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Differences in Demographic Characteristics in the Morphology of Brachial Plexus among Black African Population: A Cadaveric Study in Western Kenya.

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Abstract:- The anterior principal rami of C5 to C8 and T1 are joined to form brachial plexus (Bp), a network of nerves that wraps around neck and axilla of the body. Trauma, radiation, neoplasms, infections, and autoimmune diseases can all have an impact on Bp. The technical expertise required for clinical and surgical procedures is described in existing publications. Beginners still find it particularly difficult to use its many elements while navigating. The objective was to identify the differences in the demographic characteristics (male and female) of Bp among the population. A descriptive, cross-sectional study was carried at Maseno, Masinde Muliro, and Uzima Universities' anatomical laboratory departments. Total of 70 (35 males and 35 females) cadavers sample size was used from 86 cadavers using Yamane Taro formula. Ethical consideration was observed. Data analysis was done using SPSS vs26. X^2 test was used. Significance was set at a *P*–value = 0.05. Study comprised of 140 Bp (left and right sides). In the study population, Bp varied by gender, with median nerve accounting for a larger proportion. There was a statistically significant difference (p=0.008) in the variation of median nerve distribution in relation to the sexes. Variations noted were significant in the formation of roots, trunks, divisions, cords, and terminal branches. Coexistence of these differences is essential for it enables surgeons and anesthesiologists avoid purposeful damage to Bp nerves. Understanding these variances is crucial when evaluating sensory and motor loss that has been explained following surgery or trauma to upper limb.

Keywords:- *Anatomical variations; Brachial plexus; cadaver; demographic characteristics.*

I. INTRODUCTION

Brachial plexus is a network of nerves of spinal cord at the brachium (humerus) and neck region (Bala, Sinha, Tamang, & Sarda, 2014; Rasulic *et al.*, 2020).

It carries motor, sensory, innervation to extrinsic thoracic muscles and sympathetic impulses from spinal cord to the arms and travels through inter-scalene muscle between the anterior scalene and middle scalene muscle then via posterior triangle of the neck Vaid and Vaid (2015). The union of C5, C6, C7, C8 and T1 forms it. There are different sections thus the roots, trunks, divisions and cords (Emamhadi *et al.*, 2016).

Studies done indicated that it is found in the upper limbs in human body with embryological origin history being the initial differentiation of mesenchyme that occurs in the fourth week of embryology(Standring, 2016). Primordial of dorsal nerves reach at the length of distal stretch of the humerus inside the sheath of the growing primordial arm muscle nerves as from C5 to T1 that begin to extend on day 32 of human life, where the nerves merge and form brachial plexus (Bala *et al.*, 2014; Rasulic *et al.*, 2020).The networks of nerves conducts signals from the spine to the shoulder, arm and hands. Brachial plexus injuries are caused by damage of those nerves (Sachar, Landau, Ray, Brogan, & Dy, 2020). Usually, injuries are caused by trauma to the neck and shoulder. Symptoms may include a limp or paralyzed arm, lack of muscle control in the arm, hand, or wrist and lack of sensation in the arms or hand(Emamhadi *et al.*, 2016).

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(Pizzo, Lynch, Adams, Yoon, & Liporace, 2019) found that it's very significant in neurosurgeons, anatomists and anesthesiologists to grasp the technical awareness of anatomy of human neuron complex interconnecting network leading to a good outcome in critical and emergency patient care and better prognosis. The greatest significant challenges in human anatomy are nerve variations particularly in extreme is found in the upper limb (Pizzo *et al.*, 2019). Due to sports, car accidents or motorcycle, falls, medical conditions and physical activities the upper limbs are vulnerable to traumas (Hardcastle, Texakalidis, Nagarajan, Tora, & Boulis, 2020; Verma, Vora, Thatte, & Yardi, 2020).

It's all important to note that brachial plexus anatomical variations are very common. Most cadaveric anatomical studies of human nerves network is reported to manifest from the brachial plexus Pizzo *et al.* (2019). Professor Ogeng'o (2013) and others indicated that brachial plexus injuries can occur during the delivery of newborns when after the delivery of the head, the anterior shoulder of the infant cannot pass below the pubic symphysis without manipulation (Bahm, Bouslama, Hagert, & Andersson, 2020; El Falougy, Selmeciova, Kubikova, Stenova, & Haviarova, 2013). This manipulation can cause the baby's shoulder to stretch, which can damage the brachial plexus to varying degrees (Feigl, Litz, & Marhofer, 2020; Singh, Das, Deora, Jaiswal, & Behari, 2020). This type of injury is referred to as shoulder dystocia. Shoulder dystocia can cause obstetric brachial plexus palsy (OBPP), which is the actual injury to the brachial plexus Tay *et al.* (2021). The incidence of OBPP in the United States is 1.5 per 1000 births, while it is lower in the United Kingdom and the Republic of Ireland (0.42 per 1000 births). While there are no known risk factors for OBPP, if a newborn does have shoulder dystocia it increases their risk for OBPP 100-fold (Menticoglou, 2018) Nerve damage has been connected to birth weight with larger newborns being more susceptible to the injury but it also has to do with the delivery methods. Although very hard to prevent during live birth, doctors must be able to deliver a newborn with precise and gentle movements to decrease chances of injuring the child (Fakoya *et al.*, 2019; Tay *et al.*, 2021).

Studies done by Leone *et al.*,(2021)indicated that plexuses found to be fixed were 13 representing twenty four percent in origin, with 11 from female and male settled at 2,accounting for 5 being white and 8 taking black cadavers respectively, On percentage onto the right part acquired 54 % and left wing taking 46% Leonel *et al.* (2021). For phrenic nerve about 11 which is twenty percent arose from brachial plexus, thus nine males plus two females in a ratio of six white and five black cadavers (seventy three percent to the right and twenty seven percent at the left part. A supplementary phrenic nerve was found in twelve plexuses of about fifty percent on either side, in a ratio of three female and nine males. This is in reference to seven in black and five in white cadavers. Nerves emanating from the roots at the brachial plexus were found to be 54, dorsal scapular part had 45 plexuses. It was clear that twelve (27%) were found to be outside the muscle of middle scalene in their origin and course Martin et al (2018) extensively made an observation on a female cadaver, there was bilateral variation in the brachial plexus.

Vajapey and associates (2021) explored human cadavers aged above 18 years where 32 cadavers were contained in the study and assessment of sixty-four bilateral upper limbs eventually done. It was evident that the brachial plexus of male cadavers was normal on both sides Martin, Senders, DiRisio, Smith, and Broekman (2018). Socolovsky and her associates in contrast found a sex difference of two common origin of two or more branches being more frequent in females but no significance between the males (Socolovsky *et al.*, 2015).

Vajapey and others (2021) indicated a cadaveric median nerve being formed at the distal part of the arm making 67% in a ratio of 19 in female plus male being 29. Of these totals inferior trunk of brachial plexus gave rise to two medial cutaneous trunks all at the right part from the black male cadavers arising as from inferior trunk of brachial plexus. As from the terminal branches altogether of brachial plexus musculocutaneous and axillary nerves were not consistent as in the origin. Radial nerve got transmitting branch from 7% in the 4 cases of inferior trunk found in the male cadaver's one on the left and three on the right part. In 30% that is 16 cases thus 12 male and 4 female cadavers permitted transmitting branch as from lateral cord to the ulnar nerve. Two lateral roots plus one medial root (medial cord) formed the median nerve that's in 28 cases reflecting 52% in a ratio of three female and 25 being male, possessing nine from white origin and 19 of black cadavers. As found in four occurrences 1 in 2 lateral roots arose as from anterior division at the middle trunk along with 1 from lateral cord. The remaining twenty-four cases two lateral roots arose from lateral cord of brachial plexus. As of the median nerves four of them originated at the distal end of the same arm Vajapey, Contreras, Cvetanovich, and Neviaser (2021). The comprehensive understanding of the variations is essential for surgeons factoring into occurrence of series of procedures accomplished in the original pathways. Of note is the surgical interventions done in the pectoral sites and axilla for presence of abnormal branches must be retained into the mind. The knowledge of normal brachial plexus is important in reparative surgery.

II. MATERIAL STUDIED

The study population is represented with 70 cadavers of both gender male n=35 and female n= 35in number analyzed. This research was conducted at Maseno University School of Medicine located in Kisumu County Western Kenya. Descriptive cross- sectional study design was employed to report a description and measurements of the characteristics observed in the population under study during the time period between 2018 and 2022 on properly embalmed and formalin fixed during routine dissection practice for undergraduate was used. The inclusion criteria: Only the cadavers of black African descend, both male and female with upper limp intact was included for the study. Exclusion criteria: Cadavers with no demographic characteristic records and cadavers whose upper limbs have been dissected was excluded in the study.

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A. Sampling design

➢ *Sampling strategy*

The three universities were identified purposively and conveniently because of their functional human anatomy Department that have met the commission of university education standards for storage of human tissue. To ensure equal distribution of samples, sampling was done proportionately with the strata population by location, where the sample size per laboratory was calculated by dividing laboratory cadaver (*d*) by total location population (86), then multiplying by the desired sample size (70) as shown on Table 1. n= (*d**70)/86. Sample indicated in the table below.

Table 1: Sample Size Allocation

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

B. Dissection technique

The dissection instruments are hemostat, Adson forceps, dissecting scissors, scalpel, blade handle and measuring tape. The surgery demanded extreme vigilance to preserve the essential fine distal nerve constructions. In the process, dissection guide (Cunninghams) was used for accuracy and precise into the surgical procedure. The upper limb was placed in an abducted position, and with a surgical scalpel the skin of pectoral region was detached and slitting made along the sternoclavicular line, another cutting was made vertically from proximally to distally along the posterior neck triangle The superficial fascia was unfastened followed by deep fascia to uncover the clavicular and sternocostal heads of pectoralis major which were initially reflected to get lateral pectoral nerve probing pectoralis muscles. Pectoralis minor muscle then was reflected to unveil content of the axilla alongside the brachial plexus. The incision was extended to deltoid pectoral channel in the direction of pectoralis major with an intention of accessing the starting site of subscapular, lateral pectoral, medial pectoral, thoracodorsal, medial ante brachial cutaneous and medial cutaneous nerves. Oscillating saw was manipulated to get rid of the middle third clavicle and to identify axillary artery. In accessing the terminal branches of brachial plexus, vertical incision was made to display the site in-between the triceps and biceps muscles. The following were unveiled; roots which are in scalene gap, trunks that are established superior to the clavicle, divisions that rest around posterior portion of clavicle, cords and branches established inferior to the clavicle. Then median, axillary, ulnar, radial, and musculocutaneous nerves and their origin were pinpointed as well. Moreover, the scrutinized were the variations of the trunks, divisions, and cords. Also to detect the dimension from end to end of the entire nerves from the proximal origin toward the intent target muscles.

C. Ethical consideration

The process of obtaining cadavers is a legal process. There must be prompt court order to enable the university to acquire unclaimed bodies by the state after period of three months. The university there after get in touch with the hospital board of directors to acquire the bodies. After a court order, every facility makes a formal request to acquire bodies depending on different precise requirement. The medical institution then solely invokes transportation logistics of the bodies into the university. They are then received in human anatomy department. Then labeled and coded for easy identification proses. Cleaning and embalming with the formaldehyde 40% done immediately in readiness for the dissection purposes.

III. RESULTS

INCIDENCE OF OCCURRENCE OF VARIATIONS IN THE TOTAL UPPER LIMB SPECIMEN (N=140)

Table 2: Demographic characteristics of the study sample.

		Frequency	**Percent**
Gender	Female	35	50.0
	Male	35	50.0
	Total	**70**	**100.0**
University	Maseno University (Male)	18	25.7
	Maseno University (Female)	18	25.7
	Sub total	**36**	**51.4**
	Masinde Muliro University (Male)	7	10.0
	Masinde Muliro University (Female)	10	14.3
	Subtotal	**17**	**24.3**
	Uzima University (Male)	10	14.3
	Uzima University (Female)	7	10.0
	Subtotal	**17**	**24.3**
	Grand Total	**70**	**100.0**
Side of arm	Left	70	50.0
	Right	70	50.0
	Total	**140**	**100.0**

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A total of 70 cadavers with intact right and left upper limbs (UL) were used in the study, therefore, a total of 140 UL samples were used as the study samples. For the gender variable, there were 35 (50%) female cadavers and 35 (50%) male cadavers in the sample. The equal gender distribution was intentional to reduce bias during correlation tests (Table 2).

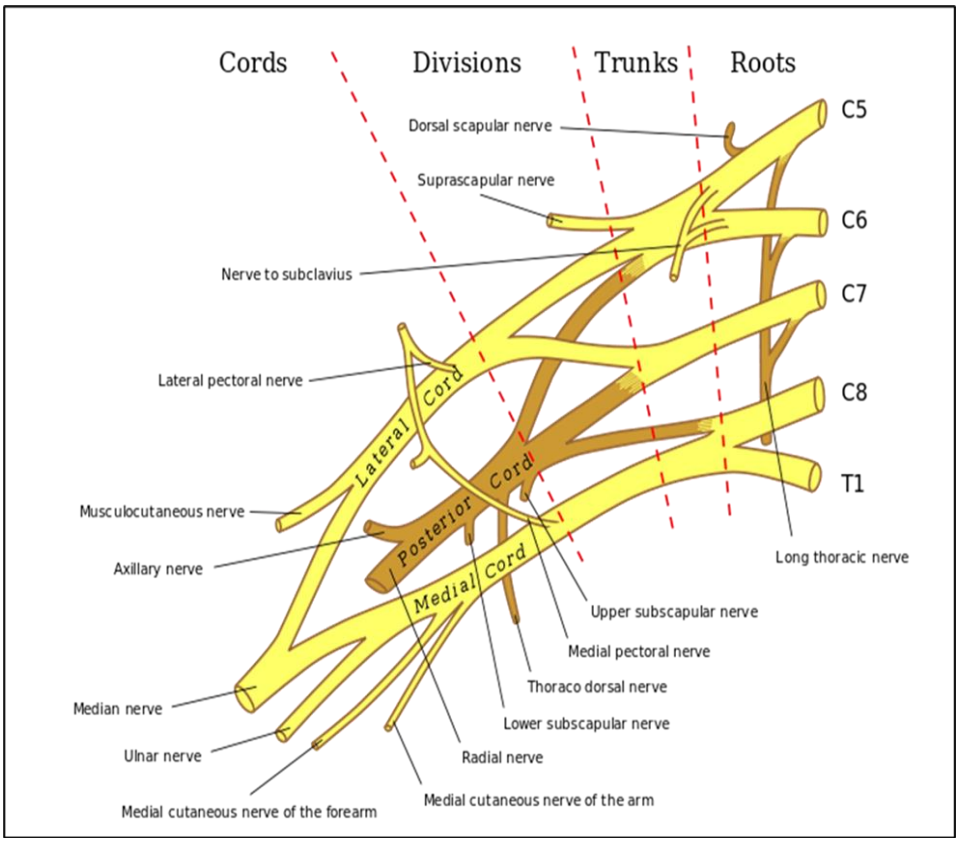

Fig. 1: The anatomical diagram of brachial plexus (M. Emamhadi et al., 2016)

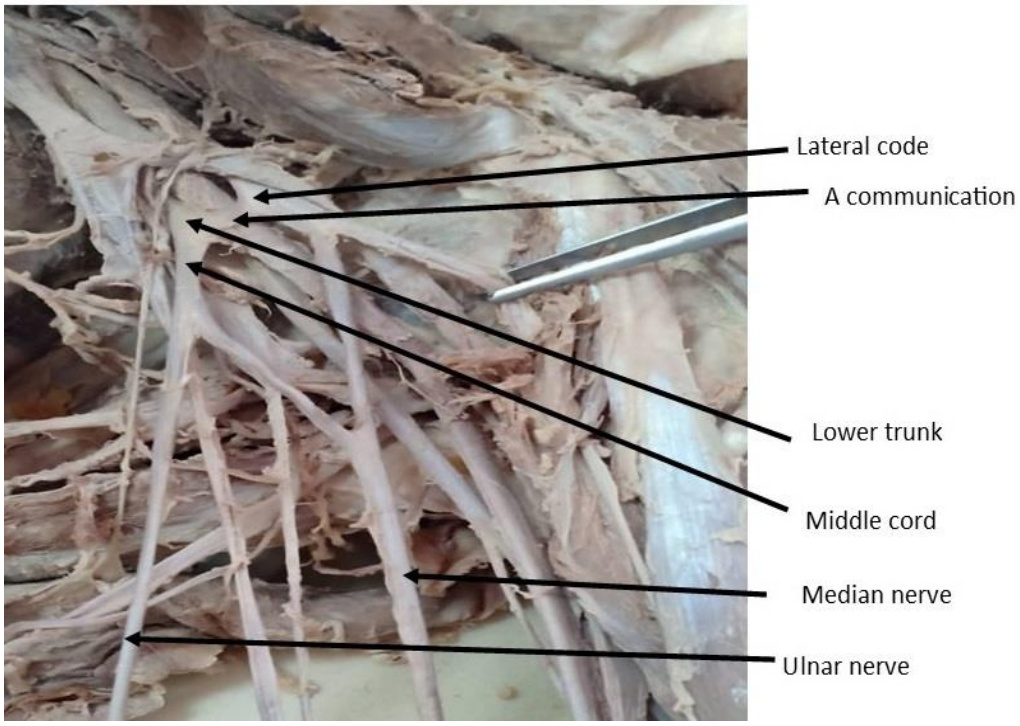

Fig. 2: Communication between lower trunk and lateral code

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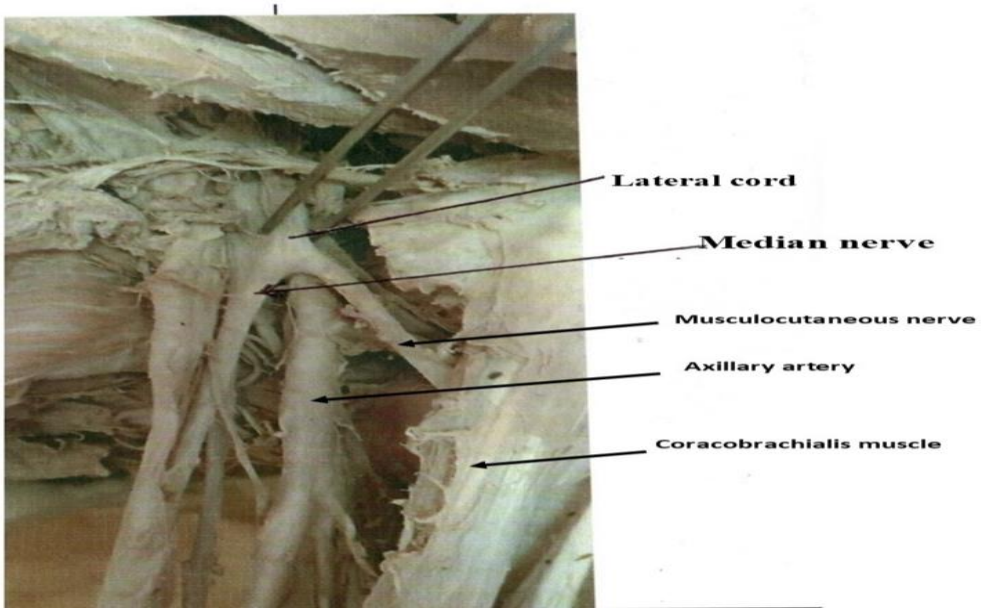

Fig. 3: Median nerve established from one lateral cord.

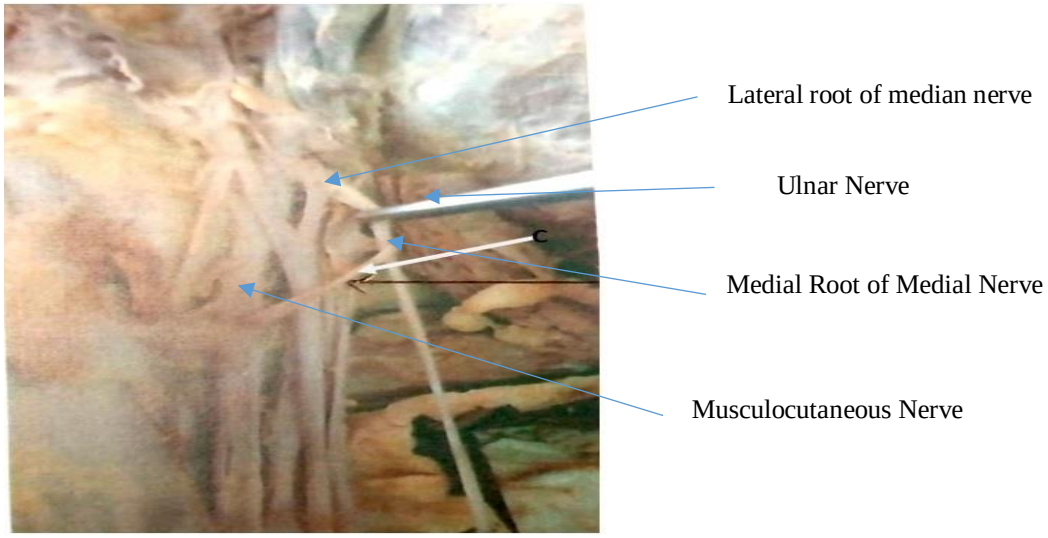

Fig. 4: Ulnar nerve communicating with musculocutaneous

Fig. 5: Prefixed BP variant (C4 is prominent and T2 is missing)

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Table 3: Frequency distribution of origin and 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

Of the total 140 upper libs studied, the most frequent variation was at the level of the trunk (7.9%) while the least variation was at the level of division at 2.2% of upper limbs studied.

Table 4: Frequency distribution of variations of terminal branches of brachial plexus

		Male	**Female**	**Total**	**Percentage**
		Frequency	**Frequency**	**L+R UL**	**%**
Axillary Nerve	Normal	61	57	118	84.2
	Variant	9	13	22	15.8
Radial Nerve	Normal	68	65	113	95
	Variant	2	5	7	5
Ulnar Nerve	Normal	61	61	121	86.4
	Variant	9	9	18	13.6
Musculocutaneous Nerve	Normal	59	55	114	81.4
	Variant	11	15	26	18.6
Median Nerve	Normal	56	63	119	85
	Variant	14	7	21	15

The variation in branching and distribution was compared against normal, the highest variation in branching was of musculocutaneous nerve with 18.6% (26) of variations whilst the lowest variation was of radial nerve at 5% of the total 140 upper limbs studied.

Table 5: Frequency distribution of origin and sections of the brachial plexus

		Total	
		Right + Left UL N=140	Percentage (%)
Roots	Normal	102	72.9
	Variant Post fixed	9	6.4
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Table 6: Frequency distribution of variations of terminal branches of brachial plexus

		Male	Female	Total	Percentage
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Axillary Nerve	Normal	61	57	118	84.2
	Variant	9	13	22	15.8
Radial nerve	Normal	68	65	113	95
	Variant	2	5	7	5
Ulnar nerve	Normal	61	61	121	86.4
	Variant	9	9	18	13.6
Musculocutaneous nerve	Normal	59	55	114	81.4
	Variant	11	15	26	18.6

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Median Nerve	Normal	56	63	119	85
	Variant	14	7	21	15

In the study, among the variations at the terminal branches, the musculocutaneous nerve had the highest variation at 18.6% (26) while the least was the radial nerve at 5% (7).

IV. DISCUSSION

The normal textbook anatomy of the brachial plexus is 5 roots originating from the C5-T1 spinal nerves, 3 trunks (upper, middle, and lower trunk), 6 divisions (3 anterior and 3 posterior divisions), 3 cords (lateral, posterior, and medial cord) and 5 branches (musculocutaneous, axillary, radial, median and ulnar) (Increase-Garcia et al., 2020). The current study found total variations at the root of brachial plexus at 27.1% (38), on the trunks 7.9% (11), at the divisions 2.2% (3) and on the cords 2.9% (4). The highest variation was at the prefixed root while the least was at the division.

A study done by (Mohammadreza Emamhadi et al., 2016) to evaluate the cords, trunks and terminal nerves of the brachial plexus of 32 cadavers which included 21 males and 11females in Iran where all study subjects were from one province found 9.4% of the brachial plexus to be prefixed while 3.1% to be post fixed. Among those with prefixed brachial plexus, 5 were males and one was a female while those with prefixed were young male study subjects. The number of prefixed and post fixed brachial plexus in the previous study was lower than the present study which could be attributed to the number of study specimen and the geographical region that the study specimen came from. On further studies, the previous study noted that the male gender was more at risk of injuries and damage to the brachial plexus because of the nature of their work therefore during corrective surgery these variations can cause confusion leading to further damage and injury of the brachial plexus by the surgeon.

Similarly, the current study had more males with variations in the prefixed than post fixed brachial plexus while females had more variations on the terminal branches. Other factors that influence variation in the brachial plexus were highlighted by (Gilcrease-Garcia et al., 2020)in their study and these included genetics, geographical location and gender noting that the factors could have a positive or negative impact on the health of an individual depending on the extent of the variation, the cause and the area innervated by the affected nerve.

Another study by (Claassen et al., 2016)observed 45 cadavers, 40 males and 5 females from the same locality and found 4 with anomalies of a single cord originating from the six divisions with normal roots, trunks, division and branches. Although this was a unique finding probably attributed to the geographical location and ethnicity of the study population, he noted that it occurred more commonly to male gender. This was dangerous since any damage to the single cord which originated from the 6 divisions could render all the branches functionless leading to loss of function on the upper limbs. Although (Edengenet Guday et al., 2017)is in agreement with the previous study by (Claassen et al., 2016), he highlights the significance of the single cord in relation to the position where it lies as deeply and safe as compared to the other 3 cords that are superficial and easily prone to injury. He however observes that 2 cords are better than 1 or the 3 normal cords because of their ability to share functions. Although the present study had equal ratio in gender of the study subject, most of the variations were found in male study subjects probably due to genetics and the nature of work that they do.

Another study by (Fazan et al., 2003)in Spain on 27 study subjects of different gender and color found 24% prefixed brachial plexus among them 2 males and 11female (5 white and 8 black) and 3 post fixed brachial plexus all from white male cadavers. The study specimen with prefixed brachial plexus was higher in the previous study than the current study while the post fixed was lower in the present study than the previous study. Although the previous study attributed the variations to factors like gender race and geographical location, the present study noted that some of these variations could have occurred later in life as a result of trauma or disease process as a mechanism for the body to attain its normal functioning hence with the current occurrence of diseases like cancer, HIV and other non-communicable diseases like hypertension, diabetes mellitus and the continuous exposure to accidents and trauma, the occurrence of these variations is expected.

While the present study found 7.9% variations in the trunk, (Fazan et al., 2003)found 9% variations which was almost similar to the present study. In the previous study, 2 anterior divisions joined to give rise to the anterior superior trunk while both posterior divisions joined to give rise to the posterior superior trunk, both nerves later joined to form the superior trunk. Furthermore, they found a rare occurrence where the middle trunk received communication from C8 and another branch from the inferior trunk. Although the previous findings were almost similar with the present study, in the present study the divisions of the middle and the superior trunk led to the formation of the posterior cord while the lateral cord was formed by the anterior divisions of the superior and the inferior trunks. The medial cord in 2 study subjects was formed by the anterior division of the inferior and middle cord. The present and the previous studies found the posterior cord originating from the posterior division of superior and middle trunks although the prevalence of the previous study was higher at 9% while the present study had 3 incidences.

(Mohammadreza Emamhadi et al., 2016)recorded 3 variations in the ulnar nerve noted that ideally the ulnar nerve originates from the medial cord, but in their study, it received a communicating branch from the lateral cord while the median nerve received communication from the posterior cord yet it was supposed to receive communication from the lateral and medial cord. In the present study, variation of the ulnar and the median nerve was higher than the previous study because the communications received by this branch

were from the posterior, lateral and medial cords combined thus increasing the number of variations.

Although this may be confusing to the surgeon during treatment of neck surgeries, the communications received from other variant branches may as well have a saving effect to the parts innervated. In case of diseases, injury or tumor of specific regions affecting the functioning of nerves innervating the regions, there can be an alternate pathway for nerve transmission which may help to prevent further injury and loss of function in the affected areas. Similarly, (Aktan et al., 2001; Benes, Kachlik, Belbl, Whitley, et al., 2021)in their study which was to determine the relationship between the terminal branches of the brachial plexus and the functioning of the arm that was done on 48 Turkish cadavers noted a lot of variations in the branches which could cause confusion to the health care providers and surgeons during assessment of nerve injuries like carpal tunnel syndrome, cubital tunnel syndrome and leprosy neuropathy. However, they also noted that these variations in connections may also be good because they may provide sensory or motor innervation when an alternate nerve has trauma or defect and cannot function. They advised that since the variants had both positive and negative implications, it was important to identify the type of variant that an individual had so that management could be established early enough.

Another study by (Patel & Smith, 2023) on 39 previously dissected cadavers among them 20 females and 19 males observed variations in the musculocutaneous branch where it was formed by the medial and the lateral cords and even changed its course of movement to innervate additional muscles of the anterior fore arm apart from the coracobrachialis, biceps and the brachialis. The same case applies to the present study where the musculocutaneous nerve had the highest variation which could be attributed to receiving branches from the posterior and medial cord. This could affect the conduction of plexus blockade as a component of anesthesia in the upper arm.

Further studies by (Yang et al., 2009)in China on 306 cadavers observed how variations in the brachial plexus could facilitate the deterioration of the functioning of the axillary artery. The previous study found variations in 12 study subjects whose axillary nerves merged from the lateral and medial cord and ran anteromedial towards the axillary artery which brought intertwining of the artery and nerve therefore compromising the activity of the axillary artery and the other blood vessels adjacent to them. In the present study, 22 axillary nerves had variations which was higher than the previous study. These variations included originating from lateral and medial cord, or both combined which could highly interfere with the distribution of the axillary artery. This could seriously affect the functioning of the upper limb due to numbness and reduced circulatory flow.

Other variations on the branches of the brachial plexus were observed by (Edengenet Guday et al., 2017)) where radial nerve received communication from the inferior trunk in 7% of the cases, the ulnar nerve had communication with the lateral cord in 30% of the cases while the median nerved originated from the 2 lateral roots and the medial root in 52% of the cases. This variation from the previous studies were higher than the present study and this could be attributed to the gender and geographical location.

V. CONCLUSION

There was gender variation in the distribution of the brachial plexus in the study population more of it being the musculocutaneous nerve. It was found that variations in musculocutaneous nerve were dominant most of them affecting the right part of the females. The astonishing anatomical variations identified had vital clinical correlation. This diversity implies some degree of impairment on the target muscle. This may lead to utmost challenge in anesthetic regional administration. These unusual spreading of variant nerve is more susceptible to damage and can expedite diversified extent of muscle debilitation. Surgeons and especially neuro and vascular surgeons must suspect a high extent of intuition for respective existence, if confronted with variations they should be prepared to transform their curative and surgical intersession by ensuring excellent plan design for the patient.

VI. RECOMMENDATION

Pre-operative radiological imaging to ascertain any anomaly of brachial plexus is key and should be enforced especially surgeries around the axilla region.

More studies should be directed on anatomical variations in terms of causes and on embryological characteristics, explore more on the genetical component and lastly on environmental causes.

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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.] 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

[4.] 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.

[5.] 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

[6.] 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

[7.] 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

[8.] 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

[9.] 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

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

[11.] Pizzo, R. A., Lynch, J., Adams, D. M., Yoon, R. S., & Liporace, F. A. (2019). 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

[12.] 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

[13.] 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

[14.] 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

[15.] Socolovsky, M., di Masi, G., Bonilla, G., Dominguez Paez, M., Robla, J., & Calvache Cabrera, C. (2015). The phrenic nerve as a donor for brachial plexus injuries: is it safe and effective? Case series and literature analysis. Acta Neurochir (Wien), 157(6), 1077-1086; discussion 1086. doi: 10.1007/s00701-015-2387-7

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

[17.] 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

[18.] 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

[19.] Vajapey, S. P., Contreras, E. S., Cvetanovich, G. L., & Neviaser, A. S. (2021). Neurologic complications in primary anatomic and reverse total shoulder arthroplasty: A review. J Clin Orthop Trauma, 20, 101475. doi: 10.1016/j.jcot.2021.06.005

[20.] 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.