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Original research article

Anatomical Study of Innervation of the Three Heads of Triceps Brachii

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Abstract

Background: The extensor compartment of the arm is occupied by triceps muscle, through which runs the radial nerve and profunda brachii artery. Triceps arises by three heads namely long head, lateral head and medial head. Triceps is innervated by radial nerve (C6,C7 and C8) with separate branches for each head. Triceps muscle and its main motor nerve namely the radial nerve have multiple connection modalities. Each of the motor branches to triceps might be used as a donor for nerve transplantation.

Methods: The present study was performed on 52 upper limbs of 26 formalin embalmed cadavers from department of anatomy, Nalanda medical college and Hospital, Patna. And helps of other medical college, Patna. Study duration of two years. Thenerve supply to each head of triceps was traced and carefully followed to the source of each nerve branch and noted.

Results: Present study of innervation of three heads of triceps brachii showed that motor branch of long head of triceps brachii was supplied by radial nerve in 82.6%, axillary nerve in 13.4%and by posterior cord in 04% of the limbs dissected. The lateral head of triceps brachii was supplied by radial nerve in spiral groove in all the cases. The medial head of triceps brachii was supplied by radial nerve in spiral groove in all cases and additionally even by ulnar collateral branch of radial nerve in 92.6% of the cases.

Conclusion: Gross anatomical knowledge of innervations pattern of triceps brachii and variations of its motor supply are important to medical personnel especially to orthopaedic surgeons, radiologists, neurophysicians and physiotherapists for surgical treatment of traumatic nerve injuries, nerve grafting, neurophysiologic evaluation to diagnose peripheral neuropathy.

Keywords: Triceps brachii, Radial nerve, Axillary nerve, Ulnar nerve, Spiral groove.

Introduction

The Upper limb is one of the most active parts of the body. The muscles of the upper limb can be classified by origin, topography, function or innervation. Grouping by innervation reveals embryological and phylogenetic origins, the functional-topographical classification reflects the similarity in action between muscles. The motor and sensory supply of the upper limb is provided by the brachial plexus which is formed by the ventral rami of spinal nerves C5-T1. In the posterior triangle of the neck these rami form three trunks from which fibres enter the axilla to innervate the muscles of the anterior and posterior compartments of the limb. In the

axilla, cords are formed which split into branches. The muscles of the upper limb are innervated segmentally proximal to distal so that the proximal muscles are innervated by higher segments (C5–C6) and the distal muscles are innervated by lower segments (C8– T1). The **triceps brachii muscle** is the large muscle on the posterior aspect of the arm of many vertebrates. It is the muscle principally responsible for the extension of the elbow joint. Triceps brachii arises by 3 heads namely long head, lateral head and medial head, each of different origin, joining together to form a single tendon and insert to the upper surface of olecranon process of ulna. All three heads of the triceps brachii are classically believed to be innervated by the radial nerve. The presence of such separately innervated muscle unit of triceps may havepossible surgical importance and can be used for motor reconstruction.New advances in peripheral nerve surgery such as neurotization of muscle by direct suture of the nerve endto muscle or transfer of healthy motor nerve branches to motor nerve end of a denervated muscle is used for motor reconstruction. Triceps muscle and its main motor nerve namelythe radial nerve have multiple connection modalities. Radial nerve is the largest branch ($C_{5,6,7,8,}T_1$) from posterior cord of brachial plexus. Knowledge of radial nerve is not only useful for anatomists but also for surgeons,orthopedicians and physiotherapists. Lesion of the radial nerve at its origin from the posterior cord in axilla may occur due to pressure from use of crutch for long duration (crutch palsy). Compression of nerve against the humerus occurs if the arm is rested on a sharp edge such as the back of the chair (Saturday night palsy). Both cause weakness of brachioradialis with wasting and loss of reflex. Gross anatomical knowledge of nerve's origin, course, branches, distribution and communication are of vital importance. Anatomical variations of peripheral nerves are important to medical personnel especially to orthopaedic surgeons, radiologists, neurophysicians and physiotherapists for surgical planning and avoidance of iatrogenic injuries to nerve during surgeries, nerve grafting, neurophysiologic evaluation to diagnose peripheral neuropathies. Axillary nerve, ulnar nerve and ulnar collateral branch of the radial nerve are previously unrecognized sources of triceps brachii innervations. Additional study will be directed towards exploring these branches as potential sources for reinnervation of denervated muscle by direct nerve transfer without nerve grafting, for management of brachial plexus injuries and biceps brachii denervation and eventually for reinnervation of other muscles in the arm and forearm.

Objectives

To determine the exact origin of motor branch of the long head of triceps brachii, To explore a possible contribution of the ulnar nerve to motor innervation of themedial head of the triceps.

Review of Literature

The triceps brachii muscle is the largest muscle on the back of the upper limb of many vertebrates. In humans, triceps accounts for approximately 2/3rd of the muscle massin the posterior compartment of arm. It is principally responsible for extension of the elbow joint. The word triceps brachii is derived from Latin origin meaning three headed arm muscle.

Long head of triceps – It arises by a flattened tendon from the infraglenoid tubercle of the scapula, blending above with the glenohumeral capsule. Its muscular fibres descend medial to the lateral head and superficial to the medial head, and join them to form a common tendon.

Lateral head of triceps – It arises by a flattened tendon from a narrow, linear, oblique ridge on the posterior surface of the humeral shaft, and from the lateral intermuscular septum. The origin on the humerus ascends with varying obliquity from its lateral border above the radial groove and behind the deltoid tuberosity to the surgical neck medial to the insertion ofteres minor. These fibres also converge to the common tendon.

Medial head of triceps - It is overlapped posteriorly by the lateral and long heads, has a particularly extensive origin, from the entire posterior surface of the humeral shaft, below the radial groove from the insertion of teres major to within 2.5 cm of the trochlea, from the medial border of the humerus; the medial intermuscular septum and the lower part of the lateral intermuscular septum. Some muscular fibres reach the olecranon directly, the rest converge to the common tendon. The long head descends between teres minor and major, dividing the wedge- shaped interval between them and the humerus into triangular and quadrangular parts. The triangular space contains the circumflex scapular vessels; it is bounded above by teres minor, below by teres major, laterally by the long head of triceps. The quadrangular space transmits the posterior circumflex humeral vessels and the axillary nerve; it is bounded above by subscapularis, teres minor and the articular capsule, below by teres major, medially by the long head of triceps, and laterally by the humerus. The long head of triceps is supplied on its anterior surface by two arteries, one arising from the axillary artery in front of the tendon of latissimus dorsi and the other arising from either the brachial artery or the superior ulnar collateral. The posterior surface receives a recurrent branch from the posterior circumflex humeral artery immediately after traversing the quadrangular space. The lateral surface receives a number of small branches from the profunda brachii in its distal portion. Triceps is innervated by the radial nerve, (C6,7, 8) with separate branches for each head. Long head and medial heads are supplied by branches given off from the radial nerve in the axilla. The branch to the medial head is a long, slender filament which,lying close to the ulnar nerve as far as the distal third of the arm, is often termed the ulnarcollateral nerve. In the humeral groove the nerve supplies the lateral head and gives another branch to the medial head , The radial nerve descends behind the third part of the axillary artery and the upperpart of the brachial artery, anterior to subscapularis and the tendons of latissimus dorsi and teres major. With the profunda brachii artery it inclines dorsally, passing through the triangular space below the lower border of teres major, between the long head of triceps and the humerus. The long head of the triceps brachii muscle satisfies most of the requirements fora free functioning muscle transfer. It is superficially located and accessible surgically. It has an easily identified vascular pedicle, the profunda brachii. The nerve is single, long, and easy to harvest from the radial nerve. It can be teased off the radial nerve proximally to obtain a greater length if needed. Loss of the muscle from its original site leaves no significant loss of function. Skin closure is primary even if a paddle of skin is taken with the muscle. The surgical scar is posteromedial on the arm and hidden from view. Disruption of the C5 and C6 roots results in an Erb's palsy, with loss of supply to muscles innervated by the suprascapular nerve, axillary nerve, and musculocutaneous nerve. This type of upper brachial plexus injuries is most common root avulsion injuries.

Material and methods

This cross-sectional study was undertaken at the Department of Anatomy, at Nalanda medical college and Hospital, Patna, Bihar. And helps of other medical college, Patna. Study duration of two years. A total of 52 superior extremities of 26 formalin embalmed cadavers including 19male and 07 female cadavers were dissected. Using a standard medial skin incision at the back of the arm, subcutaneous tissue was removed. Deep fascia were removed to expose the triceps muscle which filled theposterior compartment. Superiorly, the medially placed long head of triceps which arose from infraglenoid tubercle of scapula was separated from the lateral head whichhad a linear origin from the posterior surfaces of humerus. The nerve supply to each head of triceps was traced and carefully followed to the source of each nerve branch and photographs were taken.

Inclusion Criteria:
Formalin embalmed upper limb specimens irrespective of age, sex or race.

Exclusion Criteria:
Upper limbs showing gross asymmetry, any injury to nerve supplying the triceps, or any surgical procedures done at brachial plexus will be excluded as unsuitable.
The triceps brachii and its innervation was studied by dissection method. Using a standard medial skin incision at the back of the arm, subcutaneous tissue was removed. Deep fascia was removed to expose the triceps muscle which filled the posterior compartment. Superiorly, the medially placed long head of triceps which arose from infraglenoid tubercle of scapula was separated from the lateral head which had a linear origin from the posterior surfaces of humerus. The radial nerve was identified in the axilla posterior to the axillary artery and then traced as far as the triceps by separating the parts of the triceps by blunt dissection along the line of the nerve in the muscle. Then the lateral head of triceps was divided and reflected where it overlied the radial nerve, thus exposing the nerve and profunda brachii artery in the groove for the radial nerve. The axillary nerve was identified in axilla and followed it as it passed posteriorly around the surgical neck of humerus to the quadrangular space, and its branches were traced distally. The ulnar nerve was also identified in the posterior compartment and followed distally.

Results
Out of the 52 upper limbs dissected for identification of innervation of long head of triceps brachii, 43 limbs(82.6%) showed normal innervation of long head of triceps brachii by radial nerve. Out of the 09 cases which showed variation in innervation of longhead of triceps brachii, 07 limbs(13.4%) showed innervation by axillary nerve and 02 limbs (4%) by posterior cord directly.

Distribution of innervation of long head of triceps brachii.

Innervation	**No. Of Specimens**	**Percentage (%)**
Radial Nerve	43	82.6
Axillary Nerve	07	13.4
Posterior cord	02	4
Total	52	100

Distribution of innervation of medial head of triceps brachii

Innervation	**No. of specimen**	**Percentage (%)**
Radial nerve branchat spiral groove only	04	7.7
Ulnar Collateral branch of radial nerve and radial nervebranch at spiral groove	48	92.3

Out of the 52 limbs dissected for identification of innervation of medial head of triceps, 48 upper limbs (92.3%) showed innervation of medial head of triceps by branch of radialnerve at spiral groove and ulnar collateral branch of radial nerve. Rest of 04 upper limbs(7.7%) were innervated by radial nerve branch at spiral groove only.

Level of origin of motor branch to medial head of triceps brachii

Level of origin	No. of specimens
Axilla and Spiral groove	48
Spiral groove only	04
Brachioaxillary angle	00
Total	52

Out of the 52 limbs dissected for identification of innervation of medial head of triceps, 48 upper limbs (92.3%) showed innervation of medial head of triceps by branch of radialnerve at spiral groove and ulnar collateral branch of radial nerve at axilla. Rest of 04 upper limbs (7.7%) were innervated by radial nerve branch at spiral groove only. No motor branches from brachioaxillary angle level of origin was seen innervating medial head of triceps.

Distribution of innervation of Lateral Head Of Triceps Brachii.

Innervation	No. Of Specimens	Percentage
adial nerve branchat spiral groove	52	100

Out of the 52 upper limbs dissected for identification of innervation of lateral head of triceps brachii, all 52 limbs showed normal innervation by radial nerve branch at spiralgroove and no variation from the normal. Out of the 52 limbs dissected for identification of innervation of lateral head of triceps, all 52 limbs showed normal innervation by radial nerve branch at spiral groove and no variation from the normal. No motor branches from axillary or brachioaxillary angle levelof origin was seen innervating lateral head of triceps.

Discussion

Triceps is innervated by the radial nerve (C6, 7 and 8) with separate branches for each head. Long head and medial heads are supplied by branches given off from theradial nerve in the axilla. The branch to the medial head is a long, slender filament which, lying close to the ulnar nerve as far as the distal third of the arm, is often termed the ulnarcollateral nerve. In the humeral spiral groove the nerve supplies the lateral head and givesanother branch to the medial head , which supplies the anconeus as well. Fractures of middle of the shaft of humerus, even though they may damage the radial nerve, are not likely to cause paralysis of triceps because of the high origin of nerve branches. Most of the standard texts in various specialities and surgeons believe that the nerve supply to all three heads of the triceps brachii is by radial nerve. The present study was done to identify the innervation of all heads of triceps brachii by tracing their level of origin and to identify if any variations in their innervation. Any variation in innervation paterrn of the three heads of triceps brachii were noted and compared with previous anatomical studies. 35 limbs (20 in cadaver and 15 in surgical dissection) were studied for the innervation of long head of triceps and found that innervation of long head of triceps was predominatly from axillary nerve in 65% of the cases and the rest of the limbs showed innervation by posterior cord directly. None of the limbs showed innervation of long headof

triceps from motor branch arising from radial nerve as reported in textbooks. Another study was done in 44 upper limbs and it was found that innervation of long head oftriceps was predominantly from axillary nerve in 68.2% of the cases like the previous study and the remainder 31.8% showed innervation by posterior cord. None of the limbs in this study too showed innervation by radial nerve. The hilton's law states that the nerve which supplies the joint also supplies the muscles related to and causing movement of the joint. Since the long head of triceps is intimately related to the shoulder joint and supports the joint during the movement of abduction, it is very likely for axillary nerve to innervate the long head of triceps. Hitchhiking of nerve fibers of brachial plexus is one of the common variations, where a nerve supplying its target structure may hitchhike on another nerve on its way to reach its destination. Since radial nerve and axillary nerve arise from same cord of brachial plexus(posterior cord) with common root values and are closely placed to each other in axilla, axillary nerve may contribute in supplying long head of triceps, instead ofradial nerve. A study was done on innervation of medial head of triceps in 33 cadaveric dissections and found that radial nerve innervation originated in spiral groove in 52% cases, axilla in 09% cases and brachioaxillary angle in the remaining 39% of cases. In ourpresent study of 52 limbs showed innervations of medial head by ulnar collateral branch of radial nerve in axilla and radial nerve branch in spiral groove. Radial nerve branch arising in spiral groove only supplied 7.7% of cases and in both axilla and spiral groovein 92.3% of cases. A study was done on innervation of lateral head of triceps in 33 cadavericdissections and found that radial nerve innervation originated in spiral groove in 70% cases, axilla in 06% cases and brachioaxillary angle in the remaining 24% of cases. In ourpresent study all 52 limbs dissected were innervated by radial nerve branch arising at spiral groove. A study was done on innervation of medial head of triceps brachii in 17 upper limbs and found ulnar nerve innervation in majority of the cases(70%). In another study of 14 upper limbs to study innervation of medial head of triceps showed all medial head of triceps brachii having radial nerve innervation. In the present study of 52 upper limbs showed medial head of triceps innervated by radial nerve in all the specimens. If we compare the variations in nerve supply to all the three heads of triceps, the long head of triceps shows high percentage of alternate nerve supply.

Conclusion

Motor branches to triceps brachii is used as a donor for nerve transplantation in motor reconstruction. Thorough anatomic knowledge of innervation of triceps brachii is essential for assessing functional loss, planned reconstructive surgeries and to prevent iatrogenic injury to the nerve while fixing humerus fracture. Present study of innervation of three heads of triceps brachii showed that motor branch of long head of triceps brachii was supplied by radial nerve in 82.6%, axillary nerve in 13.4% and by posterior cord in 04% of the limbs dissected.

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