Nervous Communications in the Upper Limb. A Cadaveric Study

Abstract

**Background:** Anatomical variations of the terminal branches of the brachial plexus in terms of communication between nerves at the level of upper limb have been reported, these communications were median and musculocutaneous nerve, median and ulnar nerve, radial and ulnar nerve (at level humeral), but communications between the radial and ulnar nerve at level of the forearm are very rare.

**Methods and Findings:** 34 upper extremities of 15 male and 2 females embalmed adults cadavers in the laboratory of Morphology of the University of Pamplona. The upper limbs were studied serially during the years 2013-2016. Of the 34 upper limbs studied in the Laboratory of Morphology of the University of Pamplona, in a 75 year-old male cadaver anatomical variations were found, dissected carefully and morphological details were photographed, these variations consisted of nervous communications between median and musculocutaneous nerve in the right and left arm (proximal), in the right arm (distal); median and ulnar nerve in the right forearm; radial and ulnar nerve in the left forearm.

**Conclusions:** Knowledge of these communications is of clinical significance. Surgical, therapeutic and diagnostically invasive procedures require extreme caution to prevent lesions of the anastomotic branches.

Introduction

The brachial plexus is a complex structure which is divided into roots, trunks, divisions, cords and branches, has supraclavicular and infraclavicular part. The supraclavicular part includes roots, trunks and divisions. The infraclavicular part includes cords and their branches. The brachial plexus is formed by the union of ventral rami of C5, C6, C7,
C8 and greater part of T1. These ventral rami are the roots of brachial plexus, almost equal in size but variable in their mode of junction. Ventral rami of C5 and C6 unite at the lateral border of the scalenus medius to form upper trunk and C7 continues as middle trunk while C8 and T1 unite behind scalenus anterior to form lower trunk. All these trunks incline laterally, just above or behind the clavicle where each one bifurcates into anterior and posterior divisions. The anterior divisions of upper and middle trunks unite to form a lateral cord, lateral to the axillary artery and the anterior division of the lower trunk descends at first behind, then medial to the axillary artery, forming medial cord. Posterior divisions of all the three form the posterior cord, at first above and then behind the axillary artery [1]. From the cords arise the terminal branches of the brachial plexus including the musculocutaneous nerve (MCN), median nerve (MN), ulnar nerve (UN), axillary nerve (AN), and radial nerve (RN). The brachial plexus supplies cutaneous and muscular innervation to the upper limb and any injury at this level can lead to significant disability. Variations of the cords and their terminal branches of the brachial plexus are relatively common and have been well documented. It is important for the anatomist, surgeon, anesthesiologist, and radiologist to be aware of anatomical variations that deviate from the classic anatomy [2].

The variation in the course, distribution and formation of the brachial plexus branches are common and usually have been reported by many authors but is paucity of literature on the communication between ulnar and radial nerve [3-5, 6]. Variation in nerves with abnormal origin, distribution and course are usually more susceptible to entrapment neuropathies and iatrogenic injuries [7]. The objective of the present cadaveric study was to determine any nervous communications at level of axilla, arm, forearm and hand.

Methods
This work was previously approved by the Ethics Committee in Research and Environmental Impact of the University of Pamplona, conformed by Resolution 030 of January 16, 2014 and Resolution No. 008430 of 1993 of October 4, of the Ministry of Health of Republic of Colombia by which regulates the scientific, technical and administrative norms for health research. This descriptive cross-sectional study was designed to determine the prevalence of nervous anastomosis between terminal branches of the brachial plexus in 34 upper extremities of 15 male and 2 females embalmed adults cadavers in the laboratory of Morphology of the University of Pamplona. The upper limbs were studied serially during the years 2013-2016. The axillary region of all the limbs was exposed carefully after clearing the entire fascia. The dissection was further continued towards the arm, forearm and hand in order to probe any nervous communications. Bilateral upper limbs were carefully dissected as per the standard dissection procedure, conducted to allow examination of the origin, course, and distribution of the nerves. Meticulous observation of variant forms and/or abnormal communication if any was made. Measurements were taken with assistance of a sliding Vernier caliper, accurate to 1 mm during the course of the anatomical dissection. The data thus obtained were recorded in a physical matrix and were consigned in digital media using Excel tables.

Results
Of the 34 upper limbs studied, 33 showed normal morphology, the course and branching patterns of the nerves was normal, having classic pattern of branching without communications as per described in the standard text book of anatomy (97.06% of all upper limbs examined). The anatomical variations described were found during routine dissection performed by medical
students of second semester in one male cadaver embalmed of 75 -year-old (2.94% of all upper limbs examined).

**In the right and left arm**
The musculocutaneous nerve presented an unusual connection with median nerve, was noted almost 13.5 cm proximal to elbow joint, after emit its usual muscular branches and the emergence of lateral cutaneous branch for forearm. This nervous patterns distribution described as anatomical variables were observed in both arms. The communicating branch arose from the musculocutaneous nerve at a distance of 12.6 cm and 12.5 cms from the tip of coracoid process on right and left side and joined the median nerve a 16.5 cms same bony point (Figure 1 and 2).

**In the right arm**
The musculocutaneous nerve presented an unusual connection with median nerve, was noted almost 5.53 cm proximal to elbow joint. (Figure 3). The communicating branch arose from the musculocutaneous nerve at a distance of 24.3 cm from the tip of coracoid process. The communicating branch was approximately 7.84 cm long and 0.65 mm in diameter.

**In the left forearm**
The radial and ulnar nerves were dissected and communicating branches were observed originating near the upper third in the posterior aspect of the forearm traveling from the ulnar to the radial nerve. The communicating branch was approximately 5.84

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cm long and 1.73 mm in diameter, almost 5.33 cm distal to elbow joint. (Figure 4)

**In the right forearm**

Communication between the median and ulnar nerves was observed. The length of the anastomosis was 6.5 cm. Its origin was on 6.7 cm distal to the medial epicondyle, and its connection to the ulnar nerve was on 10.5 cm distal to the medial epicondyle. The branch had followed an oblique path since its origin, after the division of the brachial artery. The branch was located between the flexor digitorum profundus and the flexor digitorum superficialis and was located antero-medial to the ulnar artery. The communicating branch was originates from the branch of the median nerve to the flexor digitorum superficialis muscle. (Figure 5).

**Discussions**

Communications between the branches of brachial plexus are well-documented. These communications may persist at the level of arm, forearm, and wrist areas of the upper extremities. Even though Bergman et al., mentioned that the radial nerve may communicate with the ulnar nerve in the arm [8], Based on the topographical location of the communication and or nerves involved in the communication, the different types of nomenclature of anastomosis are identified as Martin-Gruber anastomosis, Marinacci communication, Berretini anastomosis, Ansas pectoralis, Froment-Rauber nerve [5, 9-11].

A) A communicating ramus from median nerve to ulnar nerve in the forearm, the so called Martin-Gruber anastomosis.

B) Ulnar to median nerve communication in the forearm, so called reversed Martin-Gruber Anastomosis or Marinacci communication.

C) The Riche-Cannieu anastomosis occurs in the palm between recurrent branch of median nerve and deep branch of ulnar nerve.
D) The communicating ramus between the
common digital nerves that arise from ulnar
and median nerve in the palmar surface of
hand is known as Berretini anastomosis.

E) The communicating ramus between the la-
teral and medial pectoral nerves termed the
ansa pectoralis.

F) The Froment-Rauber nerve is a variant of
the radial nerve where fibers from either
the posterior interosseus nerve or superfi-
cial radial nerve provide motor innerva-
tion to the intrinsic hand muscles either directly
or through communication with the ulnar
nerve.

Uysal et al. dissected 200 brachial plexus in human
fetuses, only 93 of the brachial plexuses showed
no variations [12]. In other words, the variation of
brachial plexus was observed in 53.5% of the ca-
eses. Choi et al. [13] have observed a communication
between the median and musculocutaneous ner-
vessel in 46.4%; Loukas and Aqueelah [14] described
same communication in 63%, Venieratos and Ana-
gnostopoulou [15] observed in 20%. Communi-
cations between the median and ulnar nerves have
also been reported. Kazakos et al. [16] observed
this type of communication branch between me-
dian and ulnar nerves in 10 forearms of 163 cada-
vers. Ferreira-Arquez [6] described communication
originating near the upper third in the posterior as-
pect of the forearm traveling from the ulnar to the
radial nerve. However, a percentage value for the
communications between radial and ulnar nerves
on the arm or forearm is missing in the literature.
On the other hand, dorsal sensorial branch (60%)
on the dorsal surface of the hand [17], and radial
nerve cutaneous innervation to the ulnar dorsum
of the hand (16%) have been reported [18]. Variant
nerve communications may cause ineffective nerve
blockade and also blockade of unexpected areas.
During surgical procedure, such variations may lead
to possible complications. Therefore, it is very im-
portant to know all variant communicating bran-
ches of brachial plexus for successful regional nerve
blockade and operations [19].

The presence of such communications may be
attributed to random factors influencing the me-
chanism of formation of limb muscles and the peri-
pheral nerves during embryonic life. Significant va-
riations in nerve patterns may be a result of altered
signaling between mesenchymal cells and neuronal
growth cones and or circulatory factors at the time
of fusion of brachial plexus cords [20, 21].

Iwata (1960) believed that the human brachial
plexus appears as a single radicular cone in the up-
per limb bud, which divides longitudinally into ven-
tral and the dorsal segments. The ventral segments
give roots to the median and the ulnar nerves with
musculocutaneous nerve arising from the median
nerve. He further kept the possibility of failure of
the differentiation as a cause for some of the fi-
bers taking an aberrant course as a communicating
branch [22].

Chiarapattanakom et al. (1998) are of the opinion
that the limb muscles develop from the mesenchy-
me of local origin, while axons of spinal nerves grow
distally to reach the muscles and/or skin. They bla-
med the lack of coordination between the forma-
tion of the limb muscles and their innervation for
appearance of a communicating branch [23].

Chauhan and Roy (2002) strongly recommend
the consideration of the phylogeny and the deve-
lopment of the nerves of the upper limb for the
interpretation of the nerve anomalies of the arm.
Considering the communication between the mus-
culocutaneous and the median nerve as a remnant
from the phylogenetic or comparative anatomical
point of view and that the ontogeny recapitulates
the phylogeny, they feel that the variations seen are
the result of the developmental anomaly [24].

Studies of comparative anatomy have observed
the existence of such connections in monkeys and
in some apes; the connections may represent the
primitive nerve supply of the anterior arm muscles
[25, 26]. Investigations of peripheral neuropathies
are based upon patterns of functional deficits and diagnostic testing. Therefore, an anatomical variation can often lead to confounding patterns of physical and diagnostic findings. According to Ajayi et al., anatomical variant communication between branches of the brachial plexus could obscure the management of complex regional pain syndrome [27, 28]. The knowledge of the possible communications between musculocutaneous and median nerves is also important in the approach for the fractures de humerus. A clinician’s knowledge of musculocutaneous-median nerve communication is important while evaluation of clinical neurophysiology, planning a surgery after trauma and understanding of median and musculocutaneous nerve dysfunction [11].

A positive aspect of Martin-Gruber anastomosis is that it can provide another motor and sensory innervation during a defect in these nerves after a trauma. On the other hand, these may also result in misdiagnosis during the assessment of nerve injuries, carpal tunnel syndrome, cubital tunnel syndrome and leprosy neuropathy. In such cases, identification of Martin-Gruber anastomosis becomes very crucial because it not only generates exacerbated or attenuated clinical symptoms, different from the usual ones but also mode of treatment differs accordingly. However, nerve conduction study remains a reliable tool for its diagnosis [29].

Knowledge of Berretini communications is necessary to avoid injury to the communicating branch while performing release of the recurrent motor branch of median nerve in case of carpal tunnel syndrome. The presence of the communicating branch between the two nerves may compromise the sensory loss occurring due to lesion in median nerve to a certain extent. This variation can also be of significant use to neurologists and orthopedists while examining cases with sensory loss over the distal part of the upper limb. Care should also be taken to prevent injury of the nerve while performing endoscopic release of carpal tunnel for carpal tunnel syndrome by looking out for the communicating branch prior to the surgery [30]. Ferrari and Gilbert, described a danger zone, defined as an area that extends from the half of the hypothenar eminence limited distally by the transverse crease of the carpal on the palmar region and radially by a longitudinal fold between the thenar and hypothenar eminence, in which there is greater possibility of iatrogenic lesions in the approach to the carpal tunnel [31]. According to Agge et al., and Jimenez et al., these lesions are more frequent after endoscopic carpal tunnel release, although this technique has lower risk of complications in general, and provides quicker return to functional activities [30, 32, 33]. In the present study reported an anatomical variation of communication between median and musculocutaneous nerve, median and ulnar nerve, and ulnar and radial nerve in forearm of rare occurrence and lack of description in available scientific literature. The variations which are reported here, have already been reported as individual cases, but occurrence of nervous communications, bilaterally, in the same person, is a rare variation.

Conclusion
Knowledge of the any communications of the terminal branches of brachial plexus at level of upper limb is of clinical significance to the anesthesiologists, orthopedic surgeon, radiologists, general surgeon, clinicians in achieve proper diagnosis, sure diagnostic procedures, surgical intervention free of iatrogenic complications.

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family, or persons responsible for their care, process subject to compliance with the legal regulations in the Republic of Colombia.

Competing interests
None

References


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