

Gross morphological features of *plexus brachialis* in the chinchilla (*Chinchilla lanigera*)

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ABSTRACT

This study documents the detailed features of the morphological structure and the innervation areas of the *plexus brachialis* in the chinchilla (*Chinchilla lanigera*). The animals (5 female and 5 male) were euthanased with ketamine hydrochloride and xylazine hydrochloride combination, 60 mg/kg and 6 mg/kg, respectively. Skin, muscles and nerves were dissected under a stereo-microscope. The brachial plexus of the chinchilla is formed by *rami ventrales* of C5–C8, T1 and T2, and possesses a single truncus. The subscapular nerve is formed by the rami of the spinal nerves originating from C6 (one thin ramus) and C7 (one thick and 2 thin rami). These nerves innervate the subscapular and teres minor muscles. The long thoracic nerve, before joining with the brachial plexus, obtains branches from C6 and C7 in 5 cadavers (3 male, 2 female), from C7 in 4 cadavers (2 male, 2 female) and from C6–C8 in only 1 female cadaver. These nerves disperse in variable combinations to form the extrinsic and intrinsic named, nerves of the thoracic limb. An undefined nerve branch originates from the *rami ventrales* of C7, C8 and T1 spinal nerves enter the coracobrachial muscle.

Key words: brachial plexus, chinchilla, spinal nerves.

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24 hours at room temperature. To observe the spinal nerves that form the brachial plexus and branches originating from the brachial plexus, skin, muscles and nerves were carefully dissected under a stereo-microscope. The photographs were taken using a digital camera (Sony DSC F-717, Japan). For terminology, *Nomina Anatomica Veterinaria*²⁴ (5th edn) was used.

RESULTS

The brachial plexus of the chinchilla is composed of a highly complex network of nerves involving the ventral rami of C5–C8, T1 and T2. It was observed that C5 immediately divides into 3 branches, namely cranial, ventral and caudal after leaving from the foramen intervertebrale. The caudal branch, together with C6, participated in the formation of the brachial plexus. C6–C8 and T1 are also involved in the formation of the brachial plexus after leaving from the foramen intervertebrale as a single root. T2 emerges from the *foramen intervertebrale* and divides into 2 branches, namely cranial and caudal. The cranial branch joins T1 before it joins the brachial plexus. The brachial plexus was observed as a single *truncus* involving the caudal branch of C5 and C6, C8, T1 and cranial branch of T2 (Figs 1A,B, 2A,B), before segregating in various combinations to form the named nerves of the thoracic limb.

The subclavius nerve, innervating the subclavius muscle, was formed by the ventral rami of the spinal nerves that arose from the merged C5 and C6 (Fig. 2A/j, B/j).

The subscapular nerve was formed by the ventral rami of the spinal nerves coming from C6 (one thin ramus) and C7 (one thick and 2 thin rami) and innervates the subscapular muscle. The *teres minor* muscles are innervated by the ancillary nerve (Figs 1A,B/b, 2A,B/b).

The phrenic nerve is formed by the ventral rami of spinal nerves arising from C5–C7 and innervates the diaphragm.

The musculocutaneous nerve is formed by the ventral rami of the spinal nerves originating from C7 and supplies the biceps brachii muscle (Figs 1A,B/c, 2A,B/c).

The axillary nerve originates from the

INTRODUCTION

Chinchillas are perhaps the best known for their soft, thick and luxurious fur and they are becoming more popular as pets¹⁶. They belong to the class Mammalia, and the order and family Rodentia and Chinchillidae (Chinchillas and Visachas), respectively^{11,16,20}. They originated from South American countries *i.e.* Chile, Peru and Bolivia^{16,27}. This animal is similar to the squirrel with big ears and has a rabbit's body with mouse-like ears and squirrel's tail¹⁶. They are also closely related to the porcupine and the guinea pig¹⁷.

The peripheral nervous system plays a crucial role between the central nervous system and target organs, providing a 2-way impulse transportation which enables the body to regulate motor, sensory and autonomic functions¹⁴. Since the 19th century, the morphology of the brachial plexus within the peripheral nervous system has been the focus of many investigators of both mammal and non-mammal species. A number of studies have been carried out on the morphology,

histology and physiology of peripheral nerves, nerve injuries, diagnosis and outcome of nerve damage and nerve repair techniques²⁸.

The morphology of the brachial plexus has been studied in a variety of species, including porcupines², rabbits^{1,31}, mice^{8,25}, rats^{5,7,19}, cats²¹ and dogs^{10,23}. Studies of the morphology of the *plexus brachialis* in chinchillas appear to be rare. Therefore, this study aims at describing the morphology of the brachial plexus and its innervation in the chinchilla as a laboratory animal.

MATERIALS AND METHODS

A total of 10 (5 males and 5 females) apparently healthy adult chinchillas (*Chinchilla lanigera*) obtained from the Center for Experimental Medicine, Research and Application, Afyon Kocatepe University, Turkey, were used in the study. The live body weight of males and females varied from 550 to 600 g and 450 to 500 g, respectively. Animals were euthanased by the methods described by Flecknell *et al.*¹³ and Poore *et al.*²⁶. To this end, regulations of the ethical committee of Afyon Kocatepe University were adhered to where necessary. Cadavers were fixed in 10% formaldehyde solution for

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ventral rami of C6 and C7 and disperses into the *teres major*, *teres minor* and deltoid muscles (Figs 1A,B/d, 2A,B/d).

The cranial pectoral nerve is formed by the ventral rami of the spinal nerves arising from C7, C8, T1 and T2 and innervates the descending pectoral and transverse pectoral muscles (Figs 1A,B/e, 2A,B/e).

The long thoracic nerve, before joining the brachial plexus, obtains branches from C6 and C7 in 5 cadavers (3 males and 2 females), from C7 in 4 cadavers (2 males and 2 females) and from C6–C8 in only 1 female cadaver. These nerves disperse into the *serratus ventralis thoracis* muscle (Fig. 2A,B/k).

The thoracodorsal nerve is formed by the ventral rami of the spinal nerves arising from C8 and innervates the *latissimus dorsi* muscle (Fig. 1A,B/i).

The lateral thoracic nerve is formed by ventral rami of the spinal nerves originating from T1 and T2 and innervates the cutaneous omobranchial muscle (Fig. 2A,B/l).

The caudal pectoral nerve is formed by the ventral rami of the spinal nerves arising from T1 and T2 and disperses into the cutaneous trunci and ascending pectoral muscles (Fig. 2A,B/m).

The radial nerve is formed by ventral rami of the spinal nerves originating from C8, T1 and T2. The radial nerve innervates the *triceps brachii* (*caput medialis*, *caput lateralis* and *caput longus*), *tensor fascia antebrachii*, *extensor carpi radialis*, *extensor digitorum communis* and *extensor digitorum lateralis* muscles (Figs 1A,B/f, 2A,B/f).

The median nerve has a large number of roots originating principally from C7, C8 and T1 and innervates the flexor muscles of the carpus and digits (Figs 1A,B/h, 2A,B/h).

The ulnar nerve is formed by the ventral rami of the spinal nerves originating from T1 and T2 and innervates to the *flexor carpi radialis*, *flexor carpi ulnaris* and *flexor digitorum* muscles (Figs 1A,B/g, 2A,B/g).

Finally, an unnamed nerve arising from C7, C8 and T1 was observed and it coursed through the coracobrachial muscle.

No distributional differences were noted between male and females in both left and right brachial plexuses except for the long thoracic nerve.

DISCUSSION

In terms of comparative anatomy and contribution to the phylogenetic standards, there are indeed a number of reports indicating some differences in the formation of the brachial plexus in different species.

According to Hutchison¹⁸, the brachial

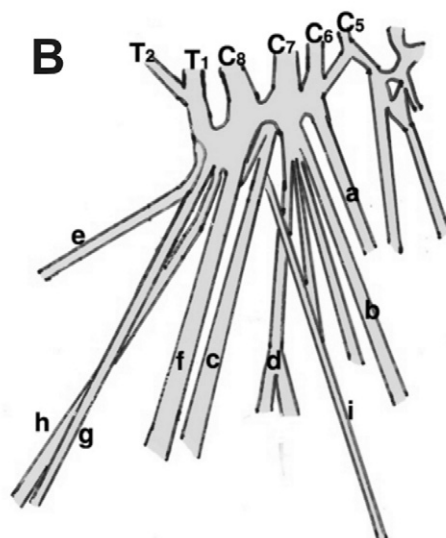
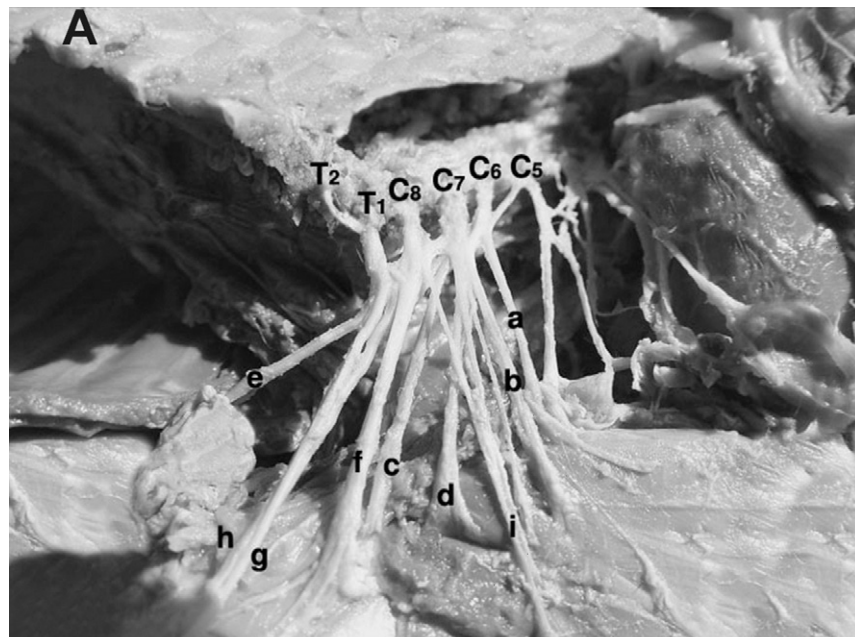


Fig. 1: A, Lateral view of the right brachial plexus in the chinchilla. C5: caudal branch of *ramus ventralis* of C5, C6: *ramus ventralis* of C6, C7: *ramus ventralis* of C7, C8: *ramus ventralis* of C8, T1: *ramus ventralis* of T1, T2: *ramus ventralis* of T2; a: suprascapular nerve, b: subscapular nerves, c: musculocutaneous nerve, d: axillary nerve, e: cranial pectoral nerve, f: radial nerve, g: ulnar nerve, h: median nerve, i: thoracodorsal nerve.

B, Drawing of the lateral view of right brachial plexus in the chinchilla. C5: caudal branch of *ramus ventralis* of C5, C6: *ramus ventralis* of C6, C7: *ramus ventralis* of C7, C8: *ramus ventralis* of C8, T1: *ramus ventralis* of T1, T2: *ramus ventralis* of T2; a: suprascapular nerve, b: subscapular nerves, c: musculocutaneous nerve, d: axillary nerve, e: cranial pectoral nerve, f: radial nerve, g: ulnar nerve, h: median nerve, i: thoracodorsal nerve.

plexus of vertebrate animals is formed by the contributions of the ventral rami of C6–C8, T1 and T2. The brachial plexus of the rat is formed by the ventral rami of C5–C8 and T1 (C5 receives a branch from C4), but T2 is not involved in the formation of the plexus^{4,5,28}. However, Greene¹⁹ and Chiasson⁷ previously suggested that a larger contribution from C4 and T2 (*via* T1) could have important findings in rats. Yilmaz *et al.*³¹ reported that the rabbit brachial plexus was formed by the ventral rami of C5–C8, T1 and T2 but McLaughlin and Chiasson²² disagreed with regards to

the contribution of C5 and T2. In guinea pigs and mice, the plexus originates from the ventral rami of C5–C8, T1 and T2^{9,25}, but the contribution from T2 is debatable^{6,8}. The brachial plexus of the chinchilla is formed by the contributions of ventral rami of C5–C8, T1 and T2 in our study, which is the same as described in porcupines (*Hystrix cristata*)². The brachial plexus of rabbits³¹ and porcupines² consist of caudal and cranial trunks whereas in rats⁵ it is formed by caudal, medial and cranial trunks. In our study, it differed from that of rabbits, porcupines and rats,

as the caudal branch of C5 and the cranial branch of T2 contribute to the formation of the brachial plexus as a single trunk.

Despite the fact that the suprascapular nerve of rabbit originates from C6^{15,30}, it is C5 and C6 in chinchillas in our study as well as in New Zealand white rabbits³¹, porcupines³ and guinea pigs⁹.

The subscapular nerve is formed by the ventral rami of C5 and C6 in porcupines³ and New Zealand white rabbits³¹, and by C5–C7 in guinea pigs⁹. In our study it originates from 1 ventral ramus of C6 and 3 ventral rami of C7.

The musculocutaneous nerve arises from C6 and C7 in rabbits^{29,30}, from C5–C7⁵ or C6 and C7¹⁹ in rats. However, in chinchillas, we observed that this nerve arose from C7 only.

The axillary nerve came from C7 and C8 in guinea pigs⁹, from C5–C8 and T1⁵ or only from C6 and C7¹⁹ in rats, and from the caudal trunk together with a branch of the subscapular nerve in porcupines³. In our study, this nerve arose from C6 and C7 as described in rabbits³¹.

The cranial pectoral nerve has 4 branches, 2 spreading to the descending pectoral muscle, 1 to the descending pectoral muscle and transverse pectoral muscle, 1 together with lateral thoracic nerve and caudal pectoral nerve to cranial part of the transverse pectoral and ascending pectoral muscles in porcupine³ and from C7, C8, T1 and T2 in our study innervating the descending pectoral and transverse pectoral muscles. The caudal pectoral nerve arises from the caudal trunk in porcupines³ and from T1 and T2 in our study and innervates the ascending pectoral muscle.

The long thoracic nerve arises from C6 and C7 at the right side and C7 and C8 at the left side in capybaras¹²; from C7, C8 and T1 in other laboratory rodents^{9,19,29}, and from C6 and C7 in porcupines². In chinchillas, we showed that it originated from C6 and C7 in 5 cadavers (3 males and 2 females), from only C7 in 4 cadavers (2 males and 2 females) and from C6, C7 and C8 in 1 female cadaver, and these nerves dispersed into the *serratus ventralis thoracis* muscle.

The thoracodorsal nerve originates from C6 and C7 in rats¹⁹, from C7 in New Zealand white rabbits³¹, and from the caudal trunk as 2 separate branches together with radial and axillary nerves in porcupines³. This differed from our findings, where this nerve arose from C8 only.

The lateral thoracic nerve originates from C6–C8 and T1 in rats¹⁹, guinea pigs⁹ and other laboratory rodents²⁹ and from the caudal trunk in porcupines³. In chinchillas, it comes from T1 and T2.

The radial nerve originates from C6–C8

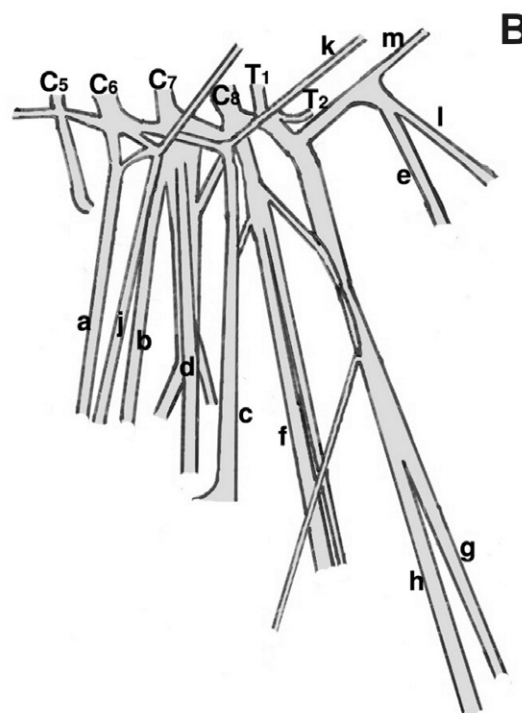
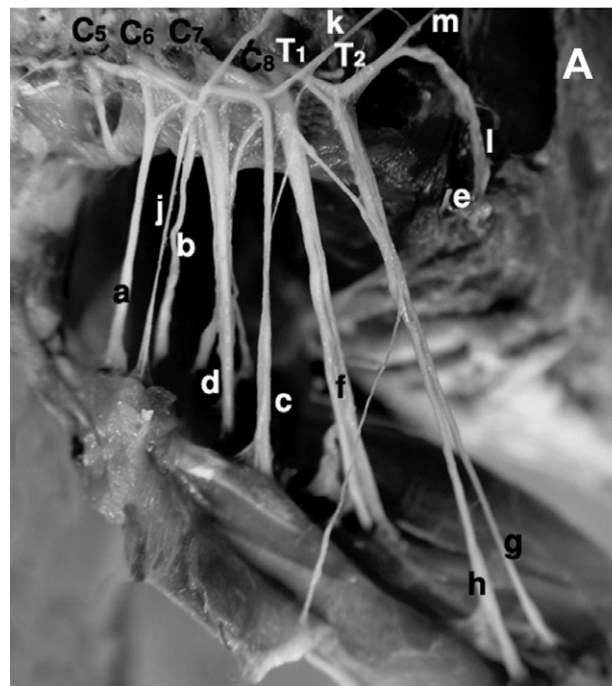


Fig. 2: A, Medial view of the left brachial plexus in the chinchilla. C5: caudal branch of *ramus ventralis* of C5, C6: *ramus ventralis* of C6, C7: *ramus ventralis* of C7, C8: *ramus ventralis* of C8, T1: *ramus ventralis* of T1, T2: *ramus ventralis* of T2; a: suprascapular nerve, b: subscapular nerve, c: musculocutaneous nerve, d: axillary nerve, e: cranial pectoral nerve, f: radial nerve, g: ulnar nerve, h: median nerve, j: subclavius nerve, k: long thoracic nerve, l: lateral thoracic nerve, m: caudal pectoral nerve.

B, Drawing of the left medial view of brachial plexus in the chinchilla. C5: caudal branch of *ramus ventralis* of C5, C6: *ramus ventralis* of C6, C7: *ramus ventralis* of C7, C8: *ramus ventralis* of C8, T1: *ramus ventralis* of T1, T2: *ramus ventralis* of T2; a: suprascapular nerve, b: subscapular nerve, c: musculocutaneous nerve, d: axillary nerve, e: cranial pectoral nerve, f: radial nerve, g: ulnar nerve, h: median nerve, j: subclavius nerve, k: long thoracic nerve, l: lateral thoracic nerve, m: caudal pectoral nerve.

in rats¹⁹, and from C7, C8 and T1 in rabbits^{1,31}. This nerve obtains branches from all nerves from C5 to T2 in porcupines³. In chinchillas, it originates from C8, T1 and T2.

Similar to our findings, the median nerve arises from C7, C8 and T1 in rats^{5,19}, guinea pigs⁹, rabbits³¹ and other laboratory rodents²⁹.

The ulnar nerve originates from C7, C8

and T1 in rats^{5,19}; from the caudal trunk in porcupines³. However, in chinchillas (this study) and in New Zealand white rabbits³¹ it arises from T1 and T2.

Aydın³ reported that an undefined nerve originated from a point where a branch coming from the cranial trunk connected to the caudal trunk and innervated into the coracobrachial muscle in porcupines, whereas, in our study, it originated from C7, C8 and T1.

In conclusion, we have demonstrated the morphology of the brachial plexus and the distribution of its nerves. Nerves originating from the brachial plexus displayed some significant differences in chinchillas compared with rats, guinea pigs, rabbits, porcupines and other laboratory rodents. Although the brachial plexus consist of 2 or 3 trunks in these laboratory animals, a single trunk is formed by ventral rami of C5–C8, T1 and T2 in chinchillas.

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