Case Report

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Possible Developmental Origin and Clinical Implications of a Brachial Plexus Variation

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Abstract

The highly organized network of human nervous system is well appropriate for the perfect coordination and functioning of the body. Thus, a well studied and thoroughly researched knowledge regarding the anatomy of nerves is highly vital. The brachial plexus formation has been associated with lots of anatomical variations. The present case report describes another variation where musculocutaneous nerve after giving its motor component in the arm is not continuous with its sensory part in the forearm. The motor component of musculocutaneous nerve ends by supplying coracobrachialis muscle whereas the other forearm muscles are innervated directly from the lateral cord and one of these branches is continuous as the sensory component of the normal musculocutaneous nerve named as lateral cutaneous nerve of forearm. In our case report, we also aim to explain the possible developmental mechanisms behind the nerve variations along with their clinical implications.

Keywords: Brachial plexus; Musculocutaneous nerve; Lateral cutaneous nerve of forearm; Median nerve.

Introduction

The brachial plexus is the network of nerves supplying brachium, formed by the ventral rami of C5-T1 roots of spinal nerves. The roots join and form trunks (upper trunk C5,6; middle trunk C7; lower trunk C8,T1), each of which further separate into anterior and posterior divisions. The divisions integrate and organize into three cords- lateral, medial and posterior. The terminal branches of cords supply arm and forearm muscles. It is the lateral cord which gives rise to musculocutaneous nerve opposite the lower border of pectoralis minor which after supplying coracobrachialis muscle, courses through this muscle and runs laterally between biceps and brachialis muscle while innervating two of these. On further course, it comes out lateral to elbow joint and continue down as its sensory component- the lateral cutaneous nerve of forearm.[1] The hand to hand knowledge regarding brachial plexus variations is greatly useful for the surgeons to assess the functional loss due to trauma, to plan constructive surgeries, during reduction of fractures and dislocations, repair of wounds and nerve entrapement syndromes.

Case Report

A unilateral variation in brachial plexus was noticed during routine educational dissection of right arm of 55 yr old male cadaver in the department of anatomy, All India Institute of Medical Sciences, New Delhi, India. The brachial plexus dissection was started by exposing first the coracobrachialis and short head of biceps muscles arising from the tip of coracoid process. A branch from the lateral cord was noticed distributing to the deep surface of coracobrachialis muscle which was

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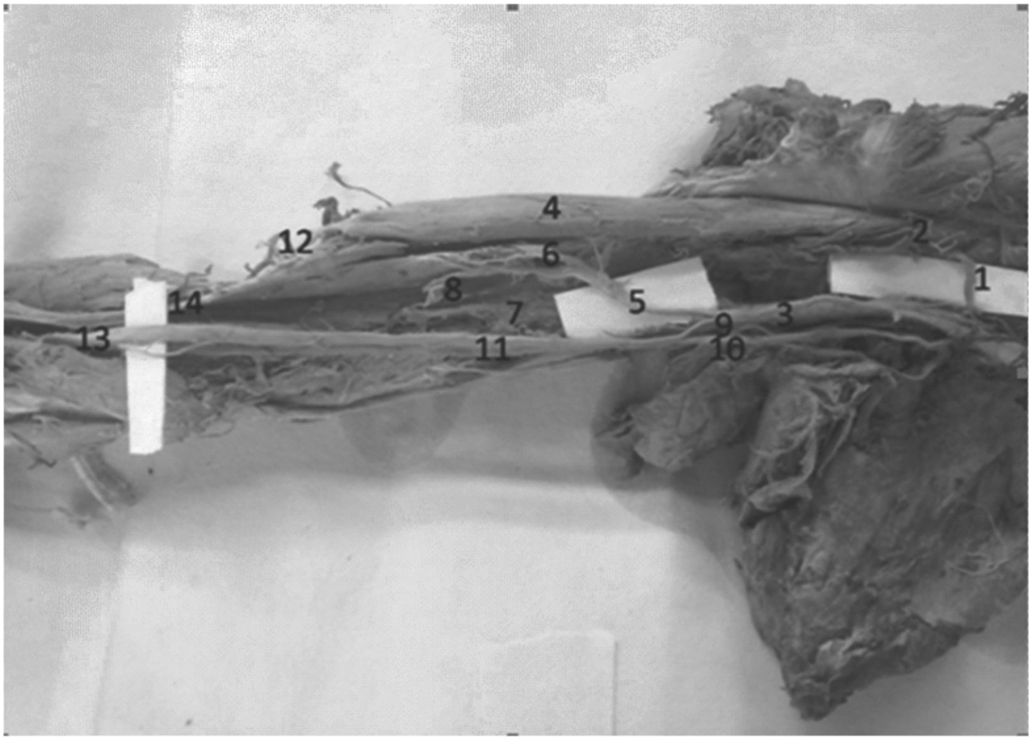
Fig 1: 1. Nerve to coracobrachialis; 2.Coracobrachialis; 3.Lateral cord; 4.Biceps; 5.Branch from lateral cord; 6. Branch to biceps; 7.Brachialis; 8.Nerve to brachialis; 9.Lateral root of median nerve; 10.Medial root of median nerve; 11.Median nerve; 12. Lateral cutaneous nerve of forearm; 13. Median nerve in cubital fossa; 14.Tendon of biceps



initially thought to be the musculocutaneous nerve. On further dissection, it was found to end in the muscle itself. On searching the other branches of lateral cord, we found one branch given distally soon dividing into multiple small twigs supplying biceps and brachialis muscle. The branch given to the biceps passed further distally and came out laterally through it in a more superficial plane above elbow joint which continuous down as lateral cutaneous nerve of forearm. At the same level from the lateral cord, fibers of lateral root of median nerve joined with the medial root from medial cord to form median nerve. The course of median nerve was found normal. There were no other variations seen in medial or posterior cord branches. (Fig 1)

Discussion

Variations in Literature

The complexity of brachial plexus anatomy makes it vulnerable to present with various alterations in its formation and branches. The variations have been mentioned in literature since 19th century. The nerve distribution and variations in the upper limb have been given in detail in the past.[2] Le Minor classified these variations in five types.[3]

Type 1: No communication between Median and Musculocutaneous nerve

Type 2: Medial root of median nerve passes through musculocutaneous nerve and later join the median nerve

Type 3: Lateral root of median nerve passes through musculocutaneous nerve and later form the lateral root of median nerve

Type 4: The musculocutaneous nerve join the lateral root of median nerve and later musculocutaneous nerve arise from median nerve

Type 5: The musculocutaneous nerve is absent, all fibers pass through lateral root of median nerve and fibers to the muscles supplied by musculocutaneous branch out directly from median nerve.

Our case report presents a different variation not coinciding with any of the types stated above. Musculocutaneous nerve not piercing coracobrachialis and communicating with median nerve was also noticed.[4] Median nerve with three roots and its communication with musculocutaneous nerve has also been mentioned.[5] Absence of musculocutaneous nerve, median nerve with three roots, accessory head of biceps was found.[6] A case of four headed biceps brachii, three headed coracobrachialis muscle with communicating branch between median and musculocutaneous nerve has also been reported.[7] The brachial plexus consisting of a single common cord with absence of musculocutaneous nerve have also been mentioned.[8]

Developmental Origin

The understanding of these nerve variations is highly complex as it starts during embryonic development. The mesenchymal cells of lateral plate mesoderm initiates the limb development. The patterning in this process is guided through homeobox genes HOX D1-D5.[9] The limb buds are formed deep to a thick band of ectoderm (apical ectoderm ridge). Therefore, each limb bud consists of a mass of mesenchyme derived from the somatic layer of mesoderm covered by ectoderm. Simultaneous to this phenomenon of limb development, nerve axons from the spinal cord segment also assemble opposite to limb buds and start growing into the limb. The axons are distributed to the muscles getting differentiated from the myogenic cells originating from the somites. The ventral primary rami of these nerves are joined and form plexuses that grow into the developing limb. The growth of motor axons into the limb buds occur during 5th wk and later continued with entry of sensory axons. Once the axonal transport occurs, neural crest cells, the precursor of schwann cells, surround the motor and sensory nerve fibers and form myelin sheaths.[10] The brachial plexus cone after entering into the upper limb bud divide into dorsal and ventral segments.[11] The ventral segment give rise to median and ulnar nerve. The musculocutaneous nerve further arises from median nerve and so the lateral cutaneous nerve of forearm also.[12] During the axonal course from the spinal cord to the developing limb bud, the failure of differentiation and coordination between nerve fibers and axonal growth cone migration leads to communications and hence, variations. A nerve growth cone is the region of tip of the axon which leads ahead during nerve outgrowth and is considered to be the locomotor organelle of the neuron. During migration of this growth cone, the complete neuronal pool gets arranged in to three longitudinal columns.[13] Column of Terni projects ventrally into the sympathetic ganglion. Lateral motor column extends into the developing limbs and medial motor column projects into the axial muscles. Each group of neurons is specified by a particular group of Lim proteins. These gets induced during neuronal migration and guide the neurons towards their target cells.[14] This guiding process occur in three steps of selection process.[15] Firstly, axons travel along a path to a particular region in embryo (pathway selection). Once the axons reach a particular region, they recognize and bind to the specific cells by making connections (target selection). Each axon binds to a subset of target cells due to interneuronal activity (address selection). This process further refine the overlapping projections into a fine pattern of connections. The pattern of axon transfer is decided by various factors guiding the growth cone of different neurons in different directions so that even the adjacent neurons are given different instructions. The guiding factors can be the matrix substrates or diffusible molecules. Extracellular matrix substrates facilitate the axons to travel on these substrate which can be either chemotactic like laminins.[16] causing adherence and axonal migration by a process known as “haptotaxis” or the chemorepulsive like ephrins, semaphorins leading to retraction of growth cone.[17] The diffusible molecules can also be chemotactic like netrin 1,2[18] or chemorepulsive like slit proteins.[19] Once axons reaches the target cells, its response is guided by various chemical substances termed as neurotrophins produced by target cells (nerve growth factor, brain derived growth factor, neurotropic factors 3,4,5).[20] Throughout the course of axonal migration, the growth cone sense a wide range of chemotactic and chemorepulsive substances. The growth cone integrates simultaneously with these molecules and the response is based on the combined input of these molecules. Any alteration between the mesenchyme target cells and these signaling molecules can lead to variation in nerve patterns.[21]

Clinical Implications

The knowledge regarding the anatomical variations is essential for perfect interpretation of clinical neurophysiology as these can cause unusual clinical signs. Musculocutaneous nerve is involved in traumatic nerve compressions during weight lifting, neuralgic amyotropy, during anterior dislocation of shoulder joint. It leads to flexor paralysis and anaethesia in nerve distribution. According to our case report, nerve damage at axilla may leads to paralysis of coracobrachialis muscle, the other stronger flexor muscles like biceps and brachialis and sensory function of lateral cutaneous nerve of forearm are spared. Therefore, the present case report should be considered during assessment of nerve entrapement injuries. This becomes also important while doing surgeries like constructive arthroplasty on shoulder and nerve grafting using musculocutaneous nerve.[22] The more superficial lateral cutaneous nerve of forearm can get injured in elbow injuries and compression by anomalous head of biceps.[23] Cutaneous nerves running in more superficial plane in the region of elbow increases the probability of a needle injury during venipuncture. This leads to pain and internal bleeding. This condition is often referred as complex regional pain syndrome. Therefore, location of superficial vein should be considered along with location of superficial nerves by selecting safer site for venipuncture.[24] During surgeries on forearm, wrist and hand, the axillary approach is most commonly used for producing brachial plexus block. The radial side of forearm is anesthesised in addition by targeting musculocutaneous nerve separately in the belly of coracobrachialis just superior to pulsation of axillary artery at the lateral border of pectoralis major muscle.[25] The present case definitely alter the result of anesthesia procedure as the nerve to coracobrachialis is localised at the muscle, therefore, to bring about anesthesia in its distribution, lateral cutaneous nerve of forearm should be blocked separately between brachioradialis and lateral side of biceps tendon. This variation can increase chances of nerve block failure in surgical procedures.

It is beyond doubt that the present case report along with the previously reported ones should be thoroughly remembered by the neurophysicians and surgeons to avoid confusions in clinical settings. More important step to be taken by the researchers is to find out the factors causing imbalance between chemical molecules leading to nerve variations as well as to search for the ways by which the ongoing or soon occurring imbalances can be estimated during intrauterine life. This is to ensure that preventive and therapeutic measures can be taken during fetal growth and development.

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