial plexus anatomical variation regardingorigin, length, distribution, and course. This was demonstrated in the distribution of the brachial plexusin observed cadavers in the studypopulation between 2018 and 2022.The cadavers were properly embalmed and formalin-fixed before routine dissection practice for undergraduates was used. The inclusion criteria

International Journal Dental and Medical Sciences Research
Volume 5, Issue 5, Sep-Oct 2023 pp 637-646 www.ijdmsrjournal.com ISSN: 2582-6018

entailed cadavers of black African descent,both genders (male and female) with theupperlimp intact, were included in the study. Exclusion criteria entailed Cadavers with no demographic characteristic data, and those whose upper limbs had been dissected were also excluded from the study.

2.1 Sampling design

Sampling strategy

The three universities were purposively and conveniently identified because of their operational human anatomy department that met the CUE standards forstoring human tissue. For equal distribution of samples, the sampling procedure was actualized proportionately with the strata population by location, whereby the sample size per laboratory was then calculated by dividing the cadaver in the laboratory (d) by the total location population (86) and then multiplying it by the desired sample size (70) as projected on Table 3.1. n= (d*70)/86. The sample is shown in Table 1.

Locations of laboratory	Location population	Sample size per location
Maseno university	43	35
Masinde Muliro University	23	19
Uzima University	20	16
Total	**86**	**70**

Table 1: Sample Size Allocation

2.3 Dissection technique

The dissection tools usedwere Adson dissecting forceps, hemostats, dissecting pair of scissors, tapemeasure, blade handle, and scalpel. This procedure demanded extreme care to preserve the essential fine distal nerve fibers. A dissection guide (Cunninghams) was used foraccuracy andpreciseness in the surgical dissection. The upper limb was abducted, and then, with a surgical scalpel,the skin of the pectoral part was removed, and an incision was made along the sternoclavicular plane.Another incision pressed vertically from the superior to inferior margin along the posterior neck triangle.Then, the superficial fascia was removed, and subsequently, the deep fascia exposed the clavicular and sternocostal heads of the pectoralismajor afterward reflected to get lateral pectoral nerve piercing the pectoralis muscles. Thepectoralis minor muscle was later reflected to expose the contents of the axilla along with the brachial plexus fibers. The cut was elongated to a deltoid, pectoral groove in the direction of the pectoralis central to get the starting point of the subscapular nerve, lateral pectoral, thoracodorsal, medial pectoral, medial brachial cutaneous plus medial antebrachial cutaneous nerves. An Oscillating saw cut the middle third of the claviclebone to identify the axillary artery. , thevertical incision was made to unveil the site between the triceps and biceps muscles. Then, the following was displayed: roots were located at the scalene gap, trunkslay bare superiorly to the clavicle, divisions manifested around the posterior portion, and cords plus branchesuncovered inferiorly to the clavicle.Median, axillary, radial,musculocutaneous, and ulnar nerves, plus their origin, were displayed in the infraclavicular region as well. Variations in the trunks, divisions, and cords were equallyscrutinized.Dimension from the end-to-end part of the nerves from the origin toward the intent target muscles were located and measured.

2.4 Ethical consideration

The procedure of acquiring cadavers is a legal process. A court order must be obtained to enable theuniversity to receive unclaimed bodies from the state after three months from the time of death. The university then contacts specific hospital boards of directors and the court to acquire selected bodies. After a court order, the university formally requests to accept bodies depending on different precise demands. The medical institution then liaises with the university to invoke transportation logistics of these bodies. The bodies are thenreceived in the department of human anatomy. Labeling and coding are then concluded for an easy identification process. Cleaning plus embalming with formaldehyde 40% is done immediately in preparation fordissection.

International Journal Dental and Medical Sciences Research
Volume 5, Issue 5, Sep-Oct 2023 pp 637-646 www.ijdmsrjournal.com ISSN: 2582-6018

III. RESULTS

Levene's test for equality of thevariances was used to determine if the variances of the main terminal branching patterns are equal and then to assess the strength of the relationship of variations from normal. An F value and its entire associated p-value were reported. If a p-value is less than .05, the assumption of equal variances isviolated, and therefore "equal variances were not assumed" row is used.A 95% confidence interval of the difference between the means was recorded. The standard error difference, the mean difference, and the upper and lower limits of the confidence interval wereprovided.

Table 4.1: Independent Samples Test (Right Terminals of Brachial Plexus)

		Levene's Test for Equality of Variances		t-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	T	df	One-Sided p	Two-Sided p	Mean Difference	SED	Lower	Upper
Axillary Nerve	EVA	.196	.659	-1.860	68	.034	.067	-.0886	.0476	-.1836	.0064
	EVA			-1.860	67.374	.034	.067	-.0886	.0476	-.1836	.0065
Radial Nerve	EVA	.161	.689	.575	68	.284	.567	.0343	.0597	-.0847	.1533
	EVA			.575	67.978	.284	.567	.0343	.0597	-.0847	.1533
Ulnar Nerve	EVA	1.952	.167	-1.300	68	.099	.198	-.5429	.4175	-1.3760	.2902
	EVA			-1.300	64.425	.099	.198	-.5429	.4175	-1.3768	.2911
Musculocutaneous Nerve	EVA	.965	.329	-1.422	68	.080	.160	-.3429	.2411	-.8241	.1383
	EVA			-1.422	67.270	.080	.160	-.3429	.2411	-.8242	.1384
Median Nerve	EVA	2.720	.104	.558	68	.289	.579	.2743	.4916	-.7067	1.2553
	EVA			.558	64.163	.289	.579	.2743	.4916	-.7078	1.2563

Key: EVA=Equal variance assumed; SED=Std. Error Difference

InTable 4.1, there was no statistically significant variationrecognized in all the branching patterns of the brachial plexus; even though variations were reported, Levene's test didn't show any strong atypical variation away from the normal anatomical standards.

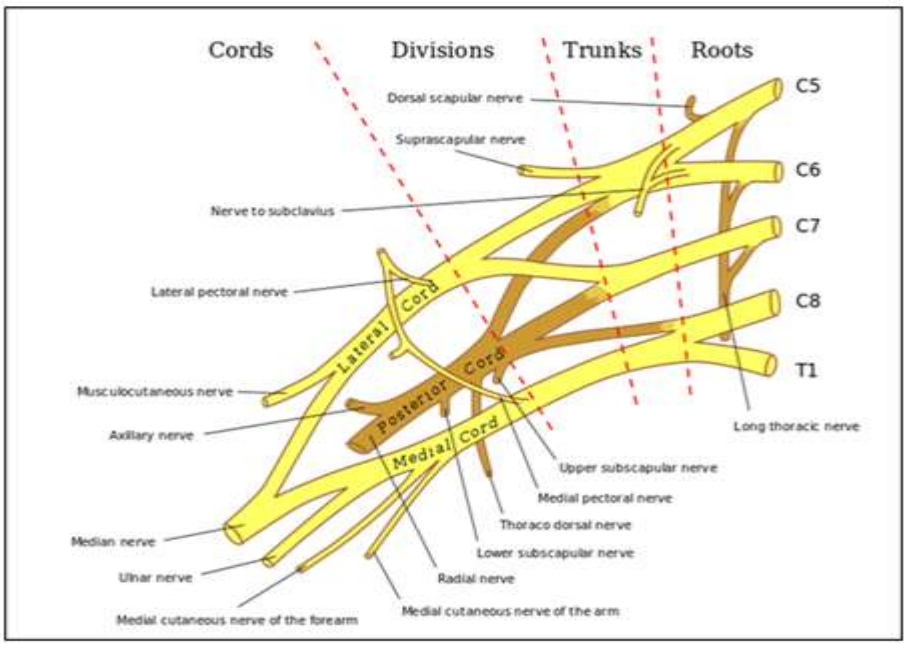

Figure 4.1: Anatomical diagram of an actual normal brachial plexus (M. Emamhadi et al., 2016)

International Journal Dental and Medical Sciences Research
Volume 5, Issue 5, Sep-Oct 2023 pp 637-646 www.ijdmsrjournal.com ISSN: 2582-6018

Figure 4.2: The median nerve is formed by a single nerve root, while the musculocutaneous nerve provides a communicating offshoot to the median nerve.

KEY: M=Musculocutaneous nerve, CM= Communicating branch of the musculocutaneous connecting the median nerve.MN= Median nerve.

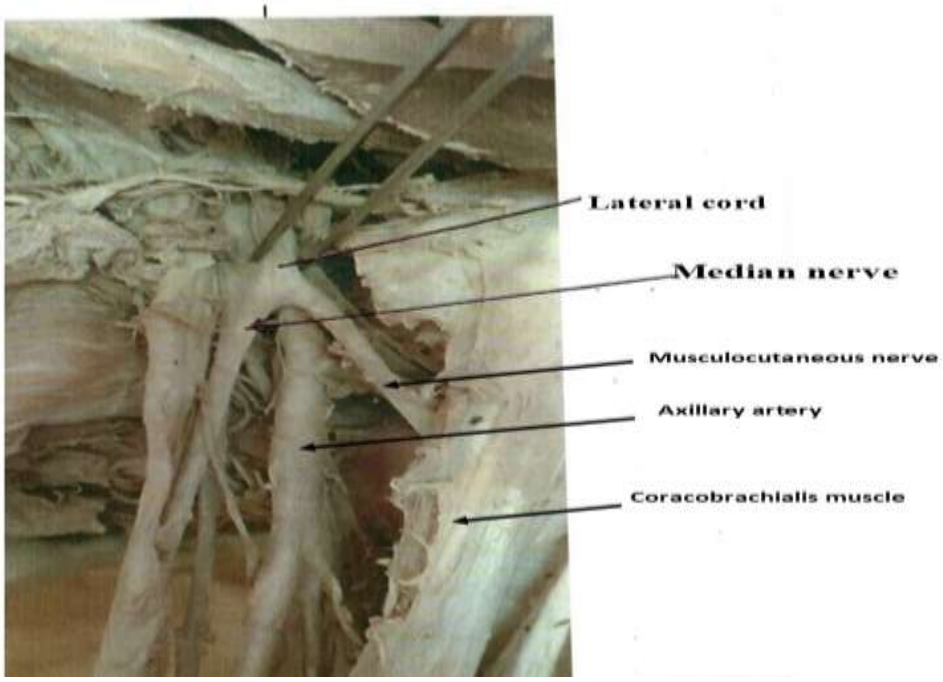

Figure 4.4:Median nervewell-established from only one lateral cord.

International Journal Dental and Medical Sciences Research
Volume 5, Issue 5, Sep-Oct 2023 pp 637-646 www.ijdmsrjournal.com ISSN: 2582-6018

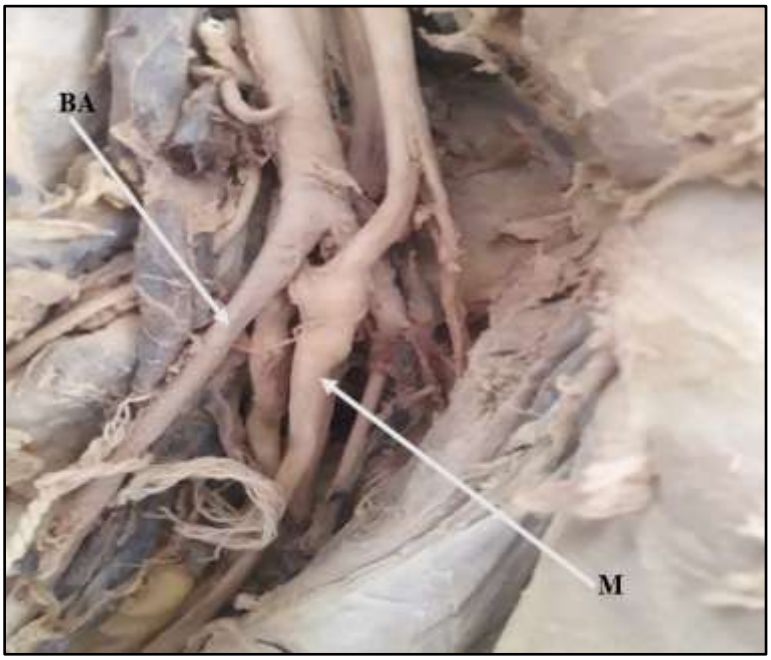

Figure 4.5: Brachial artery passingsuperficially and superiorly to the median nerve**.**
KEY: BA=Brachial artery, and M=Musculocutaneous nerve.

Table 4.2: Frequency distribution of origin plus sections of the brachial plexus

		Total	
		Right + Left UL N=140	Percentage (%)
Roots	Normal	102	72.9
	Variant Post fixed	9	6.4
	Variant Prefixed	29	20.7
	Total	140	
Trunks	Normal	129	92.1
	Variant	11	7.9
Divisions	Normal	137	97.8
	Variant	3	2.2
Cords	Normal	136	97.1
	Variant	4	2.9

InTable 4.2, total variations in the root of the brachial plexus were 27.1% (38), the trunks 7.9% (11), the divisions 2.2% (3), and the cords 2.9% (4). The highest variation was in the prefixed root, while the least was in the division.

IV. DISCUSSION

In the current study, it ascertained that there was a statistically significant difference (p=0.008) in a variation of distribution of the median nerve with gender (male and female). It is in agreement with observations byPandey and Shukla (2007)in India, whereby it was confirmed that median nerve variation prevalence was at 12.8% and 13.2%, 10.7% among males and females, respectively. These alterations are variant in terms of origin, course, and location of the axillary artery. Therefore, this study postulates that these variations are mainly prone to injury during radical neck and axilla surgical dissection procedures. The formation of the median nerve arises lateral to an axillary artery in theaxilla, which is normal humananatomy.

Nevertheless, the median nerve may be correlated with variations in the uncommon communication with nerves such as musculocutaneous and ulnar or even splitting and penetrating adjacent blood vessels. The following anatomical variations were detected in the reports of (Budhiraja, Rastogi, & Asthana, 2017; Samarawickrama, 2017) in Brazil, whereby 22.4% of upper limbs three rootswere associated inthe formation of the median nerve, 6.12% medial to the axillary artery and 1.53% ventral to axillary artery. In this current study, notably, the median nerve was formed byone singleroot rather than the usual two

roots, which isanatomicallypeculiar. It was also detected that the brachial artery was superficial to the median nerve, which is inconsistent with the normal humananatomy of the brachial artery, whichcourses below the median nerve.

This study established total variations of brachial plexus at the root to be 27.1% (38), and on the trunks, 7.9% (11), the divisions 2.2% (3), and at the cords 2.9% (4). The highest variation was found at the prefixed root, while the least was in the division compared to studies realized by (Gilcrease-Garcia and others (2020), who indicated that the standard anatomy textbook of brachial plexus has five roots originating from C5-T1 spinal nerves, three trunks (superior, middle, and inferior trunk), six divisions (3 posterior and three anterior divisions), three cords (lateral, medial and posterior cord) and five main terminal branches (musculocutaneous, axillary, radial, ulnar and medial nerve)

In the entire study population, the findingsrealized no statistical significance in the variation of ulnar, axillary, musculocutaneous,radial, and medial nerve. The current study findingsdiffered from those of Sinha, Khani, Mansoori, and Midha (2016) in Iran, who recognized a significant variation in the main terminal branches of the brachial plexus. Someother authors, Demis and Bekele (2017) From Ethiopia, collaborated with the current study pronouncementin reporting no statistically significant variation in the terminal branching of brachial plexus in both males and females. Nonetheless, it documented deviations mostly of the median, the musculocutaneous, and axillary nerve, respectively.

V. CONCLUSION

Amidst surgical excursionencompassing the axilla and the neck region, variations assume a great deal of significance, for the nerves are furthermore vulnerable to injury. Nonetheless, some more variations we have cited may alter the typical operative functioning procedure of the arm appertaining to an individual.

This must be kept up-to-date by the surgeon in standard surgical intervention, including an anesthesiologist,during regional anesthesia block.

Its significance owing to surgeries is indeed undisputed to a large extent during trauma surgeries. Existenceas regards entrapment of either the median nerve or brachial artery or both open on to several neuropathies largely attributed to compaction of the median nerve.

Regardless of any extent of morphological or anatomical variations, cliniciansought to nurture a high index of suspicion for theirtechnical surgical interventions for a better prognosis for respective clients.

VI. RECOMMENDATION

Brachial plexus variations are mainly encountered in many cases, but extremely little is known about the Bp on the etiology of embryologicalmorphogenesis and the environmental factors. More studies should be undertaken in this scope. Receptors leading to this variation, to our knowledge, are unknown; however, this might incorporate and rarely be limited to hemodynamic and either oxygenation or nutrition indicators. Peri-surgical maneuvers encircling the axilla should undergo a radiological investigation to identify the leastpossible brachial plexus variations.

Acknowledgement

The authors wish to thank the entire committee of human research, publications, andethics. We would also like to thank the three universities for their study protocol preceding its implementation, granting us the opportunity to undertake a Master of Science in HumanAnatomy Degree at Maseno University. We must sincerely acknowledge support from the two supervisors, Dr. Domnic Marera and Prof. Gideon Magak, remembering all the lectures, our peers, and extra-mural studies for their support and direction in any respect towards completing this manuscript.

REFERENCES

[1]. Bahm, J., Bouslama, S., Hagert, E. M., & Andersson, J. K. (2020). Ulnar Wrist Deviation in Children With Obstetric Brachial Plexus Palsy: A Descriptive Study of Clinical and Radiological Findings of Impaired Ulnar Growth and Associated Incongruence of the Distal Radioulnar Joint. Hand (N Y), 15(5), 615-619. doi: 10.1177/1558944719831243

[2]. Bala, A., Sinha, P., Tamang, B. K., & Sarda, R. K. (2014). Anatomical variation: median nerve formation - a case vignette. J Clin Diagn Res, 8(6), AD03-04. doi: 10.7860/JCDR/2014/7620.4455

[3]. Budhiraja, V., Rastogi, R., & Asthana, A. (2017). Anatomical variations of median nerve formation: embryological and clinical correlation. Journal of Morphological Sciences, 28(4), 0-0.

[4]. Demis, E. G., & Bekele, A. (2017). Anatomical variations of the brachial plexus terminal branches in Ethiopian cadavers. Anatomy Journal of Africa, 6(1), 896-905.

[5]. El Falougy, H., Selmeciova, P., Kubikova, E., Stenova, J., & Haviarova, Z. (2013). The variable communicating branches between musculocutaneous and median nerves: a morphological study with clinical implications. Bratisl Lek Listy, 114(5), 290-294. doi: 10.4149/bll_2013_061

[6]. Ellabban, M. A., Sadek, A. F., Galhom, A., Hafez, A. E., & Ramadan, A. (2021). Comparison between long and lower medial head triceps branches in dual neurotization for shoulder function restoration in upper brachial plexus palsy. Microsurgery, 41(2), 124-132. doi: 10.1002/micr.30690

[7]. Emamhadi, M., Chabok, S. Y., Samini, F., Alijani, B., Behzadnia, H., Firozabadi, F. A., & Reihanian, Z. (2016). Anatomical Variations of Brachial Plexus in Adult Cadavers; A Descriptive Study. Arch Bone Jt Surg, 4(3), 253-258.

[8]. Fakoya, A. O. J., Aguinaldo, E., Velasco-Nieves, N. M., Vandeveer, Z. T., Morales-Marietti, N., Mathew, S., . . . McCracken, T. (2019). Unusual Splitting of Medial Cord of the Right Brachial Plexus and Its Relation to the Axillary Artery and Subscapular Artery: A Case Report. Open Access Maced J Med Sci, 7(12), 2006-2009. doi: 10.3889/oamjms.2019.561

[9]. Feigl, G. C., Litz, R. J., & Marhofer, P. (2020). Anatomy of the brachial plexus and its implications for daily clinical practice: regional anesthesia is applied anatomy. Reg Anesth Pain Med, 45(8), 620-627. doi: 10.1136/rapm-2020-101435

[10]. Hardcastle, N., Texakalidis, P., Nagarajan, P., Tora, M. S., & Boulis, N. M. (2020). Recovery of shoulder abduction in traumatic brachial plexus palsy: a systematic review and meta-analysis of nerve transfer versus nerve graft. Neurosurg Rev, 43(3), 951-956. doi: 10.1007/s10143-019-01100-9

[11]. Kuhn, J. E., Lebus, V. G., & Bible, J. E. (2015). Thoracic outlet syndrome. J Am Acad Orthop Surg, 23(4), 222-232. doi: 10.5435/JAAOS-D-13-00215

[12]. Lam, W. L., Fufa, D., Chang, N. J., & Chuang, D. C. (2015). Management of infraclavicular (Chuang Level IV) brachial plexus injuries: A single surgeon experience with 75 cases. J Hand Surg Eur Vol, 40(6), 573-582. doi: 10.1177/1753193414553753

[13]. Leaper, D. J., Tanner, J., Kiernan, M., Assadian, O., & Edmiston, C. E., Jr. (2015). Surgical site infection: poor compliance with guidelines and care bundles. Int Wound J, 12(3), 357-362. doi: 10.1111/iwj.12243

[14]. Leijnse, J. N., de Bakker, B. S., & D'Herde, K. (2020). The brachial plexus - explaining its morphology and variability by a generic developmental model. J Anat, 236(5), 862-882. doi: 10.1111/joa.13123

[15]. Leonel, L. C. P., Carlstrom, L. P., Graffeo, C. S., Perry, A., Pinheiro-Neto, C. D., Sorenson, J., . . . Peris-Celda, M. (2021). Foundations of Advanced Neuroanatomy: Technical Guidelines for Specimen Preparation, Dissection, and 3D-Photodocumentation in a Surgical Anatomy Laboratory. J Neurol Surg B Skull Base, 82(Suppl 3), e248-e258. doi: 10.1055/s-0039-3399590

[16]. Martin, E., Senders, J. T., DiRisio, A. C., Smith, T. R., & Broekman, M. L. D. (2018). Timing of surgery in traumatic brachial plexus injury: a systematic review. J Neurosurg, 1-13. doi: 10.3171/2018.1.JNS172068

[17]. Menticoglou, S. (2018). Shoulder dystocia: incidence, mechanisms, and management strategies. Int J Womens Health, 10, 723-732. doi: 10.2147/IJWH.S175088

[18]. Pandey, S. K., & Shukla, V. K. (2007). Anatomical variations of the cords of the brachial plexus and the median nerve. Clin Anat, 20(2), 150-156. doi: 10.1002/ca.20365

[19]. Pizzo, R. A., Lynch, J., Adams, D. M., Yoon, R. S., & Liporace, F. A. (2019). The unusual anatomic variant of the axillary nerve challenging the deltopectoral approach to the shoulder: a case report. Patient Saf Surg, 13, 9. doi: 10.1186/s13037-019-0189-1

[20]. Rasulic, L., Savic, A., Lepic, M., Kovacevic, V., Vitosevic, F., Novakovic, N., . . . Samardzic, M. (2020). Viable C5 and C6 Proximal Stump Use in Reconstructive Surgery of the Adult Brachial Plexus Traction Injuries.

Neurosurgery, 86(3), 400-409. doi: 10.1093/neuros/nyz179

[21]. Russo, S. A., Topley, M. T., Richardson, R. T., Richards, J. G., Chafetz, R. S., Rapp van Roden, E. A., . . . Kozin, S. H. (2020). Assessment of the relationship between Brachial Plexus Profile activity short form scores and modified Mallet scores. J Hand Ther. doi: 10.1016/j.jht.2020.10.003

[22]. Sachar, R., Landau, A. J., Ray, W. Z., Brogan, D. M., & Dy, C. J. (2020). Social Support and Coping Strategies in Patients with Traumatic Brachial Plexus Injury. HSS J, 16(Suppl 2), 468-474. doi: 10.1007/s11420-020-09814-z

[23]. Samarawickrama, M. (2017). A Study of Anatomical Variations of Median Nerve Formation and Its Relation to the Arteries in the Axilla and Arm. International Journal of Morphology, 35(2).

[24]. Sharma, G., Aycart, M. A., Najjar, P. A., van Houten, T., Smink, D. S., Askari, R., & Gates, J. D. (2016). A cadaveric procedural anatomy course enhances operative competence. J Surg Res, 201(1), 22-28. doi: 10.1016/j.jss.2015.09.037

[25]. Singh, S., Das, K. K., Deora, H., Jaiswal, A. K., & Behari, S. (2020). Traumatic Partial Posterior Cord Brachial Plexus Injury in a Patient with Aberrant Innervation of the Long Head of the Triceps by the Axillary Nerve: Implications in Nerve Transfer Surgery. Asian J Neurosurg, 15(2), 391-393. doi: 10.4103/ajns.AJNS_160_19

[26]. Sinha, S., Khani, M., Mansoori, N., & Midha, R. (2016). Adult brachial plexus injuries: Surgical strategies and approaches. Neurology India, 64(2), 289.

[27]. Standring, S. (2016). A brief history of topographical anatomy. J Anat, 229(1), 32-62. doi: 10.1111/joa.12473

[28]. Tay, E., Grigorian, A., Schubl, S. D., Lekawa, M., de Virgilio, C., Scolaro, J., . . . Nahmias, J. (2021). Brachial Plexus Injury Significantly Increases Risk of Axillosubclavian Vessel Injury in Blunt Trauma Patients With Clavicle Fractures. Am Surg, 87(5), 747-752. doi: 10.1177/0003134820952832

[29]. Vaid, S., & Vaid, N. (2015). Normal Anatomy and Anatomic Variants of the Paranasal Sinuses on Computed Tomography. Neuroimaging Clin N Am, 25(4), 527-548. doi: 10.1016/j.nic.2015.07.002

[30]. Verma, C. V., Vora, T., Thatte, M., & Yardi, S. (2020). Patient Perception after Traumatic Brachial Plexus Injury - A Qualitative Case Report. J Hand Ther, 33(4), 593-597. doi: 10.1016/j.jht.2019.03.007

[31]. Yee, A., Coombs, D. M., Hildebrandt, S., Seidelman, W. E., Coert, J. H., & Mackinnon, S. E. (2019). Nerve Surgeons' Assessment of the Role of Eduard Pernkopf's Atlas of Topographic and Applied Human Anatomy in Surgical Practice. Neurosurgery, 84(2), 491-498. doi: 10.1093/neuros/nyy159