Case Report

Anatomy Section

Bilateral Non-Formation of Upper Trunk of the Brachial Plexus with a Unilateral Communication Between the Musculocutaneous Nerve and the Median Nerve: A Case Report

RAJAN KUMAR SINGLA, RITIKA MAHAJAN, RAJAN SHARMA, TRIPTA SHARMA

ABSTRACT

Variations in the brachial plexus are common and they have been reported in relation to the origin of the roots, trunks, cords, divisions and the branches. They may prove to be valuable to the orthopaedic surgeon, the radiologist, the anaesthesist, the neurosurgeon, the neurologist, and the vascular surgeons while they perform their respective procedures. In this report, a rare, bilateral non-formation of the upper trunk of the brachial plexus with a unilateral communication between the musculocutaneous nerve and the median nerve has been reported. C_5 and C_6 on both the sides did not join to form the upper trunk. On the right side, it separately divided into the anterior and the posterior divisions. On the left side, C_5 did not give any anterior division and continued as the posterior cord after receiving the posterior division of C_6. A communicating branch from the musculocutaneous nerve to the median nerve was also seen on the left side. An earlier unilateral non-formation of the brachial plexus has been reported, with an incidence of 1%, but a bilateral variation is extremely rare. Further, its ontogeny and clinical implications have been discussed in detail.

Key Words: Roots, Cords, C_5, C_6

INTRODUCTION

The brachial plexus is formed in the posterior triangle of the neck by the union of the anterior primary rami of the $C_5 – T_1$ roots. These roots join with each other to form three trunks viz the upper, the middle and the lower by the union of $C_5 – C_6$; the continuation of C_7 and the union of the C_8 and T_1 respectively. These three trunks bifurcate into the anterior and the posterior divisions. The anterior divisions of the upper and the middle trunks unite to form the lateral cord. The anterior division of the lower trunk continues as the medial cord. The posterior divisions of all the three trunks unite to form the posterior cord. These cords give rise to different nerves for the upper limb [1].

Variations in the brachial plexus are common and they have been reported by several investigators in relation to the origin of the roots, trunks, cords, divisions and the branches.

According to Kerr [2], the variations in the formation of the trunks of the brachial plexus may be divided into two groups.

1. In the first group, there is no true cephalic or the caudal trunk, but some or all the nerves divide into the dorsal or the ventral branches and these combine to form the lateral, dorsal and medial fasciculi or no true dorsal or lateral fasciculi are formed, but the branches from the dorsal and the ventral rami of the nerves or the trunks unite to form the branches of the plexus.
2. In the second group of variations, the lateral fasciculus receives fibers from the nerves which are caudal to the 7th cervical or in which the medial fasciculus receives fibers from the nerves which are cephalic to the 8th cervical nerve.

The commonly reported variations in the brachial plexus have been in the form of:

i. A prefixed (contribution from the C_4 large, T_2 absent and the T_1 reduced), or postfixed (contribution from the C_4 absent, T_2 present and the T_1 enlarged) brachial plexus [1]
ii. All roots joining to form a single trunk [3,4]
III. Absence of the posterior cord [4]
iv. Communications between the musculocutaneous nerve and the median nerve or the absence of the musculocutaneous nerve [5]
v. Three roots of the median nerve [6]
vi. Communication between the median nerve and the ulnar nerve [7], etc.

One such bilateral variant pattern of the brachial plexus was observed in the present case and is being reported.

CASE REPORT

During a routine undergraduate dissection of the upper limbs in the department of Anatomy, Government Medical College, Amritsar, Punjab, India a sixty years old female cadaver, the following observations were made.

On the right side, the C_5 and the C_6 roots did not join to form the upper trunk. Instead, they separately divided into the anterior and the posterior divisions. The two posterior divisions joined with each other to form a common posterior division (PD_1). It received the posterior division of C_7 and continued as the posterior cord (PC). The posterior cord gave the axillary nerve (AN) and then immediately after that, received the posterior division of the lower trunk (PD_2) (root value C_8, T_1) and further continued as the radial nerve (RN). Thus, the axillary nerve was not receiving any contribution from C_8 and T_1. The anterior division of C_5 and C_6 joined with each other and then received the upper anterior division of C_7 (UAD) to form the lateral cord (LC). The lateral cord immediately bifurcated into the

musculocutaneous nerve (MCN) and the lateral root of the median nerve (LR). The lower anterior division (LAD) of C_7 joined with the anterior division (AD) of the lower trunk to form the medial cord. The latter gave the medial cutaneous nerve of the arm/forearm and bifurcated into the ulnar nerve (UN) and the medial root of the median nerve (MR) [Table/Fig-1].

On the left side, C_5 and C_6 failed to unite and thus, no upper trunk was formed. The C_5 root did not give any anterior division, but it received the posterior division of C_6 (PD_1) and continued as the posterior cord. The C_6 root divided into the anterior and the posterior divisions. The posterior division of C_6 joined the C_5 root to continue as the posterior cord, while its anterior division (AD_1) received the upper anterior division of C_7 (AD_2) to continue as the musculocutaneous nerve (MCN). The lower anterior division of C_7 (AD_3) continued as the lateral root (LR) of the median nerve. The lower trunk was formed as usual i.e. by the union of the C_8 and the T_1 roots and it divided into the anterior and the posterior divisions. Its anterior division (AD_4) gave the medial cutaneous nerve of the arm and the forearm (MCFA) and the ulnar nerve (UN) and then continued as the medial root (MR) of the median nerve. The latter joined with the lateral root (LR) of the median nerve to form the median nerve (MN). The musculocutaneous nerve, after a short distance (1 cm) of its formation, gave a communicating branch (CB) to the median nerve [Table/Fig-2].

Thus, on both the sides, there was failure to form the upper trunk. The C_5 and the C_6 roots separately divided into the anterior and the posterior division on the right side, while on the left side, the C_5 root did not give any anterior division, but continued as a whole as the posterior division and received the posterior division of C_6. Similarly, the C_7 root on both the sides, gave two anterior divisions, the upper and the lower. However, their further distribution differed on the two sides. While on the right side, the upper anterior division joined the anterior division of C_5 and C_6 to form the lateral cord which further gave the musculocutaneous nerve and the lateral root of the median nerve; on the left side, it joined with the anterior division of C_6 to form the musculocutaneous nerve. Similarly, the lower anterior division on the right side joined with the anterior division of the lower trunk to form the medial root of the median nerve. On the left side, the lower anterior division continued as the lateral root of the median nerve. Thus, the fibers of C_7 were entering the median nerve via its lateral root only on the left side, but via both the lateral and the medial roots on the right side.

Apart from this, another important variation which was seen unilaterally, was a communicating branch from the musculocutaneous nerve to the median nerve on the left side.

DISCUSSION

Although they are uncommon, the following trunk variations have been noted in the literature.

1. In particular, the absence of the inferior trunk which is characterized by the nonunion of the C_8 and the T_1 nerve roots, have been reported [8,9].
2. The absence of the middle trunk has also been observed.
3. The ventral rami of the C_5, C_6 and the C_7 nerve roots have been found to form the superior trunk at the expense of an absent middle trunk [9].
4. Unilateral upper trunk variations which were similar to the one which was observed bilaterally in this case, have been reported [8,9].

A study by Uysal et al [8] revealed that the absence of the superior trunk was less common (1%) than the absence of the inferior trunk (9%). In such cases, the roots which were destined to form the superior or the inferior trunks directly divided into the anterior and the posterior divisions which joined to form cords, as was seen in the present case.

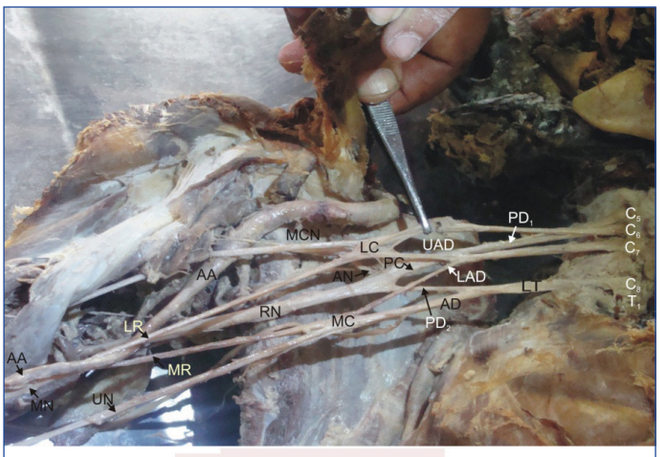
Harris [10] encountered a case in which no lateral cord was formed. Instead, the C_5 and the C_6 roots gave two ventral branches each. One of these from both united to form the musculocutaneous nerve, while others (one each from both) descended and united with a ventral branch from C_7 to form the lateral root of the median nerve. Another ventral branch from C_7, along with a ventral branch of C_8 and T_1 formed the medial cord. He further highlighted that this type of arrangement, with the musculocutaneous nerve emanating from C_5–C_6 before the formation of the lateral cord, was very unusual in humans, which was seen only in some marsupials like Armadillo. Our case was similar to this on the left side, where no upper trunk was formed. C_5 did not give any anterior division. The C_6 root divided into the anterior and the posterior divisions. Its anterior division joined with the upper anterior division of C_7 (AD_3) to continue as the musculocutaneous nerve (MCN). The lower anterior division of C_7 (AD_3) continued as the lateral root (LR) of median nerve. So, there was no lateral cord formation on this side. Thus, sporadic cases of the non formation of the upper or lower trunk have been reported, apart from a study by Uysal et al [8]. However, none of these made a mention of the bilateral non formation of the upper trunk, as was seen in the present case.

Another variation which was noted only on the left side was a communicating branch from the musculocutaneous nerve to the median nerve, which joined the latter, 1cm distal to its formation.

Li Minor [5] classified the communications between the median nerve and the musculocutaneous nerve into five types [see Table/Fig-3]:

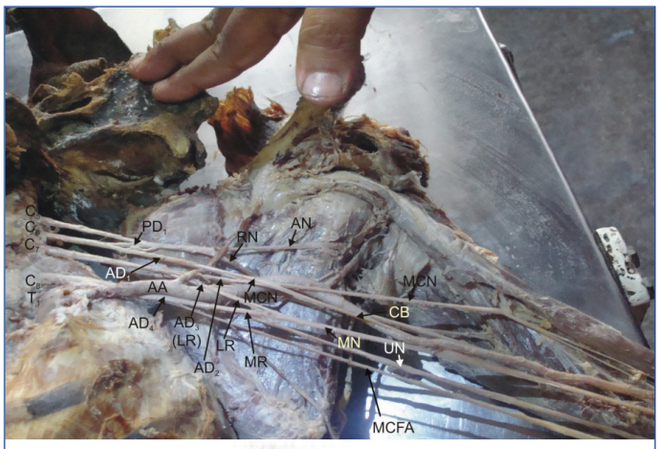
Type-I: There was no communication between the median nerve and the musculocutaneous nerve.

Type-II: The fibres of the lateral root of the median nerve passed through the musculocutaneous nerve and joined the median nerve in the middle of the arm.



AA:	Axillary artery	MC:	Medial cord
AD:	Anterior division of lower trunk	MCN:	Musculocutaneous nerve
AN:	Axillary nerve	MN:	Median nerve
C_5-T_1:	Roots of brachial plexus	MR:	Medial root of median nerve
LAD:	Lower anterior division of C_7	PD_1:	Posterior division of C_5, C_6
LC:	Lateral cord	PD_2:	Posterior division of lower trunk
LR:	Lateral root of median nerve	UAD:	Upper anterior division of C_7
LT:	Lower trunk	UN:	Ulnar nerve

[Table/Fig-1]: Showing variant anatomy of brachial plexus on right side



AA:	Axillary artery
AD_1:	Anterior division of C_6
AD_2:	Upper anterior division of C_7
AD_3:	Lower anterior division of C_7
AD_4:	Anterior division of lower trunk
AN:	Axillary nerve
C_5-T_1:	Roots of brachial plexus
CB:	Communicating branch from musculocutaenous nerve to median nerve
LR/AD_3:	Lateral root of median nerve
MCN:	Musculocutaneous nerve
MCFA:	Medial cutaneous nerve of forearm
MN:	Median nerve
MR:	Medial root of median nerve
PD_1:	Posterior division of C_6
RN:	Radial nerve
UN:	Ulnar nerve

[Table/Fig-2]: Showing variant anatomy of brachial plexus on left side

Type-III: The lateral root fibres of the median nerve passed along the musculocutaneous nerve and after some distance, left it to form the lateral root of the median nerve.

Type-IV: The musculocutaneous fibres joined the lateral root of the median nerve and after some distance, the musculocutaneous nerve arose from the median nerve.

Type-V: The musculocutaneous nerve was absent and the entire fibres of the musculocutaneous nerve passed through the lateral root and the fibres to the muscles were supplied by the musculocutaneous nerve branch, out directly from the median nerve.

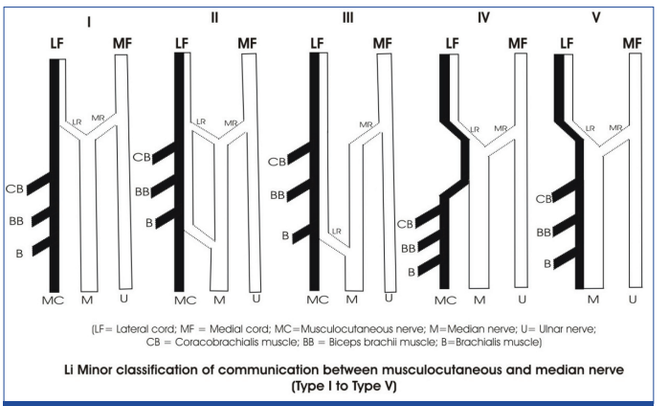
Thus, our case fits into type II of Li Minor's [5] classification, whereby the median nerve was formed normally by the union of the medial and the lateral roots. Apart from this, some fibres of the lateral root passed through the musculocutaneous nerve and joined the median nerve in the middle of the arm.

ONTOGENY

Harrison [11] established two essential factors in the development of different components of the limbs by his experiments on amphibian larvae i.e.

1. The nerves which take part in the innervations of a limb are determined by the position and the width of a limb bud. A limb bud which is transplanted to some other part of the body acquires a complete system of nerves, which is supplied by the region in which the limb is implanted.
2. The distribution of the nerves within a limb is determined by its own component structures. The segregation of the developing structure within the limb has a directive action upon the growing nerve fibres and this determines their grouping into definite characteristic bundles.

At an early developmental stage, the plexus is rectangular, then it becomes trapezoidal and finally it forms a triangular shape [12].



[Table/Fig-3]: Classification of communication between musculocutaneous nerve and median nerve (as per Li Minor)

Although it is unclear why neuronal processes assemble to form a mixed nerve, in this complex developmental event, there are multiple possibilities for the route which is taken by the developing axons and thus, for their arrival at the main trunk. Once formed, any developmental differences would obviously persist postnatally [13]. As the guidance of the developing axons is regulated by the expression of chemoattractants and chemorepulsants in a highly coordinated site specific fashion, any alterations in signaling between the mesenchymal cells and the neuronal growth cones can lead to significant variations [14].

In the present case, it seems to be the overexpression of the chemoattractants/ repulsants, leading to the separation of the C_5 and the C_6 roots, presenting as the non formation of the upper trunk and the formation of the double anterior divisions of the C_7 roots.

PHYLOGENY

Miller [15] summarized the differences in the normal patterns of the roots, trunks, divisions, cords and the branches of the brachial plexus in different vertebrates. According to him, no trunk formation is seen in amphibians, reptiles and dogs. So, our case partially fits into this category as the upper trunk was not formed on both the sides.

A communicating branch from the musculocutaneous nerve to the median nerve as was seen in the left limb of the present case is usually seen in dogs [16].

CLINICAL IMPORTANCE

For a surgeon, to have the variational patterns of the brachial plexus at his finger's ends is essential in the light of not only the frequency with which a surgery is performed in the axilla and the surgical neck of the humerus [8,17] and the rapid development of microsurgical techniques [12], but also to give an explanation when he encounters an incomprehensible clinical sign [7].

Apart from the surgeon, the brachial plexus variations are of interest not only to the radiologists who interpret the plain and computerized imagings and MRI and the anaesthesiologists who place needles in the neck to administer anaesthetic blocks, but also to the neurosurgeons, neurologists, vascular surgeons and the orthopaedic surgeons [18,19].

While Ongoiba et al [20] laid stress on the fact that a variable brachial plexus could fail the brachial plexus loco-regional anaesthesia, Sargon et al [21] and Uzun and Seelig [22] commented that such a brachial plexus was more prone to injury in radical neck dissections and in other surgical operations of the axilla.

The present variant of the brachial plexus may give incomprehensible clinical signs in Erb's palsy. Since the upper trunk is not formed, the

chances of involvement of C_6 are remote. Moreover, on the left side, since C_5 did not give any anterior division and continued as the posterior division only, the C_6 root would face the main brunt of the injury, thus causing Erb's palsy. Thus, the clinical picture would be of injury to C_6, but sparing C_5, which would be extremely confusing if the clinician was not familiar with such variations. Also, since C_5 was totally going as the posterior division, if at all it was involved in the injury, it would affect the muscles which were supplied by the posterior cord or its branches i.e. radial and axillary etc only and not the muscles which were supplied by the branches of the lateral cord. This would further complicate the clinical picture.

The knowledge of a common variation like the communication between the musculocutaneous nerve and the median nerve may prove to be valuable in the traumatology of the shoulder joint as well as in relation to the repair operations [16,23,24]. Also, it may be correlated to the entrapment syndromes of the musculocutaneous nerve in which a part of the median nerve also passes through the coracobrachialis and may exhibit the symptoms which are similar to those which are encountered in median nerve neuropathy as in the carpal tunnel syndrome [16].

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