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**UNUSUAL VARIATIONS IN THE FORMATION AND BRANCHING PATTERN OF
BRACHIAL PLEXUS**

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ABSTRACT

Anatomical variations in the formation and branching pattern of the brachial plexus are known. However, presence of various anomalies in the same cadaver, differing on the two sides is very rare. The present study aims to record the prevalence of such variations with embryological explanation and clinical implications. The study was carried out on thirty upper limbs from fifteen adult human cadavers. The brachial plexuses were exposed and dissected as per standard guidelines. The formation and branching pattern was observed. Numerous anomalies were observed in one cadaver, differing on the two sides. On the right side it was seen that the lower trunk did not divide and continued as medial cord. The posterior cord was absent and common pectoral nerve was formed. On the left side the main findings were absence of lateral cord, absence of musculocutaneous nerve and abnormal formation of Pectoral nerve. The medial cord was formed by anterior division of middle and lower trunk. A variation in branching pattern of posterior cord was also seen. Anomalous vascular relations were observed. Superior Thoracic artery was seen passing through the lateral and medial roots of Median nerve. Knowledge of these variations is important to anatomists, surgeons, anesthetists and radiologists.

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INTRODUCTION

Anatomical variations in the formation and branching pattern of the brachial plexus are known and well documented (Kerr, 1918; Hollinshead, 1958). A high incidence of variations from the normal textbook description suggests that the entity is not rare and awareness of such frequently occurring variations is important. Such variations are vulnerable to damage in radical neck dissection and other surgical operations of axilla and upper arm (Uzun and Seeling, 2002). Presence of anatomic variations of the peripheral nervous system is often used to explain unexpected clinical signs and symptoms of nerve compressions and vascular problems (Malukar and Rathva, 2011). The present study deals with some of the common variations and some as yet unknown variations of the brachial plexus, explaining its morphological and clinical significance.

MATERIALS AND METHODS

The study was conducted on thirty upper limb specimens from fifteen adult human cadavers of known sex (male: female ratio 13: 2) with age ranging from 30-80 years, obtained from Dept.

of Anatomy. The brachial plexus was dissected and exposed as described by Romanes (Romanes, 1995). The clavicle and scalenus anterior muscle were cut to expose the roots and trunks of the plexus. The divisions and their branches were followed to the muscle they supplied for confirmation. The pattern of its formation and branching was seen.

RESULTS

The following variations were observed in a 55 year old male cadaver. The findings were different on both the sides. On the right side-The roots were traced till the origin and were found normal. The upper and middle trunks divided into anterior and posterior divisions. The anterior divisions of upper and middle trunks joined to form the lateral cord. The lower trunk did not divide into anterior and posterior divisions and continued as medial cord. Hence medial cord was formed by the direct continuation of lower trunk. The posterior cord was not formed as the posterior divisions of upper and middle trunk joined and continued as Radial Nerve. The branches arose from the posterior division of upper trunk. A common Pectoral nerve was formed by the branches from the anterior divisions of upper and middle trunks and the main lower trunk, which supplied both Pectoralis major and Pectoralis minor. There

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were no separate lateral and medial pectoral nerves from Lateral and Medial cords respectively. Other branches from Lateral and Medial cords were normal. A communicating branch was seen from C 7 to Medial cord. On the left side - The roots were traced till the origin and were found normal. The anterior division of upper trunk continued to join with medial root of median nerve to form the Median Nerve, hence the formation of Lateral cord was not observed. Anterior divisions of middle and lower trunks joined to form the Medial cord. The formation of posterior cord was also anomalous, but here the findings were different from that of the right side. At first posterior divisions of middle and lower trunks joined and subsequently the posterior division of upper trunk joined to it and then continued as Radial Nerve. The branches arose from the posterior division of upper trunk. Three sub scapular nerves were seen named as upper, middle and lower sub scapular nerves and the thoracodorsal nerve arose from the axillary nerve. The musculocutaneous nerve was absent and the biceps, coracobrachialis and brachialis muscles were seen to be supplied by the Median nerve. A common Pectoral nerve was formed by union of branches arising from anterior division of upper, middle & lower trunks, which was seen to supply both the Pectoralis muscles. Here, anomalous vascular relations were also seen. The Axillary artery did not pass through the brachial plexus at all. Instead the superior thoracic artery was seen passing through the Lateral and Medial Roots of Median nerve.

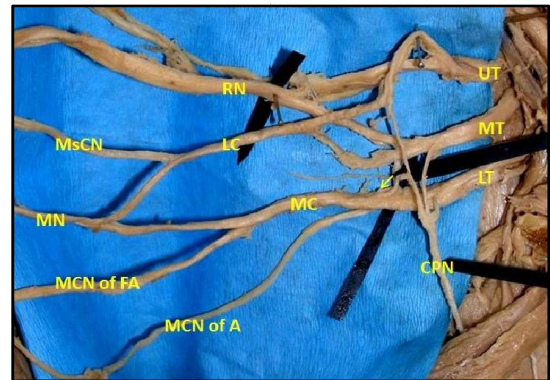


Fig. 3. Shows the findings on right side

UT- Upper Trunk, MT- Middle Trunk, LT- Lower Trunk, MC- Medial Cord, LC- Lateral Cord, CPN- Common Pectoral Nerve, MN- Median Nerve, RN- Radial Nerve, MscCN- Musculocutaneous Nerve, MCN of A- Medial Cutaneous Nerve Of Arm, MCN of FA- Medial Cutaneous Nerve of Forearm . Arrow- branch of C7 to MC

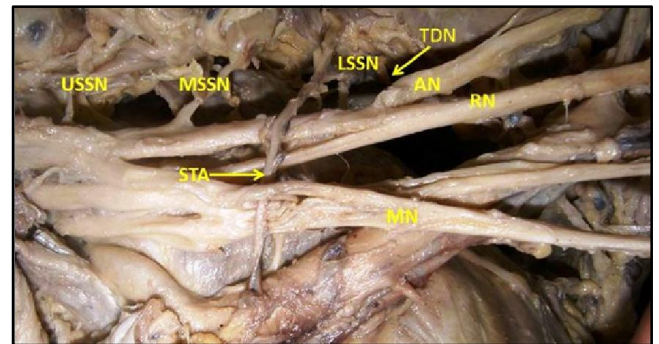


Fig. 4. showing the findings on left side

USSN-Upper Subscapular Nerve, MSSN- Middle Subscapular Nerve, LSSN- Lower Subscapular Nerve, TDN-Thoracodorsal Nerve, AN- Axillary Nerve, MN-Median Nerve, RN- Radial Nerve, STA- Superior Thoracic Artery

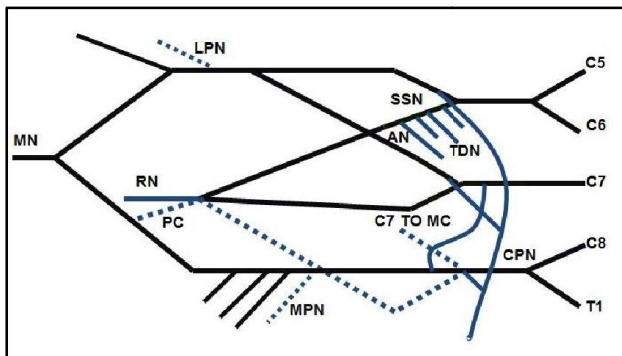


Fig. 1. Schematic representation of findings on right side

Black lines indicate the normal parts of brachial plexus, blue lines show the anomalous parts, dotted line show the absent parts. PC- Posterior Cord , MC- Medial Cord, MN-Median Nerve, RN- Radial Nerve, CPN- Common Pectoral Nerve, LPN- Lateral Pectoral Nerve, MPN- Medial Pectoral Nerve, SSN- Subscapular Nerve, TDN- Thoracodorsal Nerve, AN- Axillary Nerve

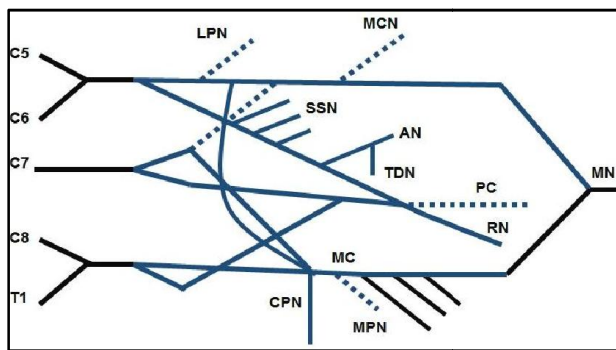


Fig. 2. Schematic representation of findings on left side

Black lines indicate the normal parts of brachial plexus, blue lines show the anomalous parts, dotted lines show the absent parts. PC- Posterior Cord , MC- Medial Cord, MN-Median Nerve, RN- Radial Nerve, CPN- Common Pectoral Nerve, LPN- Lateral Pectoral Nerve, MCN- Musculocutaneous Nerve ,MPN- Medial Pectoral Nerve, SSN- Subscapular Nerve, TDN- Thoracodorsal Nerve, AN- Axillary Nerve

DISCUSSION

Variations in brachial plexus may be due to unusual formation during the development of trunks, divisions or cords. In man, the forelimb muscles develop from the mesenchyme of the paraaxial mesoderm during 5th week of the embryonic life (Larsen, 1997). As the embryonic somites migrate to form the extremities, they bring their own nerve supply so that each dermatome and myotome retain its original segmental innervations. Throughout so mite migration, some of the nerves come into close proximity and function in a particular pattern, forming a plexus early in fetal life. The medial cord typically is formed by the anterior division of the lower trunk and therefore contain only C8 and T1 fibers (Gray, 2010). The more common variations occur at the junction or separation of the individual parts (Bhatt and Girijavallabhan, 2008). In the present study medial cord on the right side was formed by the direct continuation of lower trunk which did not divide into anterior and post divisions. Similar pattern was seen in 1 out of 175 cases which tells about the rarity of this finding (Kerr, 1918). Absence of posterior cord has been demonstrated by Kerr in 20% cases where branches arose from posterior division of upper trunk (Kerr, 1918).

In the present study also, posterior cord was absent on the right side with branches arising from the posterior division of upper trunk. In another study abnormal formation and branching pattern of posterior cord has been presented where

axillary nerve took origin from posterior division of upper trunk in 10.8% and thoracodorsal nerve arose from axillary nerve in 22.9% (Rastogi *et al.*, 2013). The findings of present study on left side were in accordance with the above mentioned study. Anomalous formation and branching of lateral cord has been reported earlier (Gupta *et al.*, 2005). In the present study lateral cord was absent on the left side as the anterior division of upper trunk continued to join with the medial root of median nerve to form the median nerve. The variations of the cords of brachial plexus and its terminal branches are significant during surgical exploration of the axilla and arm to avoid damage to important nerves. In the present study variations were seen in origin of pectoral nerve on both sides. On the right side a common pectoral nerve was formed by the branches of anterior divisions of upper and middle trunks and the main lower trunk, in contrast to a study where lateral pectoral nerve arose from posterior division of upper trunk (Singhal *et al.*, 2007). On the left side also a common pectoral nerve was formed. On both sides there were no separate lateral and medial pectoral nerves. Absence of musculocutaneous nerve has been presented earlier by many authors (Rao and Chaudhary, 2001; Guerri Guttenberg and Ingololli, 2009; Pacholczak *et al.*, 2001; Arora and Dhingra, 2005). The present study showed findings in accordance with the previous studies by presenting absence of musculocutaneous nerve on the left side. Interestingly in the present study a communicating branch was seen from C7 to Medial cord. This has also been reported by Kerr (Kerr, 1918). Anomalous plexus artery relationship has been reported by Miller (1939). In the present study the Axillary Artery did not pass through the brachial plexus. Instead the superior thoracic artery was seen passing through the lateral and medial roots of Median nerve. This explains the abnormal development of Axillary artery probably from the 9th segmental branch of dorsal aorta instead of the 7th segmental branch (Larsen, 1997). It passed caudal to T1 root and infero-medial to the lower trunk and did not appear in the brachial plexus at all.

Conclusion

Knowledge of these variations is important to anatomists, surgeons, anesthetists and radiologists. It is of great value during surgical exploration of axilla and arm regions, during nerve block, in orthopedic treatment of the cervical spine, for treating tumors of nerve sheaths and also in treatment of humeral fractures. Awareness of anatomical variations would avoid injury to these nerves.

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