A Cadaveric Study of Ulnar Nerve Innervation of the Medial Head of Triceps Brachii

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Abstract The presence of a separately innervated muscle unit of the triceps may have possible surgical importance and can be used for motor reconstructions. The ulnar nerve is closely situated to the triceps muscle and rarely examined above the elbow. The aim of this cadaveric study was to explore a possible contribution of the ulnar nerve to motor innervation of the medial head of the triceps. We dissected 18 limbs from axillae to midforearm. The path of the ulnar nerve was followed, and examination was conducted of attachments to the triceps. Gross photographs were taken and samples histologically stained. Seventeen limbs had ulnar nerve branches proximal to the epicondyles that inserted on the medial head. Eleven of these branches were from the ulnar nerve trunk. The other six were nerve branches from the ulnar collateral branch of the radial nerve. The ulnar nerve and the ulnar collateral branch of the radial nerve are previously unrecognized sources of innervation of the medial head of the triceps brachii. These motor branches must be carefully preserved during the medial surgical approach above the elbow. The ulnar innervated part of the medial head of the triceps muscle may be used like an independent motor unit.

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Introduction

The triceps brachii has been recognized as receiving motor innervation from the radial nerve with contributions from C7 and C8, although studies have noted the branching pattern to be inconsistent [4, 5]. The specific origins of radial innervation for each of the three heads of the triceps have been described [9, 10]. Gerwin et al. [3] likewise observed trifurcation of the radial nerve at the lateral aspect of the humerus that sent one branch to the medial head of the triceps. Another branch has been reported to accompany the ulnar nerve in its path for a time before insertion and therefore is known as the ulnar collateral branch [7, 8].

The ulnar nerve is the continuation of the medial cord of the brachial plexus with contributions from C8 and T1 [11, 12]. The branching pattern of the ulnar nerve is not consistently characterized. Sunderland [11, 12], agreeing with Linell's original 1921 observation [6], noted the nerve gives off no branches in the upper arm. Doyle and Botte [2] noted the first branch of the ulnar nerve is classically articular and originates in the cubital tunnel up to approximately 1 cm proximal to the medial epicondyle.

We observed a thus far unreported phenomenon in anatomic branching of the ulnar nerve. The presence of an ulnar nerve branch contribution to triceps motor function was observed in many surgical procedures that needed ulnar nerve dissection proximal to the elbow.

The presence of an ulnar nerve-innervated muscle unit of the triceps muscle has more than just scientific importance. The unit of triceps muscle innervated by the ulnar nerve, completely independent of the radial nerve-innervated main part of the triceps, may be used for motor reconstructions. This cadaveric study was designed to further document this connection with the aim of determining anatomically and histologically the ulnar nerve

contribution to the motor innervations of the medial head of the triceps muscle.

Materials and Methods

Eighteen upper limbs from 10 skeletally mature fresh-frozen cadavers were used in this study. Eight were left arms and 10 were right. The mean age of the cadavers was 67 years (range, 41–82 years).

Using a standard medial skin incision, subcutaneous tissues were exposed from the axillae to the midforearm. The intermuscular septum was identified. The ulnar nerve was found positioned behind the proximal edge of the septum, preserved, and dissected along the anterior surface of the medial head of the triceps muscle. At the elbow, the ulnar nerve passes behind the medial humeral epicondyle and medial to the ulnar collateral ligament and the olecranon. It tracks distally between the humeral and ulnar head of the flexor carpi ulnaris, reaching a position deep to that muscle where it rests on the flexor digitorum profundus. Our dissection was terminated at this level.

Careful examination was made of attachments between the ulnar nerve and the medial head of the triceps brachii. Where a nerve connection was noted, the ulnar nerve, nerve branch, and portion of medial head of the triceps muscle presumably innervated by the nerve were resected and placed in formalin. Gross photographs were taken of the nerve and its connection to the triceps.

Representative samples from each cadaver were embedded in paraffin and 8- μ m sections were cut using a microtome. After deparaffinization and rehydration with xylene and ethanol, some slides were stained with silver nitrate, whereas others were stained with hematoxylin and eosin. Nerve to muscle connections were noted.

The ulnar collateral branch of the radial nerve also was identified in some of the specimens where it branched from the radial nerve at the level of the brachioaxillary angle.

Results

Dissection was completed successfully in all 18 specimens. In 17 of the 18 limbs, nerve branches were observed to originate in the area of the ulnar nerve and to insert into the medial head of the triceps. These nerve branches originated between 4 and 10 cm proximal to the medial epicondyle. They were either encased in or located in close proximity with the mezonervosum but were easily grossly distinguished from this tissue. In 11 of the 17 specimens, the nerve branch originated from the main ulnar nerve (Fig. 1). The other six specimens had the accessory ulnar collateral branch of the radial nerve described previously (Fig. 2). On

Fig. 1A–B (A) A photograph ($\times 3.5$ loupe magnification) and (B) diagram show the origin of the nerve branch. The arrow indicates the connective branch from the ulnar nerve to the medial head of triceps brachii. Eleven of the 18 cadaveric specimens had this gross connection, supporting our theory of ulnar innervation of at least a portion of the triceps motor function. The branch passes over the ulnar collateral branch of the radial nerve.

each specimen, this branch left the radial nerve at the level of the brachioaxillary angle and traveled with the ulnar nerve along the groove in the medial head of the triceps. The branch, although not visible to the naked eye, was identifiable at all times through $\times 3.5$ loupe magnification as a distinct bundle of fascicles traveling with but not intermingled with the ulnar nerve. In these specimens, the nerve branches to the medial head of the triceps were seen to originate from the ulnar collateral branch of the radial nerve.

Histologic staining confirmed the observed connection between the ulnar nerve and the medial head of the triceps was indeed a nerve to muscle connection (Fig. 3).

Discussion

The presence of a separately innervated muscle unit of the triceps may have possible surgical importance because it might be used for motor reconstructions. The ulnar nerve is very closely situated to the triceps muscle and rarely is examined above the elbow. In this cadaveric study, we

Fig. 2A–B (A) A photograph ($\times 3.5$ loupe magnification) and (B) diagram show the presence of the accessory ulnar collateral branch of the radial nerve and the origin of the motor nerve branch. The accessory ulnar collateral branch of the radial nerve is situated close to and is grossly distinguishable from the ulnar nerve.

Fig. 3 The triceps muscle and nerve branch were clearly seen on histologic examination of the specimen (Stain, Masson's trichrome; magnification, $\times 40$).

dissected 18 limbs from axillae to midforearm to explore a possible contribution of the ulnar nerve to motor innervation of the medial head of the triceps. The ulnar nerve innervation of the medial head of the triceps was supported by this cadaveric study. The limitation of this study is that we did not measure the precise location of the branches. In a cadaver study, it is impossible to determine whether a branch is motor or sensory, but the location of each branch can be mapped. During this particular study, our main goal was to determine the presence or absence of nerve

connection. Our attention was focused on defining the nature of each connection; ie, whether it was a nerve or whether it was connective tissue. Therefore, we did not measure the location of the branches.

Although the majority of the observed nerve branches originated from the main ulnar nerve, some also came from the ulnar collateral branch of the radial nerve. This branch of the radial nerve, although easily separated from the ulnar nerve by loupe magnification, is situated so close to the ulnar nerve as to be indistinguishable by the naked eye.

With the ulnar nerve branch innervation of the triceps, the dual nerve supply could allow separation of the triceps muscle. This could explain the clinical observation that radial nerve denervation does not result in complete lack of triceps function.

The triceps muscle and its main motor nerve, the radial nerve, have multiple connection modalities. New advances in peripheral nerve surgery such as neurotization of muscle by direct suture of nerve end to muscle, or transfer of healthy motor nerve branches to the motor nerve end of a denervated muscle have given the surgeon great capacity for motor reconstructions.

Witoonchart et al. [13] described the concept of using the radial nerve branch to the long head of the triceps brachii for reinnervation of the anterior branch of the axillary nerve in upper brachial plexus injuries. In selected cases, the ulnar collateral branch of the radial nerve to the ulnar nerve or motor branch ramifying from the ulnar nerve could be used for reinnervation of a denervated muscle closely situated. Another possibility may be the transfer of the entire muscle unit for motor use. This independent motor unit may be helpful in restoring elbow flexion in selected cases or it may be used like a motor unit of forearm movement in the manner the brachialis muscle is used [1]. If well described, this small selective donor site would have an easy anatomic approach and acceptable potential morbidities.

It is essential to change the current thought that no major ulnar nerve branches occur above the elbow. Dissections proximal to the epicondyles must be performed carefully so as to avoid destruction of these branches, preventing partial denervation and atrophy of the triceps muscle and additional fibrosis of the medial head and resultant postsurgical elbow stiffness. Finally, the importance of the ulnar collateral branch of the radial nerve must be emphasized. Our anatomic dissections showed this nerve to be a distinct entity with a diameter large enough to be appreciated easily on loupe magnification. With popularization of neurotization, this nerve would be a prime candidate for reinnervation of denervated muscle through nerve-to-nerve repair (for example, musculocutaneous nerve interruption with resultant denervation of the biceps brachii). The nerve also could be used for direct transfer to another muscle.

We conclude the ulnar nerve and the ulnar collateral branch of the radial nerve are previously unrecognized sources of triceps brachii innervation. Additional study will be directed toward exploitation of 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.

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