Surgical Implications of Innervation Pattern of the Triceps Muscle: A Cadaveric Study

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J Hand Microsurg 2018;10:139–142

Abstract

The innervation pattern of triceps is complex and not fully comprehended. Anomalous innervations of triceps have been described by various authors. We have attempted to delineate the nerve supply of the triceps and documented the anomalous innervations of its different heads. The brachial plexus and its major branches (in the region of the axilla and arm) and triceps were dissected in 36 embalmed cadaver upper limbs. Long head received one branch from radial nerve in 31 (86%) specimens. Four (11%) specimens received two branches including one that had dual innervation from the radial and axillary nerves, and one (3%) specimen had exclusive innervation from a branch of the axillary nerve. Medial head received two branches arising from the radial nerve in 34 (94%) specimens. One (3%) specimen received three branches from the radial nerve whereas one (3%) had dual supply from the radial and ulnar nerves. Lateral head received multiple branches exclusively from the radial nerve, ranging from 2 to 5, in all (100%) specimens. Knowledge of the variations in innervation of the triceps would not only help the surgeon to avoid inadvertent injury to any of the nerve branches but also offers new options for nerve and free functional muscle transfers.

Keywords
► triceps
► innervation pattern
► nerve transfer
► nerve injury
► brachial plexus branches
► surgical approach

Introduction

Triceps is the muscle of extensor compartment of the arm. It has three heads, viz., long, lateral, and medial, which eventually converge to be inserted as a single tendon. The medial head is active in all phases of elbow extension whereas long and lateral heads contribute minimally except in extension against resistance.[1] Traditionally, it is taught that the triceps is innervated by the radial nerve with separate branches for each of the heads.[2] However, it is now recognized that the pattern of innervation of the triceps is complex and is not fully comprehended.[3]

Anomalous innervations of the triceps have been described by various authors. Some cadaveric studies have shown that the long head of the triceps is innervated by the axillary nerve.[4–6] In some studies, the medial head is found to be innervated by a branch of the ulnar nerve.[7–10] Musculocutaneous nerve substituting for the distal portion of the radial nerve has also been described.[11]

There are multiple branches supplying the different heads of the triceps, and these can be used as potential donors for neurotization procedures and free functional muscle transfers. Awareness of these variations is important during surgical and interventional procedures on the axilla, shoulder, and arm. This led to the present cadaveric study to delineate the nerve supply of the triceps muscle and to document the anomalous innervations of the different heads of triceps.

Materials and Methods

Thirty-six embalmed cadaveric upper limbs were studied. None of the specimens were observed to have any evidence of deformity, previous surgical procedures, or traumatic lesions. The study was conducted in the Department of

received
January 9, 2018
accepted after revision
May 1, 2018
published online
June 20, 2018

DOI https://doi.org/10.1055/s-0038-1660771
ISSN 0974-3227.

Anatomy, All India Institute of Medical Sciences (AIIMS), Bhopal, after due clearance from the institutional human ethics committee (IHEC AIIMS Bhopal: IM0069).

The brachial plexus and its major branches (in the region of the axilla and arm), that is, radial, axillary, median, and ulnar nerves, and the triceps muscle were dissected as per the standard description in *Cunningham's Manual of Practical Anatomy*.[12] The dissections were photographed; innervation of the three heads of the triceps were traced and documented.

Results

Long Head

Long head received one branch arising from the radial nerve, before it entered the spiral groove, in 31 (86%) specimens. Four (11%) specimens received two branches including one that had dual innervation from radial and axillary nerves and one (3%) had exclusive innervation from a branch of the axillary nerve (►**Fig. 1**).

Medial Head

Medial head received two branches arising from the radial nerve, one branch before it entered the spiral groove and another while in the spiral groove, in 34 (94%) specimens. One (3%) specimens received three branches from the radial nerve, one branch before it entered the spiral groove and the distal two branches arising in the spiral groove. One (3%) specimens had dual supply, one branch arising from the radial nerve in the spiral groove and one branch from the ulnar nerve; the ulnar nerve branch was 8.8 cm from the tip of the medial epicondyle in the extended position of the elbow (►**Fig. 2**).

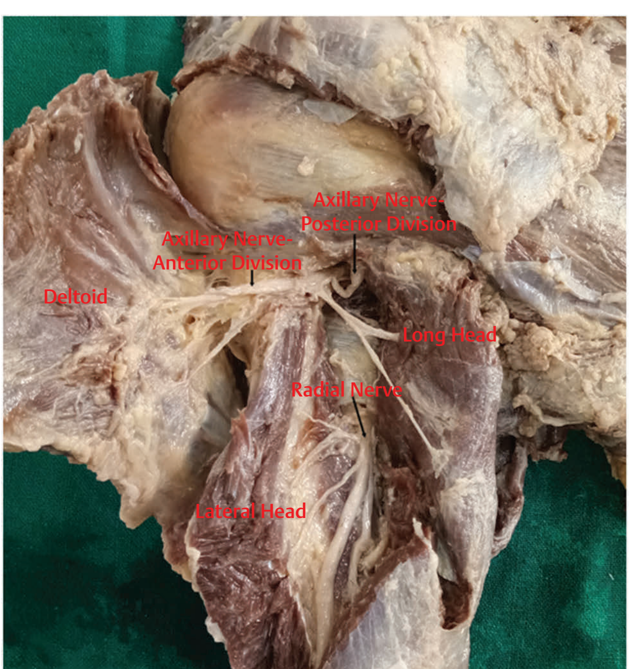

Fig. 1 Dissection of the left axilla showing innervation of long head of triceps by branch from axillary nerve.

Lateral Head

Lateral head received multiple branches exclusively from the radial nerve, ranging from 2 to 5, in all specimens (►**Fig. 3**). Thirty-four (94%) specimens received the branches that arose within the spiral groove. Two (6%) specimens received one branch before the radial nerve entered the spiral groove and remaining branches in the spiral groove.

►**Table 1** shows the number of branches to each head of triceps seen in this study and the comparison with other studies.

Discussion

Awareness of the variations of innervation pattern of the triceps is important in planning and carrying out surgical and interventional procedures on the axilla, shoulder, arm, and elbow. Some cadaveric studies have shown that long head of the triceps is sometimes innervated by the axillary nerve,[4,5] and medial head is innervated by a branch of the ulnar nerve.[7–9] In this study, in 5% specimens, the axillary nerve innervated the long head, whereas in 3%, the medial head was innervated by the ulnar and radial nerves.

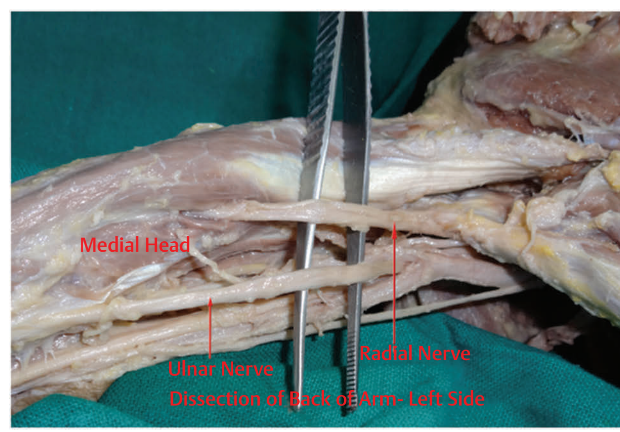

Fig. 2 Dissection of the left arm showing innervation of medial head of triceps by branch from ulnar nerve.

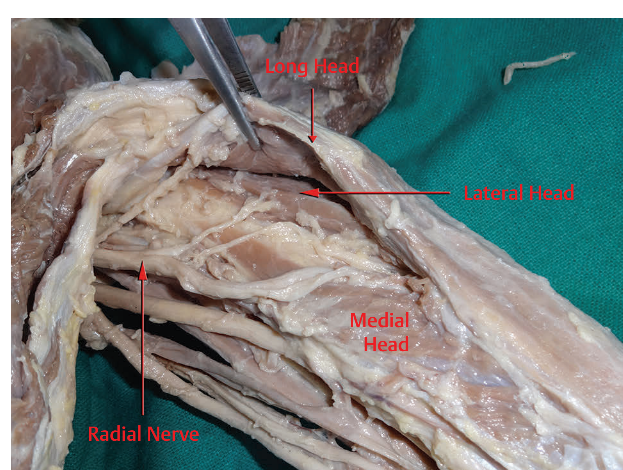

Fig. 3 Dissection of the right arm showing multiple branches from radial nerve innervating lateral head of triceps.

Table 1 Number of branches to each head of triceps seen in the present study and the comparison with other studies

Author	Sample size	Long head					Lateral head		Medial head				
		Radial		AXN	Dual*	PC	Radial		Radial		UN	MCN	Dual#
		1	> 1				2	> 2	1	> 1			
Al-Meshal and Gilbert	25	23	2	0	0	0	11	14	22	3	0	0	0
Bekler et al	18	Not studied					Not studied		7	0	11	0	0
de Sèze et al	35	0	0	24	0	11	Not studied		Not studied				
Loukas et al	50	Not studied					Not studied		36		14	0	0
Erhardt and Futterman	22	8	0	3	11	0	Not studied		Not studied				
Present study	36	31	3	1	1	0	8	28	0	35	0	0	1

Abbreviations: AXN, axillary nerve; MCN, musculocutaneous nerve; PC, posterior cord; RN, radial nerve; UN, ulnar nerve.
Note: Dual*—RN + AXN; Dual#—RN + UN.

In 86% specimens, the long head received only a single branch whereas in all specimens the lateral head received at least two branches. Our findings are consistent with those of Al-Meshal and Gilbert[13] who dissected 25 cadaveric arms and found that the long head of the triceps received a single branch in 92%, medial head received a single branch in 88%, and lateral head received more than one branch in all cases, ranging from two to five branches.

de Sèze et al[5] have reported branches arising from the posterior cord innervating the long head of the triceps in 11 (31%) out of 35 dissections. They observed no branches from the radial nerve innervating the long head. However, this study concurs with studies by Al-Meshal and Gilbert[13] and Erhardt and Futterman,[14] in which no branches from the posterior cord were found supplying the long head. The findings of this study are consistent with those of Al-Meshal and Gilbert[13] who have reported at least two or more branches to the lateral head of triceps.

Loukas et al[9] examined 50 specimens and found ulnar innervation of the medial head in 28%. They noted that the clinical implication of this innervation pattern could be retained medial head function in the presence of radial nerve injury that could mislead the treating surgeon. In this study, 3% specimen had similar innervation with the branch from the ulnar nerve arising 8.8 cm from the tip of the medial epicondyle. This finding is consistent with that of Bekler et al[7] who in their series of 18 dissection specimens found a branch from the ulnar nerve to medial head of the triceps in 11 (61%) specimens; these nerve branches originated between 4 and 10 cm proximal to the medial epicondyle. Therefore, it is suggested that during posterior and medial approaches to the elbow and during anterior transposition of the ulnar nerve, the surgeon should be aware of such anomalous innervation and should routinely look for it to prevent iatrogenic nerve injury.

Pascual-Font et al[10] studied contributions of the ulnar and radial nerves to innervation of the triceps in 15 embryonic and fetal arms. They reported that the medial head was always innervated by the radial nerve (ulnar collateral branch). In their dissections, the branches to the medial head that appeared to leave the ulnar nerve at elbow level were continuation of the radial nerve that had joined the ulnar nerve sheath via a connection in the axillary region. They concluded that a connection between the radial and ulnar nerves sometimes may exist, resulting in an apparent ulnar nerve origin of muscular branches to the medial head even though the fibers can be traced back to the radial nerve. In this study, there was one incidence of innervation of medial head by ulnar nerve, and there was a communicating branch from the radial to ulnar nerve in another specimen that did not supply the medial head.

Nerve transfers, intra- as well as extraplexal, are routinely used in the management of traumatic brachial plexus palsies. Intraplexal nerve transfer involves transfer of functioning motor fascicles within the ipsilateral plexus to produce the required function without producing any residual functional deficit. Witoonchart et al[15] in the anatomic feasibility study for nerve transfer to deltoid muscle using the nerve to the long head in 84 cadaveric specimens recorded the length and diameter of the nerves to the long and lateral heads at the level of triangular space. Based on these findings, the authors conducted the now-popular Somsak procedure.[16] The average diameters of the nerve to the lateral head was 1.2 mm (1.1–1.6) and nerve to long head was 1.2 mm (1.0–1.6), respectively.

Based on our observations, we agree with Khair et al[17] who have suggested that it is anatomically feasible to transfer multiple branches of the radial nerve supplying the medial, lateral, and, sometimes, long head of the triceps to all branches of the axillary nerve to reinnervate the deltoid and teres minor muscles. We also agree with Al-Meshal and Gilbert[13] who have suggested transfer of the most proximal nerve branch to the lateral head of triceps as the preferred choice for deltoid muscle innervation in comparison to the branch of the long head of triceps as the latter transfer risks compromising elbow extension against resistance. McRae and Borschel[18] reported data on five children who underwent transfer of medial head branch for shoulder abduction. All children were able to actively abduct their shoulders against gravity with no compromise of elbow extension in the postoperative follow-up at 1 year.

Limitations

Knowledge of fascicular topography by histomorphometry would facilitate better choice during nerve transfer procedures. However, we could not perform the same for lack of fresh cadaveric material.

All surgical approaches to the humerus and elbow take into consideration the complicated neural anatomy of the arm. Because routine anatomical dissections were performed, we could not observe the nerve branches that could have been at risk, in the different surgical approaches.

It is known that the peripheral nerves glide with change in the position of adjacent joints. Because we used embalmed specimens, the resiliency of the tissues was inadequate to measure alteration in the position and glide of the radial nerve and its branches with elbow movement; we did not measure the distances of nerve branches from fixed bony landmarks as these would change with position of the limb during live surgery and our measurements would not serve much purpose.

Conclusion

Knowledge of the many variations of the innervations of triceps would not only help the surgeon to avoid inadvertent injury to any of the nerve branches but also opens a whole new gamut of options for nerve and free functional muscle transfers. One or more branches innervating the medial or lateral heads of triceps can be safely used for deltoid innervation. The surgeon can confidently choose one or more donor nerves for the best clinical outcome.

Conflict of Interest
None.

Acknowledgments
The authors wish to place on record the assistance received from the staff in the Department of Anatomy, All India Institute of Medical Sciences, Bhopal, during the study and in cadaver maintenance.

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