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Topographic and Biometric Study of Radial Nerve Branches to the Muscles of the Anterior Compartment of the Arm

Estudio Topográfico y Biométrico de los Ramos del Nervio Radial para los Músculos del Compartimiento Anterior del Brazo

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SUMMARY: The radial nerve is a terminal branch of the brachial plexus that innervates the entire posterior compartment of the upper limb. Researches have shown that the branches can contribute to innervation of the muscles from the anterior compartment of the arm. This study sought to identify branches of radial nerve for brachialis and coracobrachialis muscles and its clinical value during surgery. Dissection was performed in 60 arms, from 30 corpses selected from the Human Anatomy Laboratories of Universidade Estadual de Ciências da Saúde de Alagoas (UNCISAL). In each arm, three segments of the same proportion were considered (proximal, middle and distal) in order to observe the number of radial nerve branches to brachialis and coracobrachialis muscles. Branches were identified in 4 of the 60 upper limb (6.66%) with the following distribution: nerve with 1 branch to the brachialis muscle in the distal third (1.66%); with 1 branch to the middle third of the coracobrachialis (1.66%) and 5 branches to the coracobrachialis muscle in the proximal third; 1 branch being found in an upper limb (1.66 %) and 4 branches in the other upper limb (1.66 %). The event was not bilaterally in the same body, and in four cases there was no branching, but only communication with other terminal nerves of the brachial plexus. In conclusion, although most authors do not describe the possibility of the occurrence of radial nerve branches to the muscles of the anterior compartment of the arm, this condition exists as an anatomical variation.

KEY WORDS: Anatomy; Radial nerve; Brachialis muscle; Coracobrachialis muscle.

INTRODUCTION

The radial nerve supplies sensitive innervation to the postero-lateral skin of upper limbs and motor innervation to triceps brachialis muscle. This nerve does not send branches to the muscles from the anterior compartment of the upper limbs (van de Graaff, 2003). It arises from posterior cord of brachial plexus and receives fibers from roots of cervical segments like C5, C6 and C8 (Rouvière, 1943).

In the region of radius head, the radial nerve divides in two terminal branches: deep and superficial. In the forearm (s), only the superficial branch has communication with lateral cutaneous nerve of the forearm (Testut & Jacob, 1950). Nonetheless, few researches report the contribution of this nerve in innervation of the anterior compartment of the arm.

The anterior compartment of arm muscles are innervated by musculocutaneous nerve after it perforates the coracobrachialis muscle. It arises in lateral cord of brachial plexus, from C5 to C7 (Benninghoff & Goerttler, 1986). The musculocutaneous nerve communicates, in almost all the path, with superficial branch of radial nerve. In the distal segment of the arm, this nerve presents a branch connecting it to median nerve too (Prives *et al*., 1971).

Some texts and researches have been reporting a dual innervation of brachialis muscle, from musculocutaneous and radial nerves (Leonello *et al*., 2007; Bendersky & Bianchi, 2012), being the inferolateral segment the part that receives the biggest supply of radial nerve (Spinner *et al*.,

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2003). Some authors allege that the importance of these contributions from radial nerve is not known (Frazer *et al*., 2007). The first suspicion of dual innervation arose when Jones (1919) described a patient that had contraction of brachialis muscle after disruption of musculocutaneous nerve.

Therefore, is important to know the distribution of radial nerve in the arm, trying to find its branches to muscles of the anterior compartment, especially to brachialis and coracobrachialis, presenting its clinical applications.

MATERIAL AND METHOD

Upper limbs of 30 adult Brazilian corpses of both sexes and estimated age between 20 and 80 years old were used, preserved using formaldehyde at 10%, made available by the laboratory of descriptive and topographic anatomy of Universidade de Ciências da Saúde de Alagoas (Uncisal). All of upper limbs were articulated in the corpses. Due to the high miscegenation in Brazil, especially in northeast region, the ethnicities of the corpses were not identified.

To dissect, each one of the corpses was positioned in supine position with upper limb abducted on the table of Anatomy Laboratory. A longitudinal incision was made in the middle of the anterior elbow surface, going by the arm to the posterior neck trine, folding the skin. After defining the region of the study, the tissues were dissected into many planes, trying to expose muscles and nerves to observe.

All studied cases had the nerves and their branches quantified, measured with Metrica® manual mechanical caliper and photographed with a Canon® digital camera.

To the analysis, from acromioclavicular joint, the arms were proportionally divided in 3 segments: proximal, middle and distal. In each segment the data of these variables was registered: the quantity of branches from radial nerve; variations of radial nerve branches; length of radial nerve branch from its origin to its apparent input in muscle and the muscle innervated by each branch.

The data of these variables were recorded in individual forms with the data of the following other variables: localization and distribution of radial nerve, its branches, possible connections between these branches or with other branches of brachial plexus, the existence of other nerves sending branches to muscles of anterior compartment of the arm was also recorded.

All the data was recorded in an Excel® spreadsheet to verify the distribution of frequencies, average calculus and standard deviation to the data about length of radial nerve branches to the muscles of anterior compartment of the arm.

RESULTS

In 30 selected corpses, 23 were of male sex and 7 of female sex. In a group of 60 upper limbs, 56 (93.34%) had no visible branches communicating radial nerve with musculocutaneous nerve, only communications of branches from radial nerve with other terminal branches of brachial plexus could be perceived. Thus, in only 4 upper limbs (6.66%), all of male sex, contributions from radial nerve to the muscles of anterior compartment of the arm could be perceived. About the side of the limb, we found 2 right upper limbs (3.33%) with 5 branches to the anterior compartment, in the proximal segment. From the middle segment, in 1 left upper limb (1.66%) we found branch to the anterior compartment, while arising from lower segment was perceived in just one case (1.66%), and also in the left side.

About the sex, no branches were found to the anterior compartment muscles of the arm in corpses of female sex, however, in these arms, we noticed one case of communication between the ulnar nerve and radial nerve. In relation to branches of radial nerve to the anterior compartment of the arm, in male sex, 1 branch to distal segment (14.3%) and 1 branch to the middle segment (14.3%) were found. In the proximal segment, we recorded 5 branches (71.4%), resulting in a total of 7 branches found in this study. The length of branches varied from 0.4 cm to 7.8 cm (Table I), with average length of 2.88 cm and standard deviation of 2.69 cm.

The brachialis and coracobrachialis muscles were innervated by musculocutaneous nerve in all cases (100%). In relation to innervations of muscles of anterior compartment by radial nerve, branches of radial nerve in three segments of the arms were found, we noticed 1 branch (14.3%) to brachialis muscle in the distal segment, 1 branch to coracobrachialis muscle in the middle segment and 5 branches (71.4%) to the coracobrachialis muscle in the proximal segment, 1 branch in a upper limb and 4 other branches in the other upper limb (Table II).

About the radial nerve distribution, it was uppermost the presence of branches in inferolateral segment, both in brachialis muscle and in coracobrachialis muscle (Fig. 1), one branch (1.66%) to the superolateral segment.

Table I. Length of radial nerve branches to anterior compartment muscles.

Upper Limbs	Length (cm)
1	0.4
	0.5
	1.6
	7.8
2	5.7
3	2.6
4	1.6

In relation to the communication with musculocutaneous nerve, no cases were recorded. Nonetheless, 3 communications between radial nerve and ulnar nerve, one (1.66%) was found in the proximal segment and 2 (3.33%) in the middle segment. The length of these communications varied from 4 to 6.2 cm, with an average length of 4.67 cm and standard deviation of 1.70 cm. A communication of radial nerve to medial cord of brachial plexus was also found, which reached the proximal segment of the arm, with a length of 2.9 cm.

Despite not having noticed communication of the musculocutaneous nerve with radial nerve, other communications were perceived, 2 with median nerve and 1 with ulnar nerve, with a possibility of an indirect contribution of these nerves in innervations of some muscle of anterior compartment of the arm.

Fig. 1. Radial nerve branch to coracobrachialis muscle. BB= Biceps Brachialis; C= Coracobrachialis; RN= Radial Nerve; RNBC= Radial Nerve Branch to Coracobrachialis; MN= Median Nerve; BA= Brachial Artery; DBA= Deep Brachial Artery.

Table II. Distribution of radial nerve to brachialis and coracobrachialis muscles according to the arm segment.

Muscle	Arm segment					
	Distal		Middle		Proximal	
	F	%	F	%	F	%
Brachialis	1	14.3	0	0	0	0
Coracobrachialis	0	0	1	14.3	5	71.4

F= frequency of limbs with variation; %= Percentage.

DISCUSSION

In this study, in more than 80% of analysed corpses, radial nerve branches to the anterior compartment of the arm could not be noticed. This condition is different from what was reported in studies such as of Srimathi & Sembian (2011), who studied 50 upper limbs of Indian corpses, recording branches in 88% of the cases, i.e, contributions from radial nerve to brachialis muscle. In research carried out in Thai (Mahakkanukrauh & Somsarp, 2002), in Caucasians of United Kingdon (Blackburn *et al*., 2007), in Indians (Prakash *et al*., 2009), in Chileans (Molina *et al*., 2011) and Argentine population (Bendersky & Bianchi), records percentage of occurrence of contribution from radial nerve to the anterior compartment of the arm muscles were between 65 and 100% in the upper limbs studied. However, researches like of Awori & Inyimili (2013), with 57 upper limbs of Kenyans corpses, recorded a lower value (57.9%), but higher yet, to this study (Table III).

The inexistence of statistical difference between male and female corpses, as well as between the sides that the branching, about variables related to the innervations of brachialis and coracobrachialis muscles, reinforces the conclusions of studies done by Mahakkanukrauh & Somsarp who did not find statistical difference in their study with Thai corpses.

The results of this study in all cases of branching described, the innervation of brachialis and coracobrachialis muscles by the musculocutaneous nerve, reinforces what the previous studies related to these muscles stated, recognizing that all the anterior compartment of the arm present innervation from this nerve (Spinner *et al*.; Blackburn *et al*.; Frazer *et al*.; Leonello & Bain; Dang & Rodner, 2009; Bendersky & Bianchi) as well as in classic anatomy textbooks (Gérard, 1912; Hollinshead, 1966; Prives *et al*.; Woodburne, 1984; Benninghoff & Goerttler; van de Graaff; García-Porrero & Hurlé, 2005).

The single case of radial nerve branches innervating brachialis muscle in this study was found in the distal segment of arm, variation also noted in other reports like of Prakash *et al*., in which 65.71% of 140 upper limbs of Indian corpses, one branch of radial nerve to brachialis muscle was observed in the lower segment of the arm.

We did not find reports about the possibility of innervation of coracobrachialis muscle by radial nerve, nonetheless, in this study thick branches of radial nerve to this muscle were found, they were mostly observed in distal segment of the arm, an innovative fact, as shown in Figure 1, but it is an odd fact that it was not widely reported, since we found a case with 4 branches of radial nerve while drilling this muscle.

In this study, the distal-lateral segment of brachialis and coracobrachialis muscles presented higher number of records about branches from radial nerve. In brachialis muscle, this finding corroborates with the description of some books (McMinn, 1994; Snell, 1995; Rosse & Gaddum-Rosse, 1997) and in the study of Mahakkanukrauh & Somsarp which in its research with 76 corpses, found in 103 (87%) of 142 upper limbs, branches of radial nerve to the distal-lateral segment of brachialis muscle.

The thickness of branches from radial nerve (for the anterior compartment of the arm), were not measured in this study, because a lot of them had a diameter of 1 millimeter or less. We believe that due to this fact and for it being too easily cut during dissecations, many authors do not find it, which explains the fact that these variations are not constantlydescribed.

Finally, we conclude that the radial nerve contributes to the innervations of brachialis and coracobrachialis muscles, despite being only an anatomical variation and most of time with no thick branches, it is not easy to dissect and measure these contributions. These contributions can be important in cases of nervous injury of upper limbs.

Table III. Percentage of radial nerve branches to the muscles of the anterior compartment of the arm in different populations.

Population	Number of upper limbs	Branches of radial nerve to the anterior compartment muscles percentage (%)	References
Indian	44	88.00	Srimathi & Sembian (2011)
	92	65.71	Prakash *et al.* (2009)
Thai	124	81.61	Mahakkanukrauh & Somsarp (2002)
Caucasians (United Kingdom)	28	67	Blackburn *et al.* (2007)
Argentines	13	65.00	Bendersky & Bianchi (2012)
Chileans	27	90	Molina *et al*. (2011)
Kenyans	33	57.90	Awori & Inyimili (2013)
Brazilians	4	6.66	This study (2015)

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RESUMEN: El nervio radial es un ramo terminal del plexo braquial que inerva el compartimiento posterior del miembro superior. Diversos estudios han mostrado que sus ramos pueden contribuir a la inervación de los músculos del compartimiento anterior del brazo. El presente estudio tuvo como objetivo identificar ramos del nervio radial dirigidos a los músculos braquial y coracobraquial y su importancia clínica durante las cirugías. Para ello, se disecaron 60 brazos de 30 cuerpos formolizados en los Laboratorios de Anatomía Humana de la Universidad Estadual de Ciencias de la Salud de Alagoas, Brasil (UNCISAL). En cada brazo, se consideraron tres partes de similares proporciones (proximal, medio y distal) para localizar los ramos dirigidos a los músculos mencionados. En 4 de los 60 brazos (6,66%) se identificaron ramos con la siguiente distribución: un ramo para el músculo braquial en el tercio distal (1,66%); un ramo para el tercio medio del músculo coracobraquial (1,66%) y cinco ramos para este mismo músculo en su tercio proximal; en otro miembro (1,66%)se encontró solo un ramo y en la otra muestra (1,66%) se encontraron cuatro ramos. Ninguno de los casos fue bilateral y en los cuatro casos no había ninguna ramificación. No hubo comunicación con el nervio musculocutáneo pero si con otros ramos del plexo braquial. Aunque la mayoría de los autores no describe la posibilidad de que el nervio radial inerve a los músculos anteriores del brazo, esta disposición existe como una variación anatómica.

PALABRAS CLAVE: Anatomía; Nervio radial; Músculo braquial; Músculo coracobraquial.

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