Brachial Plexus. Our Anatomical Findings. (Part II)
G Milanes-Rodríguez, L Ibañez-Valdés, H Foyaca-Sibat, M Rodriguez-Neyra, M Rodriguez

Abstract
A retrospective review from our previous anatomical dissections looking for anatomical variations of the brachial plexus is made. All those dissections were made for teaching purposes at the Laboratory of Anatomy from Walter Sisulu University between January 2000 and January 2008 and the commonest findings are reported in this study. Its correlations with expected clinical manifestations in nerves injury are established.

INTRODUCTION
The brachial plexus is formed from the spinal nerves or roots, the coalescence of the ventral (motor) and the dorsal (sensory) rootlets as they pass through the spinal foramen. The dorsal root ganglion contains the cell bodies of the sensory nerves; the cell bodies for the ventral nerves lie within the spinal cord.

Typically, the brachial plexus is formed from C5-T1; in some cases with there is a contribution from C4 (prefixed, 28-62%) or T2 (postfixed, 16-73%). All nerve supply to the upper extremity passes through this plexus. The brachial plexus starts at the scalenes, courses under the clavicle, and ends at the axilla. It is typically composed of 5 roots, 3 trunks, 6 divisions (2 from each trunk), 3 cords and terminal branches.

The 5 roots are named by the level with which they correspond. The C5-7 roots give off branches to form the long thoracic nerve, and the C5 root gives branches to form the dorsal scapular nerve. C5 and C6 gives branches to form the superior trunk, C7 the middle trunk, and C8 and T1 the inferior trunk. Each trunk has 2 divisions: 1 division of each of the trunks forms the posterior cord; the anterior division of the superior trunk and the anterior division of the middle trunk form the lateral cord. The anterior division of the inferior trunk forms the medial cord. The medial, lateral, and posterior cord designations describe their relationship to the axillary artery.

As was before mentioned, the brachial plexus provides sensory and motor innervation to the upper extremity being a network of nerves originating from the ventral branches of spinal nerves C5-T1 in the posterior triangle of the neck. The nerves extend laterally along a slightly antero-inferior course, and they terminate in the axilla lateral to the pectoral minor as the musculocutaneous, axillary, radial, median, and ulnar nerves.

We reported some of our finding on brachial plexus’ anatomy and its clinical correlation just recently [1]. The main aim of this study is to report other findings on anatomy of brachial plexus from our series.

As was previously established, it is not possible to memorize each clinical picture for every anatomical change found on brachial plexus therefore we decide to show the commonest anatomical presentation of brachial plexus and to propose its clinical manifestations in nerve injuries based on those findings in the second part of this study.

MATERIAL AND METHOD
The study was done at the Department of Anatomy, Faculty of Health Sciences, Walter Sisulu University, Mthatha in South Africa. On routine dissection on embalmed African cadavers, variations in the formation of the brachial plexus were found. The clavicle and the scalene anterior were cut to expose the roots and trunks of the plexus. The divisions and their branches were followed to the muscle they supplied for confirmation.

RESULTS AND COMMENTS
The first rib divides the cervicoaxillary canal into a proximal space and the axilla. Compression of the brachial plexus
most often occurs proximally. The proximal space consists of the costoclavicular space and the scalene triangle. The costoclavicular space is bounded by the clavicle superiorly, the first rib inferiorly, the costoclavicular ligament anteromedially, and the scalenus medius muscle posterolaterally. The scalene triangle is bounded by the scalenus anterior (anterior scalene) anteriorly, the scalenus medius posteriorly, and the first rib inferiorly. The brachial plexus can also be entrapped in the pectoralis minor tunnel, which is bounded by the pectoralis minor tendon and the coracoid process. The most common cause of brachial plexus compression is an abnormal insertion of the anterior scalene on the first rib.

The anterior scalene muscle originates from the anterior tubercles of the transverse processes of C3-6. This muscle runs inferior and deep to the sternocleidomastoid muscle and inserts onto the first rib. The anterior scalene separates the subclavian vein from the roots of the brachial plexus and the subclavian artery. Relative to the anterior scalene muscle, the subclavian vein is a superficial structure, and the brachial plexus and subclavian artery are deep structures. The anterior scalene divides the subclavian artery is divided into 3 segments. The first segment lies medial to the muscle, the second segment lies deep to the muscle, and the third segment extends from the lateral border of the muscle to the outer margin of the first rib.

Our anatomy findings can be observed on the Figure 1 to 10 and main functions from cervical root are summarized in the Table I. Comments about some of those findings were made in Part I [1] but more detailed information can be found below.

**Figure 1**

Table 1

<table>
<thead>
<tr>
<th>Cervical Root</th>
<th>Clinically Relevant Gross Motor Function</th>
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<tbody>
<tr>
<td>C5</td>
<td>Shoulder abduction, extension, and external rotation; some elbow flexion</td>
</tr>
<tr>
<td>C6</td>
<td>Elbow flexion, forearm pronation and supination; some wrist extension</td>
</tr>
<tr>
<td>C7</td>
<td>Diffuse loss of function in the extremity without complete paralysis of a specific muscle group, elbow extension, consistently supplies the biceps brachii</td>
</tr>
<tr>
<td>C8</td>
<td>Finger extensions, finger flexors, wrist flexors, hand intrinsic</td>
</tr>
<tr>
<td>T1</td>
<td>Hand intrinsic</td>
</tr>
</tbody>
</table>

**LONG THORACIC NERVE**

A nerve that arises from the fifth, sixth, and seventh cervical nerves, descends the neck behind the brachial plexus, and is distributed to the anterior serratus muscle.

Whiplash injuries from motor vehicle accidents are very common. Brachial plexus traction injuries without any bone or joint lesion of the cervical spine have been reported before even in conjunction with paralysis of long thoracic nerve palsy and spinal accessory nerve at the same time. [2]. Winging of the scapula has three causes, each with different nerves and different clinical signs, one is caused by the long thoracic nerve and paralysis of serratus anterior. Camerota [3] described a patient who presented myoclonus in the left scalpa 3 months after a traumatic lesion of the left long thoracic nerve. Myoclonic activity was recorded as pseudorhythmic electromyography bursts repeated at a frequency of 2 to 4 Hz, each lasting between 100 and 200 msec, in the left serratus-dorsalis muscle region, trapezius, and deltoid muscles. A combination of peripheral and central mechanisms may have induced the myoclonus in this case.

Brachial Plexus neuritis, often referred to as Parsonage-Turner syndrome, can be a vexing problem for both the patient and the physician. It is a common condition characterized by inflammation of a network of nerves that control and innervate the muscles of the chest, shoulders, and arms (brachial plexus). Individuals with the condition first experience a sudden onset of severe pain across the shoulder and upper arm. Within a few hours or days, the muscles of the involved shoulder may be affected by, weakness, wasting, and paralysis [4]

Winged scapula is defined as a prominence of the medial border of the scapula and it is the most common scapulothoracic disorder. The causes of this condition are well-known, and they include brachial plexus injury, isolated paralysis of the serratus anterior, fascioscapulohumeral muscular dystrophy or injury to the long thoracic nerve that occurs during resection of the first rib for decompression of thoracic outlet compression syndrome [5]

**BRANCHES OF THE LATERAL CORD (FIGURE 2)**

The cords are positioned lateral to the first rib within the axilla and are named for their relationship to the axillary artery. A number of nerves arise from the 3 cords. As the cords exit the axilla, they recombine into terminal branches.

As we can see below, absence of the musculocutaneous nerve with innervation of coracobrachialis, biceps brachii, brachialis and the lateral border of the forearm by branches from the lateral cord of the brachial plexus has been reported [6]

**MUSCULOCUTANEOUS NERVE (FIGURE 3)**

A variation of the brachial plexus characterized by the
absence of the musculocutaneous nerve (MCN) on both sides was observed during the dissection of a 72 year-old female cadaver [7]. Injuries on MCN have been informed on sportsmen [8] among other anatomical variation reported [9-12].

The long thoracic nerve included only the fibers from C5 and C6 on the left side. The musculocutaneous nerve was absent and two branches from the lateral cord innervated the coracobrachialis muscle. The median nerve innervated the biceps brachii and brachialis muscles in the arm and also gave off the lateral antebrachial cutaneous nerve. Additionally, a communicating branch was found from the median nerve to the ulnar nerve in the forearm. The knowledge of the anatomical variations of the peripheral nerve system can help give explanation when encountering an incomprehensible clinical sign.

As was before mentioned, brachial plexus innervates the upper limb. As it is the point of formation of many nerves, variations are common. Knowledge of these is important to anatomists, radiologists, anesthesiologists and surgeons. The presences of anatomical variations of the peripheral nervous system is often used to explain unexpected clinical signs and symptoms, and although these variations may not have affected the functioning of upper limb in some peoples, knowledge of such variations are also essential in evaluation of unexplained sensory and motor loss after trauma and surgical interventions to the upper limb [13].

Our findings about branches from medial cord can be seen on Figure 4. We concluded without doubt that the Medial cord is a division of the brachial plexus and gives rise to the following nerves: The median pectoral nerve, C8 and T1, to the pectoralis muscle; the medial brachial cutaneous nerve, T1; The medial antebrachial cutaneous nerve, C8 and T1; the median nerve, partly. The other part comes from the lateral cord. C7, C8 and T1 nerve roots. The first branch of the median nerve is to the pronator teres muscle, then the flexor carpi radialis, the palmaris longus and the flexor digitorum superficialis. The median nerve provides sensation to the anterior palm, the anterior thumb, index finger and middle finger. It is the nerve compressed in carpal tunnel syndrome. The ulnar nerve originates in nerve roots C7, C8 and T1. It provides sensation to the ring and pinky fingers. It innervates the flexor carpi ulnaris muscle, the flexor digitorum profundus muscle to the ring and pinky fingers, and the intrinsic muscles of the hand (the interosseous muscle, the lumbrical muscles and the flexor pollicis brevis muscle). This nerve traverses a groove on the elbow called the cubital tunnel, also known as the funny bone. Striking the nerve at this point produces an unpleasant sensation in the ring and little fingers.

Our findings from brachial plexus in the axilla and the cubital fossa are shown in the Figure 5 and 6 and no remarkable variations from those reported in the medical literature were found. Other findings related to median, ulnar, axillary, and radial nerves can be seen from Figure 7 to 10 and an appropriated comments made by us were published before [1] and not differences from another reports [13-20]were found.

**Figure 2**

Figure 1. Brachial Plexus of the right side of 62 year old male cadaver (In Situ). Right axillary's region with long thoracic nerve supplying the serratus anterior muscle. (Dissection made by Dr. Milanes-Rodriguez G. MD MsC)
Figure 3
Figure 2. Right axilla with the branches of the lateral cord. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

Figure 4
Figure 3- Right arm. Musculocutaneous n traveling between biceps and brachialis m. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

Figure 5
Figure 4. Right axilla. Branches from the medial cord of the brachial plexus. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

Figure 6
Figure 5. Brachial plexus in the axilla. Main branches given forming an M. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)
**Figure 7**
Figure 6. Picture of the cubital fossa in the right arm. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

**Figure 8**
Figure 7. Median nerve at the wrist, going through carpal tunnel into the hand. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

**Figure 9**
Figure 8. Right hand. Ulnar nerve superficial to the flexor retinaculum. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

**Figure 10**
Figure 9: Posterior view of the shoulder region. The quadrangular space with the axillary nerve around the surgical neck of the humerus, and the radial nerve in the spiral groove. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)
**Figure 11**

Figure 10: Elbow region Radial nerve is branching in superficial and deep Branches. (Dissection made by Dr. Milanes-Rodriguez. MD MsC)

**References**


Author Information

G. Milanes-Rodríguez
Department of Anatomy and Neurology Unit. Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa. 5100

LdeF Ibañez-Valdés
Department of Anatomy and Neurology Unit. Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa. 5100

H Foyaca-Sibat
Department of Anatomy and Neurology Unit. Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa. 5100

ME Rodriguez-Neyra
Department of Anatomy and Neurology Unit. Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa. 5100

M Rodriguez
Department of Anatomy and Neurology Unit. Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa. 5100