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Study of Brachial Plexus With Regards To Its Formation, Branching Pattern and Variations and Possible Clinical Implications of Those Variations.

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Abstract:
Aim of the study: *to search variations in formation and branching pattern of brachial plexus and correlate them with possible clinical and surgical implications.*
Materials and Methods: *25human bodies were dissected for this study. Dissection was started in posterior triangle of neck and extended to distal part of upper limb passing through axilla . Photographs were taken and data was tabulated and analyzed .*
Observations: *All 50 plexuses had origin from C5 – T1 . Dorsal scapular nerve was absent in 2 plexuses. Long thoracic nerve was made of C5,C6 fibers in one and of C6,C7 fibers in another . Lower trunk was abnormal in 2 plexuses both of same body, their was no contribution from T1 fibers to posterior cord in one of these plexus. One plexus had double lateral pectoral nerve , communication between lateral and medial pectoral nerves , lateral pectoral and medial root of median nerve also between musculocutaneous and lateral root of median nerve . 2 more plexuses had communication between lateral and medial pectoral nerves. One plexus showed 2 branches coming from posterior division of upper trunk itself before formation of posterior cord.*
Discussion & conclusion: *These variations may make clinical interpretation of injury to plexus / disease of plexus difficult . The variations may pose challenges for surgeons and anaesthetists but at the same time they may help explain some previously ill understood presentations and outcomes of treatment procedures .*
Keywords: *Brachial plexus , roots , trunks , divisions ,cords , branches , variations .*

I. Introduction

With change in gait from quadrupedal to bipedal our forelimb acquired new functions . It became prehensile organ used for grasping , performing fine skilled works as well as coarse works requiring manual force . This modification of limbs made humans capable of performing various activities that were not possible in quadrupeds and thus helped us survive the adversities of mother nature more efficiently .

Being so important for our existence and supremacy over quadrupeds many researchers have tried to unravel the mystery behind proper functioning of our upper limb , hence they have been studying brachial plexus for centuries . Though many good works have been reported from time to time , with human population reaching more than 7 billion , studies on few hundred people at few places cannot give us the true picture of complexity , thus we need to have good work and reporting from around the world that can help us understand the true facts more candidly and confidently . To this end we would like to put in our drop in the ocean of knowledge regarding the topic .

II. Materials And Method

This work was carried out on 25 adult human cadavers brought to the department of Anatomy for educational purpose of undergraduate and postgraduate students . The bodies were of both males and females . The bodies had no obvious pathology or sign of injury or any other abnormality in the neck , axilla , pectoral region and upper limb . All the bodies were first embalmed , then dissection was done sequentially on each body starting from exposure of the plexus in the lower part of posterior triangle of neck , then in axilla and pectoral region and finally in upper limb .The observations were made carefully and record of findings was kept, these records were used to prepare the tables in this work , photographs were taken of dissected parts of both normal and variable presentation and few of them have been incorporated in this article . The data obtained were compared with those of earlier workers on this topic , and an analysis of the findings was done .

III. Observations

We had 50 brachial plexus for our study ,observation and analysis . We did not record sex of the cadaver while collecting data as we did not intend to focus on sex ratio of normal and variant structures .

The origin of brachial plexuses was as per the classical description of books in all cases i.e. from ventral rami of C5 – C8 & T1 . We did not find any prefixed or postfixed plexus .
Dorsal scapular nerve was absent in 2 plexuses , in rest it came from dorsal aspect of C5.
Long thoracic nerve had fibers from C5,C6 only in one of the plexus ,while in another plexus it came from C6,C7 only , both these variant nerves were on right side of body , rest of the plexuses had normal LTN .

Table 1- Number and percentage of normal and variant roots and their branches

	Roots	Dorsal scapular nerve	Long thoracic nerve
Normal	50 (100%)	48 (96%)	48 (96%)
Variations	00 (0%)	02 (04%)	02 (04%)

Table 2 – Number and percentage of normal and variant trunks

	Trunks	Upper trunk	Middle trunk	Lower trunk
Normal	48 (96%)	50 (100%)	50 (100%)	48 (96%)
Variation	02 (04%)	00 (0%)	00 (0%)	02 (04%)

Table 3 – Normal and variant divisions of different trunks

Divisions	Upper trunk (Normal / variant)	Middle trunk (Normal / variant)	Lower trunk (Normal / variant)
Anterior division	50 (100%) / 0 (0%)	50 (100%) / 0 (0%)	49 (98%) / 1 (2%)
Posterior division	49 (100%) / 1 (2%)	50 (100%) / 0 (0%)	49 (98%) / 1 (2%)

Table 4 – Number and percentage of normal and variant cords

	Lateral cord	Medial cord	Posterior cord
Normal	48 (96%)	50 (100%)	49 (98%)
Variant	02 (04%) , Fibers from C5 – C8	00 (0%)	01 (02%),No fibers from T1

In almost all (24) of the bodies dissected the C5,C6 roots united to form upper trunk , C7 root continued as the middle trunk and C8 & T1 united to form lower trunk . However in 1 body their was bilateral deviation from this usual pattern .

In left side of this body C8 root instead of joining T1 to form lower trunk divided into 2 portions , the major portion united with anterior division of upper and middle trunk to form lateral cord , while the smaller portion joined T1 to form the lower trunk. The lateral cord was thus formed by contribution from C5 – C8 roots (Fig.1) . Communication between lateral and medial pectoral nerve was present and it coursed in front of the axillary artery . Medial pectoral nerve appeared as tuft of branches , two of the branches pierced the pectoralis minor muscle and passed through it to the pectoralis major muscle , rest of the branches ran with the lateral thoracic artery round the lower border of pectoralis minor muscle to end in the pectoralis major muscle . Rest of cord anatomy on this side was as per the classical description of plexus in books .

In right side of the same body C8 and T1 again failed to unite to form the lower trunk , here C8 root divided into 2 parts – the anterior (major) portion joined the lateral cord , the posterior (minor) portion continued towards posterior cord but before joining the posterior cord gave off a small branch which joined T1 root fibers . T1 root fibers did not form divisions at all they ran totally into medial cord , being joined by C8 fibers in the course . Thus lateral cord received fibers from C5-C8 (instead of the usual C5-C7) while posterior cord received no fibers from T1 , it again had contribution from C5 – C8 only (Fig. 2) . The lower trunk was not formed as such and also its division into anterior and posterior divisions was missing . Lateral pectoral nerve was double and gave communicating branches to medial pectoral nerve which ran in front of axillary artery (Fig. 2) . Lateral pectoral nerve also gave communication to medial root of median nerve from close to its origin, these fibers joined the medial root of median just before it joined lateral root of median nerve to form the median nerve proper (Fig. 2) . It also had a communication between medial root of median nerve and ulnar nerve (Fig. 2) . There was a communication (about 1.5 cm long) between musculocutaneous nerve and lateral root of median nerve in this body (Fig. 3) , these fibers arose from musculocutaneous nerve close to its origin from lateral cord and ran inferomedially towards the lateral root of median to join it short distance away. Thoracodorsal nerve and lower subscapular nerves arose very close together from posterior cord and it appeared as if they had a common stalk arising from posterior cord which divided to form the two nerves . Medial cord on this side of the body was formed mainly by T1 root fibers with very little contribution from C8 root . Rest of the cord anatomy was as per the usual description of brachial plexus .

In another plexus of left side , we found that posterior division of upper trunk gave off 2 branches (upper subscapular nerve and thoracodorsal nerve) before joining posterior division of middle and lower trunk to form posterior cord (Fig. 4) . Rest of the plexus anatomy in this body was normal.

IV. Discussion

Upper limb is usually innervated by branches of ventral rami of $5^{th} – 8^{th}$ cervical spinal nerves and 1^{st} thoracic spinal nerve . The ventral ramus axons destined for the limbs apparently travel to the base of the limb bud by growing along permissive pathways . Once the motor axons arrive at the base of the limb bud , they mix in a specific pattern to form the brachial plexus . Factors controlling the plexus formation are not well-known but hepatocyte growth factor has been implicated as a tropic substance . Once the axons have sorted out in the plexus , the growth cone continue into the limb bud , presumably travelling along permissive pathways that lead in general direction of appropriate muscle compartment . Axons from the dorsal division of the plexuses tend to grow into dorsal side of limb bud and thus innervate mainly extensors , supinators and abductors . Axons from ventral divisions of the plexus grow into ventral side of the limb bud and thus innervate mainly flexors , pronators and adductors . Over the last part of an axon's path , from the point where it leaves its major nerve trunk to the point where it innervates a specific muscle , axonal path-finding is probably regulated by cues produced by muscle itself . Once motor axons have found their targets , sensory fibers innervate the sensory end organs in the limbs . The sensory axons apparently grow along the motor axons to the vicinity of appropriate sensory end organs . Local cues then direct their final branching and innervations of end organs .[1,2]

As we have noted in development , ventral rami axons have to perform a complicated and intricate process of path finding and intermingling before they reach the target tissues in the limb . This complexity in the innervations of the limb leaves scope for anomalous and deviated course and branching pattern of the plexus and this has been the subject of study for centuries and various workers have presented quite a vivid picture of the possibilities that may result from such anomalous development .

The plexus may be:

1. Prefixed or Postfixed or it may have contribution from more / less than the usual number of spinal nerves i.e from C4-T2 / C4-T1 / C5-C8 .[3,4,5,6,7] Pre-fixation was more commonly found than post-fixation , however in our study of 50 plexuses all had origin from C5-T1 .
2. The contribution of roots to different trunks , divisions and cords may vary , also the trunks , divisions and cords may be fused / bifurcated / reduced or be absent altogether .[4,5,7,8,9,10,11,12,13] We found 2 plexus in which C8 instead of joining T1 to form lower trunk , divided in 2 parts , anterior major part joined lateral cord in both but posterior part joined T1 in one of them while in the other it divided again one part joining posterior cord other part ran with T1 in medial cord , lower trunk was not formed in this case .
3. There may be variation in branching from roots and trunks .[3,6,7,9,14] Dorsal scapular nerve may have fibers from C5/C6 or it may be absent . Long thoracic nerve may receive contribution from C4-C7/ C4-C6 / C5-C6 / C6-C7 / C5-C7 . Suprascapular nerve may come from C5root / upper trunk / divisions of upper trunk . Nerve to subclavius is the least documented branch among all of the plexus branches . Fazan et al [6] in their study on 54 plexus found phrenic nerve arising entirely from brachial plexus in 11(20%) and an accessory phrenic nerve in 12 plexuses , thus a lesion of brachial plexus roots can result in diaphragm palsy in such cases . We found 2 plexus in which dorsal scapular nerve was absent . Long thoracic nerve had fibers from C5-C6 only in one plexus , while in other it received fibers from C6-C7 only .
4. There may be variation in formation and branching of lateral cord . [12,14,15] Kerr[12] found lateral cord with fibers from C4-C7 . In 3 of 175 plexus he studied lateral cord received fibers from C8 in 2 and from lower trunk in 1. In our study also we found 2 lateral cords with contribution from C8 , these fibers would run in branches of lateral cord and can thus change the presentation of plexus injury / damage . In these cases even complete injury to anterior divisions of upper and middle trunk can spare some muscles or cutaneous tissue supplied by lateral cord as they would get innervations from C8 fibers that have entered the lateral cord .
5. There may be anomalous communication between median nerve and musculocutaneous nerve / musculocutaneous nerve may be absent .[11,16,17,18,19,23] Though communication between musculocutaneous nerve and median nerve is one of the most frequently reported anomaly , we found only one plexus with communication between musculocutaneous nerve and lateral root of median nerve and we do-not know whether it has got any functional significance .
6. There may be variation in the branching from posterior aspect of brachial plexus .[7,20,21,22,23] Subscapular nerve variation is most frequently reported in this group . In one of the plexus we studied we found upper subscapular nerve and thoracodorsal nerve emerging from posterior division of upper trunk , in this plexus these 2 nerves will be spared in injury to posterior cord and can thus perplex the treating doctor regarding site of injury if he/she thinks of conventional picture of a brachial plexus . In another plexus posterior cord had no contribution from T1 and thus radial nerve in this may escape undamaged in injury to T1 root in Klumpke's palsy .
7. There may be communication between other branches of plexus like lateral and medial pectoral nerve , lateral pectoral nerve and median nerve , median nerve and ulnar nerve[15] , ulnar nerve and radial nerve [8,15] , though the significance of these communications is ill understood till date .

All these studies indicate that the common pattern of brachial plexus mentioned in the classical textbooks may not be as common and that these deviations should be kept in mind particularly by clinicians assessing neural features in upper limb associated with some pathology or following trauma which cannot be explained by the usual pattern of nerve supply .

These variations become important for surgeons doing neck surgeries as they may pose difficulty in formulating appropriate approach for the procedure and may result in accidental injury to vital nerves .

These deviations also become important for anaesthetists performing brachial plexus blocks for surgeries of the upper limb as the variations may make achievement of adequate anaesthesia difficult or may lead to inadvertent injury to the plexus / nearby structures if attempted by blind approach .

With advent of newer techniques for assessment of body non-invasively , we now have the tools to assess the brachial plexus in living persons . USG (2D , 3D) , nerve localization by nerve stimulation , CT myelography and MRI study of BP is now being used in human volunteers and in anaesthetic blocks of BP for operations in axilla and upper limb . Real time USG imaging during supraclavicular brachial plexus blocks can facilitate nerve localization and needle placement and examine the pattern of local anaesthetic spread , this in turn would improve anaesthetic outcome and reduce injury to other important structures running close by , it will also improve surgical outcome as surgeons will get stable field for work , at the same time patient would be benefitted . Advanced technique like CT myelography can be used to assess nerve root avulsion in BP injury . MR imaging can also be used to assess trauma to brachial plexus.

V. Conclusion

We can say based on our study and what earlier workers have found that though our work does not show variations to be as common as described by many but considering the impact these variations could have on patient outcome , we would suggest clinicians , anaesthetists and surgeons working on these regions to keep themselves abreast with the possibilities of variation in origin and course of brachial plexus .

References

[1]. Moore KL , Persaud TVN . The Developing Human Clinically Oriented Embryology .7th ed. Saunders . 2003 . Chapter 17 , The Limbs ;410-412 .
[2]. Larsen WJ . Human Embryology . 2nd ed. Hong Kong : Churchill Livingstone Inc. 1997 . Chapter 11 , Development of limbs ; 313-323 .
[3]. Lee et al , Variations of ventral rami of the brachial plexus . Journal of Korean Medical Science . 1992 March ; 7(1) : 19-24 .
[4]. Uzun et al , Some variations in the formation of brachial plexus in infants . Tr. J. of Medical Sciences . 1999 , 29 : 573-577 .
[5]. Uysal et al , Brachial plexus variations in human fetuses . Neurosurgery . 2003 ; 53(3) : 676-684 .
[6]. Fazan et al , Brachial plexus variation in its formation and main branches . Acta Cirurgica Brasileira . 2003 ; 18(5) : 14-18 .
[7]. Matejcik V , Variations of nerve roots of the brachial plexus . Bratisl Lek Listy . 2005 ; 106(1) : 34-36 .
[8]. Pattanshetti et al , A study of the formation and branching pattern of brachial plexus and its variation in adult human cadavers of North Karnataka . Journal of the Scientific Society . 2012 May-August ; 39(2) : 70-77.
[9]. Singhal et al , Variations in brachial plexus and the relationship of mediam nerve with axillary artery – a case report . Journal of brachial plexus and peripheral nerve injury . 2007 ; 2 : 21 .
[10]. Aggarwal et al , A rare anatomical variation of the brachial plexus : single cord anomaly . Anest Analg . 2012 february ; 114(2) :466-470.
[11]. Dahiphale et al , Variations in infraclavicular part of brachial plexus – a dissection study . Anatomica Karnataka . 2012 ; 6(1) : 62-65 .
[12]. Kerr AT , The brachial plexus of nerves in man , the variation of its formation and branches . American journal of anatomy . 1918 ; 23 : 285-395 .
[13]. Pandey et al , Anatomical variations of cords of brachial plexus and median nerve . J of Clinical Anatomy . 2006 ; 20(2) : 150-156 .
[14]. Arad E et al , Anatomic sites of origin of suprascapular and lateral pectoral nerve within brachial plexus . Plastic and reconstructive surgery . 2014 January ; 133(1) : 20e-27e .
[15]. Gupta et al , Anomalous communication in branches of brachial plexus . J Anat. Soc. India . 2005 ; 54(1) : 22-25 .
[16]. Le Minor JM , A rare variation of median nerve and musculocutaneous nerve in men . Arch Anat Histol Embryol. 1990 ; 73: 33-42 .
[17]. Venieratos et al , Classification of communication between musculocutaneous nerve and median nerve . Clinical Anatomy . 1998 ; 11: 327-331 .
[18]. Atkan et al , A cadaveric study of the anatomic variations of the brachial plexus nerves in axillary region and arm . Turkish journal of medical science . 2001 ; 31 : 147-150 .
[19]. Kaur et al , Variations in innervations of muscles in anterior compartment of arm – a cadaveric study . JCDR . 2014 May ; 8(5) :
[20]. AC01-AC03 .
[21]. Chaudhary Pet al , Branching pattern of posterior cord of brachial plexus – a cadaveric study . JCDR . 2011 August ; 5(4) : 787-790 Sinha et al , Variations in branching pattern of brachial plexus with their embryological and clinical correlation . J. Morphol. Sci. 2012 ; 29(3) : 167-170 .
[22]. Rastogi et al , Posterior cord of brachial plexus and its branches : Anatomical variations and clinical implications .Hindawi publishing corporation ISRN Anatomy . 2013 ; article ID - 501813 : 1-3 .
[23]. Darji et al , Variation in branching pattern of brachial plexus : a cadaveric study . International journal of biomedical and advanced research . 2013 ; 04(03) : 174-178 .

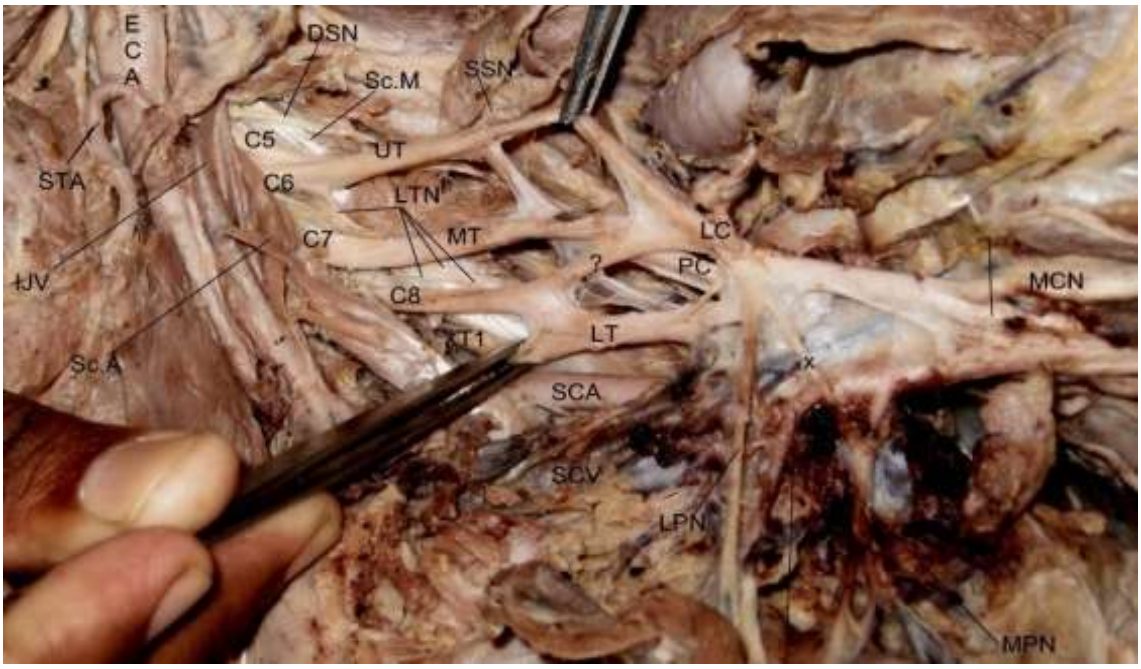

Figure1. Brachial plexus of left side of the body dissected to show the roots , trunks , divisions , cords and their branches . ? – communication from C8 to lateral cord ; x - communication between lateral pectoral nerve and medial pectoral nerve (lateral thoracic branch of axillary artery running close to medial pectoral nerve) ; C5,C6,C7,C8,T1 – roots of plexus ; DSN – dorsal scapular nerve ; ECA – external carotid artery ; IJV – internal jugular vein ; LTN – long thoracic nerve ; LT – lower trunk ; LC – lateral cord ; LPN – lateral pectoral nerve (thoracoacromial branch of axillary artery running close to it) ; MCN – musculocutaneous nerve ; MPN – medial pectoral nerve ; MT – middle trunk ; PC – posterior cord ; Sc.A – scalenus anterior ; Sc.M – scalenus medius ; SCA – subclavian artery ; SCV – subclavian vein ; SSN – suprascapular nerve .

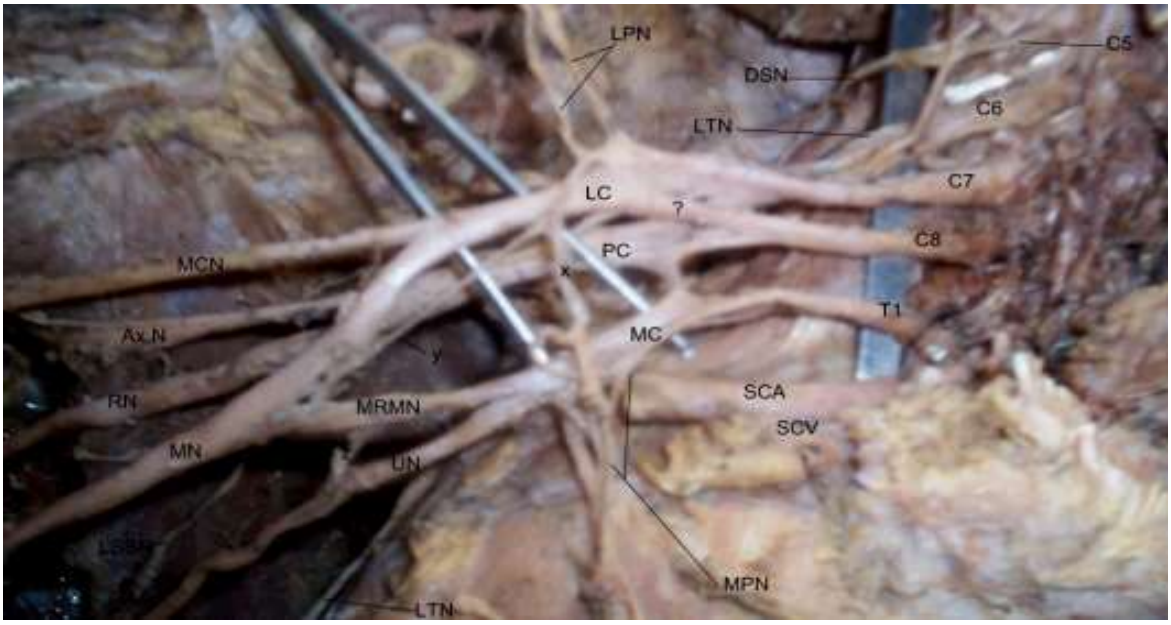

Figure 2. Brachial Plexus of right side ; ? – communication from C8 to lateral cord ;
x – communication between lateral and medial pectoral nerve ; y – communication from lateral pectoral nerve to medial root of median nerve ; z – communication from medial root of median nerve to ulnar nerve ; Ax.N – axillary nerve ; LSSN – lower subscapular nerve ; LC – lateral cord ; MC – medial cord ; MRMN – medial root of median nerve ; MN – median nerve ; PC-posterior cord ; RN – radial nerve ; UN – ulnar nerve .

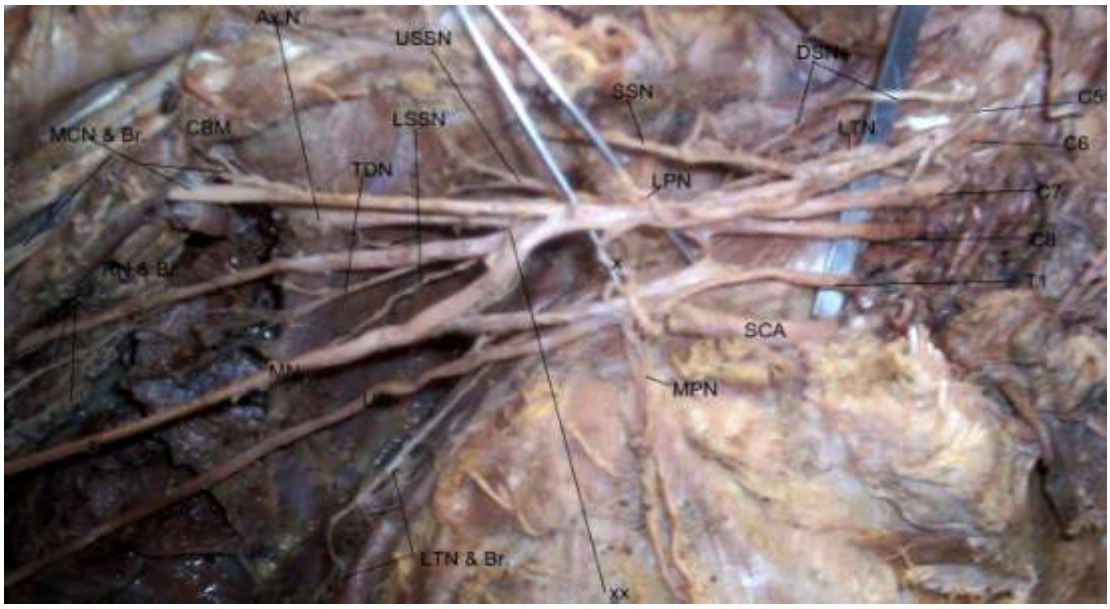

Figure 3 . same plexus as in figure 2 exposed further to show the plexus from neck up to upper arm . xx – communication between musculocutaneous nerve and lateral root of median nerve ; C5,C6,C7,C8,T1-roots of plexus ;Ax.N – axillary nerve ; CBM – coracobrachialis muscle ; DSN – dorsal scapular nerve ; LPN – lateral pectoral nerve ; LSSN – lower subscapular nerve ; LTN – long thoracic nerve ; LTN & Br. – long thoracic nerve and its branches ; MCN & Br, - musculocutaneous nerve and its branches ; MN – median nerve ; MPN – medial pectoral nerve ; RN & Br, - radial nerve and its branches ; SSN – suprascapular nerve ; TDN – thoracodorsal nerve ;USSN – upper subscapular nerve .

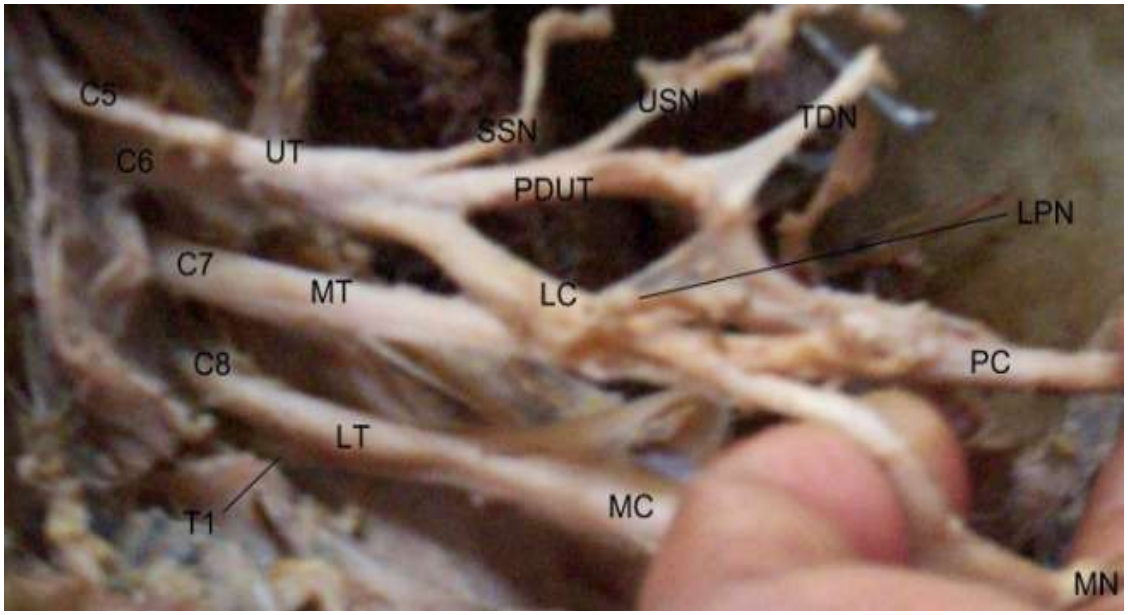

Figure 4. Brachial Plexus of left side ;one can see 2 branches arising from posterior division of upper trunk – an unusual finding ; LC- lateral cord ; LPN – lateral pectoral nerve ; LT – lower trunk ; MC – medial cord ; MN – median nerve ; MT – middle trunk; PC – posterior cord; PDUT – posterior division of upper trunk ; SSN – suprascapular nerve ; TDN – thoracodorsal nerve ; USN – upper subscapular nerve ; UT – upper trunk .