Original research article

Anatomical Study of Innervation of the Three Heads of triceps Brachii Muscle

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Abstract

Background and Objectives: 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. Axillary nerve, ulnar nerve and ulnar collateral branch of the radial nerve are previously unrecognized sources of triceps brachii innervation. Additional study was directed towards exploring the anatomy of motor branches to three heads of triceps brachii.

Methods: The present study was performed on 52 upper limbs of 26 formalin embalmed cadavers from department of anatomy, at PMCH, Patna. Study duration of Two and half years, by dissection method. The nerve supply to each head of triceps was traced and carefully followed to the source of each nerve branch and noted.

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, Compression syndrome.

Introduction

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.[1,2] Various studies have been conducted suggesting axillary nerve supplying long head of triceps and ulnar nerve supplying medial head of triceps.[4,5,6] The presence of such separately innervated muscle unit of triceps may have possible 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 end to 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 namely the radial nerve have multiple connection modalities. Each of the motor branches to triceps might be used as a donor for nerve transplantation.[5] Brachial plexus palsy with upper segment C5 and C6 root avulsion can be effectively treated using a part of the radial nerve transferred to axillary nerve.[7] 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. Most common radial neuropathy is due to external compression or trauma to Radial nerve in spiral groove of humerus.[8] Radial nerve injury is most common nerve lesion complicating fracture of humerus. Radial nerve injury is commonly seen in humerus shaft fracture surgery when performing in lateral elbow region.[9] Considering the importance of innervation of triceps brachii present work was done to study the nerve supply to the three heads of triceps brachii.

Objectives

To establish the anatomy of motor branches to triceps brachii. 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.

Material and Method

This cross-sectional study was undertaken. The present study was performed on 52 upper limbs of 26 formalin embalmed cadavers from department of anatomy, at Patna Medical College and Hospital, Patna. Study duration of Two and half years, by dissection method. The nerve supply to each head of triceps was traced and carefully followed to the source of each nerve branch and noted. 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 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 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.

Dissection - 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 branches of radial nerve were then followed till their innervation distally. The branches of radial nerve for triceps brachii were looked for at various levels-at axilla, brachioaxillary angle (angle between medial aspect of arm and posterior wall of axilla) and spiral groove. 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. Any variation in the triceps innervation was noted and the nerve was followed proximally to identify its origin.

Results

Long Head of Triceps Right side

A) Motor Nerve Supply- Radial Nerve

B) Level Of Origin of Motor Nerve Branch- In Axilla

Lateral Head of Triceps

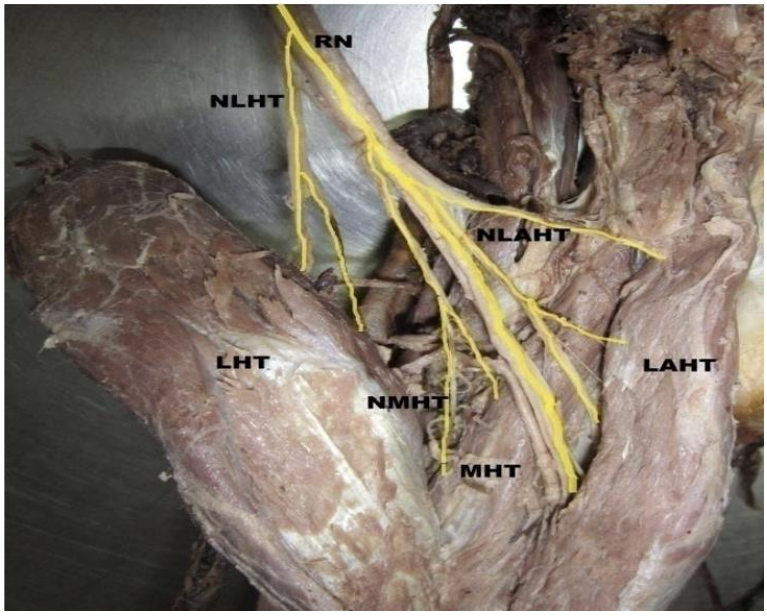
C) Motor Nerve Supply- Radial Nerve

D) Level Of Origin of Motor Nerve Branch- In Spiral Groove

Medial Head of Triceps

E) Motor Nerve Supply- Radial Nerve

F) Level Of Origin of Motor Nerve Branch- In Spiral Groove



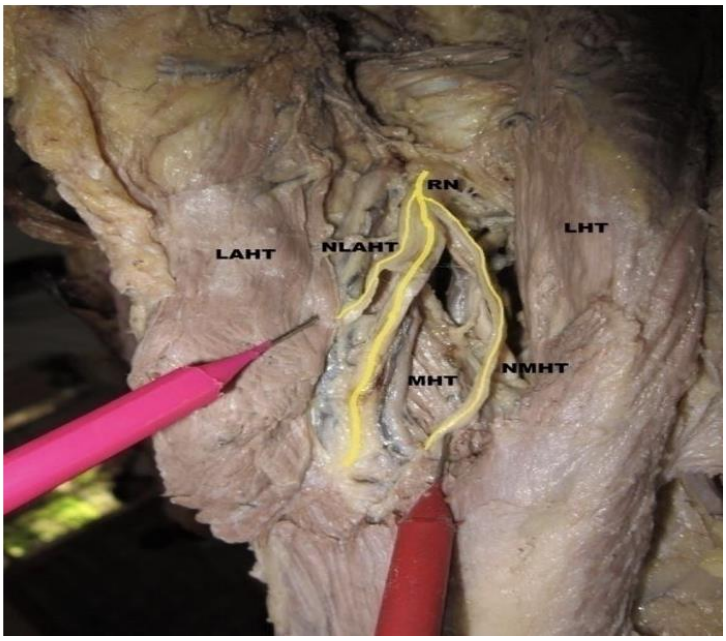
Normal Innervation of All Three Heads Of Triceps Brachii By Radial Nerve

Long Head of Triceps Left side

A) Motor Nerve Supply- Radial Nerve

B) Level Of Origin of Motor Nerve Branch- In Axilla

Lateral Head of Triceps
C) Motor Nerve Supply- Radial Nerve
D) Level Of Origin of Motor Nerve Branch- In Spiral Groove
Medial Head of Triceps
E) Motor Nerve Supply- Radial Nerve & Ulnar Collateral Nerve
F) Level Of Origin of Motor Nerve Branch- In Spiral Groove & Axilla



Lateral Head and Medial Head of Triceps Brachii of Left Upper Limb Supplied by Branches of Radial Nerve in Spiral Groove

Table 1: Distribution between normal and variation in innervation of Long Head of Triceps Brachii

Innervation	Number of Specimen	Percentage (%)
Normal	43	82.6
Variation	9	17.4
Total	52	100

Out of the 52 upper limbs dissected, 43 (82.6%) showed normal innervation of long head of triceps brachii arising from radial nerve and 09 (17.4%) showed a variation in innervation of long head of triceps brachii.

Table 2: 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

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 long head of triceps brachii, 07 limbs(13.4%) showed innervation by axillary nerve and 02 limbs (4%) by posterior cord directly.

Table 3: 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 radial nerve 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.

Table 4: Distribution of innervation of Lateral Head Of Triceps Brachii.

Innervation	No. Of Specimens	Percentage
Radial 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 spiral groove and no variation from the normal.

Table 5: Level of origin of motor branch to lateral head of triceps brachii

Level of origin	No. of specimens
Spiral groove	52
Axilla	00
Brachioaxillary angle	00
Total	52

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 level of 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 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 ulnar collateral nerve. In the humeral spiral groove the nerve supplies the lateral head and gives another 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. [1,2,8,11,12,13,14.] However various studies have been conducted and cases been reported suggesting axillary nerve supplying long head of triceps and ulnar nerve supplying medial head of triceps. [4,5,6,10]. 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 pattern of the three heads of triceps brachii

were noted and compared with previous anatomical studies. 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. The present study does not show similarity in the incidence of percentages of alternate nerve supply by axillary nerve to the long head of triceps as seen in other studies. This could be due to difference in population and race under study. In a study of innervation of long head of triceps, it was found that in the first group of 20 limb dissections in cadavers, the mean distance of motor branch of axillary nerve from terminal division of posterior cord termination was found to be 6mm (Range : 2-12mm) compared to the second group in which 15 limbs were dissected surgically had a mean distance of 4.5mm (Range : 1-10mm). In the present study, 07 limbs showed long head of triceps innervated by axillary nerve with the mean distance of motor branch of axillary nerve from terminal division of posterior cord termination being 9mm (Range : 3-12mm). A study was done on innervation of lateral head of triceps in 33 cadaveric dissections 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 our present study all 52 limbs dissected were innervated by radial nerve branch arising at spiral groove. 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 for which an explanation has already been given. The medial and lateral head are solely related to elbow joint, so less incidence of alternate innervations.

Conclusion

Among the three heads of tricpes, the long head is more prone to variation in innervations. The commonest alternate nerve supply to long head of triceps has been observed to be axillary nerve. This could be explained on the basis of Hilton's law and hitch hiking. The inconsistency in the variations of innervations to tricpes on comparison with similar studies could be due to difference in population and race under study. These findings could be relevant for surgical treatment of traumatic nerve injuries, infraclavicular brachial plexus block, management of axilla and shoulder repairsurgeries and nerve transplant procedures.

References

1. Standring Susan, Gray's Anatomy: The Anatomical Basis of Clinical practice. 39th edition. Edinburg: Elsevier Churchill Livingstone, 2005; 855-858
2. Last R.J, Anatomy Regional and Applied. 7th edition. ELBS. Edinburgh. Churchill Livingstone, 1984; 76.
3. Witooncahart K, et.al. Nerve transfer to deltoid muscle using nerve to long head of triceps. Part 1- an anatomical feasibility study 1. Journal of hand surgery. 2003; 28: 628-632.
4. De Seze M.P, Rezzouk J, et.al. Does the motor branch of the long head of the triceps brachii arise from radial nerve? Journal of surgical radiological anatomy. 2004; 26: 459-461.
5. Halil Bekler, Valerie M.Wolfe, et.al. A cadaveric study of ulnar nerve innervation of the medial head of triceps brachii. Clinical orthopaedics and related research. 2009; 467: 235-238.
6. Rezzouk J, Durandeau A. Long head of the triceps brachii in axillary nerve injury : anatomy and clinical aspects. Revue de chirurgic orthopedique et reparatrice de'l appareil moteur. 2002; 88: 561-564.
7. Bertelli J A, Santos M A, et.al. Triceps motor branch as donar or reciever in nerve transfer. Neurosurgery. 2007; 6: 333-338.

8. Snell R.S. Clinical Anatomy by regions. 8th edition.Wolters Kluwer: Lippincott Williams and Wilkins, 2008; 476.
9. Amillo S, Barrios RH, Martinez-Peric R, Losada JL. Surgical treatment of radial nerve lesions associated with fractures of the shaft of the humerus. J Orthop Trauma.1993; 7:211–215.
10. Nanjundaiah K, Jayadevaiah SM, Chowdapurkar S. Long head of triceps supplied by axillary nerve. Int J Anat Var. 2012; 5: 35–37.
11. Hamilton WJ. Textbook of the Human Anatomy, 2nd edn, Macmillan Press Ltd., London,1976; 651.
12. Tountas CP, Bergman RA. Anatomic variations of the upper extremity. Churchill Livingstone, New York; 1993; 11.
13. Turck SL. Orthopaedic principles and their applications. 4th edition. JB Lippincott, Philadelphia, 1984; 497- 498.
14. Sabiston DC. The biological basis of modern surgical practice. In:The Textbook of Surgery. 15th edn. W. B. Saunders Company, Philadelphia, 1997; 1484.