

Macroanatomical features of brachial plexus and its branches in Günther's vole (*Microtus guentheri*)

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| Article Info | Abstract |
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| Article history: Received: 30 January 2020 Accepted: 12 August 2020 Available online: 15 December 2021 | In the present study the comprisal of brachial plexus and nerves springing from the brachial plexus in Günther's vole has been determined. Ten adult voles (five males and five females) were used in this study. Nerves comprising the brachial plexus and the nerves arising from brachial plexus in vole were dissected and the findings were saved. The brachial plexus of the vole was comprised of the ventral root of cervical (C) 5 th , 6 th , 7 th and 8 th and thoracic (T) 1 st spinal nerves. Also, the brachial plexus was consisted of three trunks including cranial (C5 th and C6 th), medial (C7 th) and caudal (C8 th and T1 st) trunks. <i>Nervus (n.) subclavius, n. suprascapularis, nervi (nn.) subscapularis, n. axillaris, n. musculocutaneus, n. thoracodorsalis, nn. pectorales craniales, n. pectorales caudales, n. thoracicus lateralis, n. thoracicus longus, n. ulnaris, n. medianus, and n. radialis</i> were determined to be arising from brachial plexus. In conclusion, macroanatomical features of brachial plexus and its branches in Günther's vole have been determined. It is thought that the findings will contribute to neuroanatomy of the rodents. |
| Keywords: Anatomy Brachial plexus Peripheral nerves Rodents Vole | |

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Introduction

Günther's vole (*Microtus guentheri*) is one of the subspecies of the family Muridae of the order Rodentia. This vole appears from the south-east Balkans and Turkey through Syria, Lebanon and Israel to northern Libya.¹

The brachial plexus is a neural net comprised of the ventral radices of the cervical (C) 5th, 6th, 7th and 8th and thoracic (T) 1st spinal nerves in rat.² Cook has reported that the brachial plexus is originated by ventral radices of C5, C6, C7, C8 and T1 spinal nerves in the mouse.³ The nerves arise from the brachial plexus by naming *n. subclavius, n. suprascapularis, nn. subscapulares, n. axillaris, n. musculocutaneus, n. thoracodorsalis, nn. pectorales craniales, nn. pectorales caudales, n. thoracicus lateralis, n. thoracicus longus, n. ulnaris, n. medianus and n. radialis*.⁴

Although the researches⁵⁻⁸ performed on the brachial plexus in various domestic and wild animals were found in the literature review, a study related to vole was not found. Thus, it was aimed to detect the macroanatomical features of the brachial plexus and its branches in Günther's vole to contribute for comparative anatomy of rodents.

Materials and Methods

The permission for the study was taken from the Local Ethics Committee of Animal Experiments of Burdur Mehmet Akif Ersoy University, Burdur, Turkey (Date: 15.05.2019; Decision No.: 517). Ten adult voles, five males and five females, were used in the study. In the study, no traps were set up for the animals. The animals used in the study were collected dead after field toxic spraying within the scope of agricultural struggle of local government; so, the animals were not euthanized. As soon as the cadavers of voles were collected, they were fixed. The fixation was made by a small incision to the thoracic and abdominal cavities and the cadavers were kept in a container filled with 10.00% formaldehyde solution for 48 hr at room temperature. The nerves were dissected under the stereomicroscope (Leica S6D, Leica Microsystems Turkey) and then, their findings were noted. At the same time, brachial plexus and its branches were photographed via the same microscope. *Nomina Anatomica Veterinaria* was used for terminological nomenclature.⁹

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Results

In the study, it was observed that ventral radices of C5th, C6th, C7th, C8th and T1st spinal nerves in all specimens participate in the formation of brachial plexus (Fig. 1). Also, the brachial plexus was made by cranial, medial and caudal trunks. The cranial trunk was comprised of the ventral roots of C5th - C6th, the medial trunk was C7th and the caudal trunk was C8th - T1st spinal nerves. The nerves leaving brachial plexus in vole were determined as *n. subclavius*, *n. suprascapularis*, *nn. subscapulares*, *n. axillaris*, *n. musculocutaneus*, *n. thoracodorsalis*, *nn. pectoralis craniales*, *nn. pectoralis caudales*, *n. thoracicus lateralis*, *n. thoracicus longus*, *n. ulnaris*, *n. medianus* and *n. radialis* (Figs. 2 and 3). There was no difference between the sexes and antimers in terms of the composition of brachial plexus and its branches.

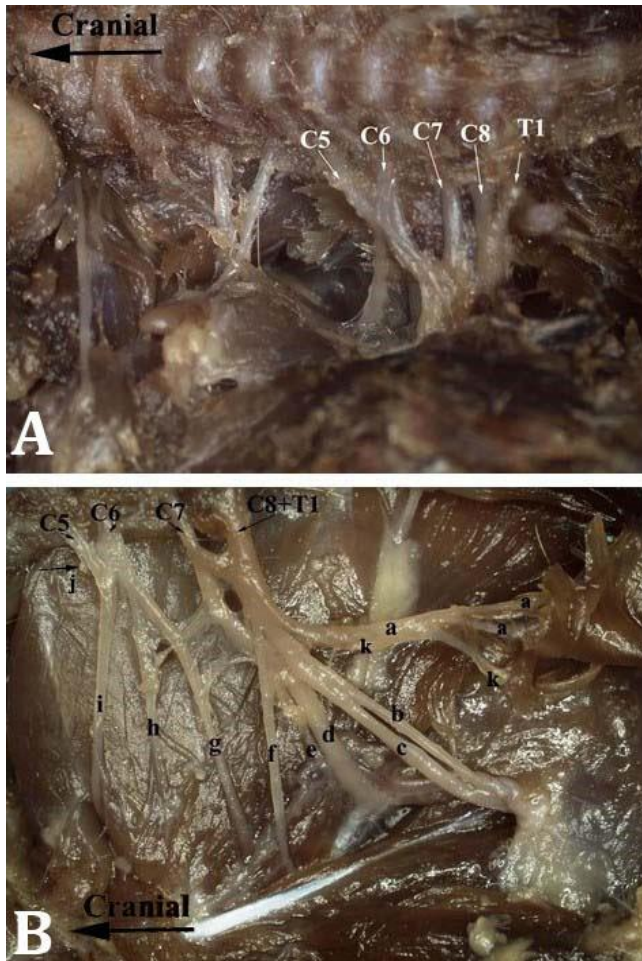


Fig. 1. Medial view of the right brachial plexus. **A)** C5, C6, C7 and C8: 5th, 6th, 7th and 8th ventral radices of the cervical spinal nerve, respectively; T1: 1st ventral radices of the thoracic spinal nerve; **B)** a: *nn. pectorales caudales*; b: *n. ulnaris*; c: *n. medianus*; d: *n. radialis*; e: *n. musculocutaneus*; f: *n. thoracodorsalis*; g: *n. axillaris*; h: *nn. Subscapulares*; i: *n. suprascapularis*; j: *n. subclavius*; k: *n. thoracicus longus*.

The *n. subclavius* was comprised of the ventral roots of C5th and C6th spinal nerves (Fig. 1). This nerve passed through the mid-level of the *margo cranialis* on the *facies lateralis* of the scapula and dispersed into the *musculus (m.) brachiocephalicus* and *m. cutaneus omobrachialis* at the level of shoulder region.

The *n. suprascapularis* was generated by the ventral radices of C5th and C6th spinal nerves (Fig. 1). This nerve innervated the *m. suprascapularis*. The *nn. subscapulares* were consisted of the ventral radices of C6th and C7th spinal nerves (Fig. 1). This nerve dispersed in *m. subscapularis*.

The *n. axillaris* was consisted of the ventral radices of C6th and C7th spinal nerves (Fig. 2). This nerve stimulated the *m. teres major*, *m. teres minor* and *m. deltoideus*.

The *n. thoracodorsalis* was comprised of the ventral radices of C7th and C8th spinal nerves and disrupted in *m. latissimus dorsi* (Fig. 1).

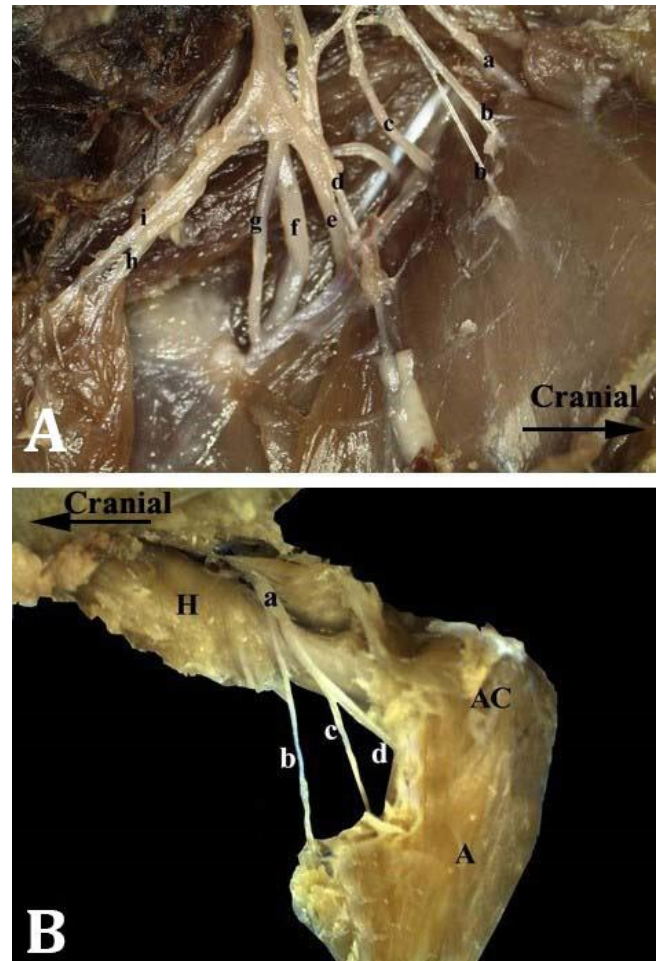


Fig. 2. Lateral view of the right brachial plexus (A) and left limb (B). **A)** a: *n. suprascapularis*; b: *nn. Subscapulares*; c: *n. axillaris*; d: *n. thoracodorsalis*; e: *n. radialis*; f: The common trunk of *n. ulnaris* and *n. medianus*; g: *n. musculocutaneus*; h and i: *nn. pectorales caudales*. **B)** H: Humerus; A: Antebrachium; AC: art. cubiti; a: *n. radialis*; b: r. superficialis of *n. radialis*; c and d: r. profundus of *n. radialis*.

The *n. thoracicus lateralis* was made up of the ventral radices of C8th and T1st spinal nerves and dispersed in the cutaneous muscles of the shoulder area. The *n. thoracicus longus* was made of the ventral radices of C8th and T1st spinal nerves (Fig. 1) and ended in *m. serratus ventralis thoracis*.

The *nn. pectorales craniales* were comprised of the ventral radices of C6th spinal nerve and innervated the pectoral muscles as two nerves. The *nn. pectorales caudales* were made of the ventral radix of C8th and T1st spinal nerves and innervated the *m. cutaneus trunci* and *m. pectoralis ascendens* (Fig. 2).

The *n. musculocutaneus* was based on the ventral radices of C7th and C8st spinal nerves (Fig. 1), supplying the muscles of *m. biceps brachi*.

The *n. radialis* was found to be comprised of the ventral radices of C7th, C8th and T1st spinal nerves (Fig. 1). It gave a branch to the *m. triceps brachi* in the middle third of the humerus and it gave another branch to the *m. brachialis* at this level. Then, this nerve separated into two branches including *ramus (r.) superficialis* and *r. profundus* (Fig. 2).

The *r. superficialis* proceeded just below the forelimb skin and the continuation of this branch shaped *n. digitalis dorsalis communis I, II, III* and *IV*, innervating lateral surface of the fingers. The *r. profundus* was divided into two branches. One of them moved into the craniolateral part of the *articulatio (art.) cubiti* and innervated the skin fields and the other branch dispersed in the fascia and skin on the lateral area of the antebrachium.

The *n. ulnaris* was comprised of the ventral radices of C7th, C8th and T1st spinal nerves (Fig. 1). It left from the median nerve at the mid 1/3 level of humerus (Fig. 2). This nerve gave a branch to *m. triceps brachi* at the distal level of humerus, entered the flexor muscles in the medial level of olecranon and gave a branch to flexor muscles. The *N. ulnaris* gave further branch to the flexor muscles at the top of the antebrachium; then, it was divided into two branches as lateral and medial branches. The lateral branch ends at the level of dorsolateral of *articulationes (artt.) carpa*. The medial branch was divided into two branches; one of them that was thicker ends at the palmar level of fourth and fifth fingers and the other one ends at the palmar level of the *artt. carpea*.

The *n. medianus* was comprised of the ventral radices of C7th, C8th and Tst spinal nerves (Fig. 1). This nerve was moving from craniomedial level of the *art. cubiti* to distal level of the front leg. The *n. medianus* gave a branch for flexor muscles of carpus and digits at the level of *art. cubiti* and immediately after this branch, gave another branch for the same muscle groups (Fig. 3). The *n. medianus* was divided into three branches at the palmar level of antebrachium. The branches were named as *n. digitalis palmaris communis I, II* and *III* from medial to lateral level, respectively (Fig. 3). These branches end at palmar level of the first, second and third digits, respectively.

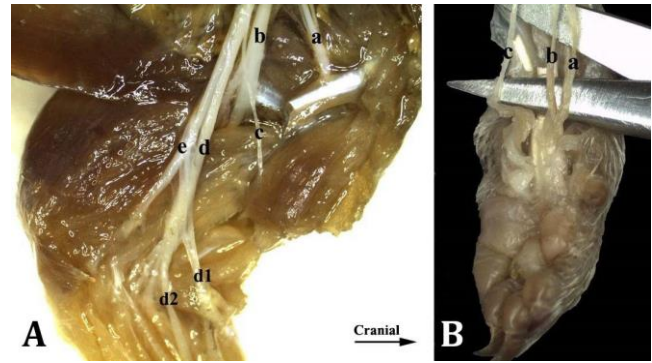


Fig. 3. Medial view of the distal third of the right forelimb and distal branches of the *n. medianus*. **A)** a: *n. axillaris*; b: *n. radialis*; c: *n. musculocutaneus*; d: *n. medianus*; d1 and d2: *r. muscularis* of *n. medianus*; e: *n. ulnaris*. **B)** a: *n. digitalis palmaris communis I*; b: *n. digitalis palmaris communis II*; c: *n. digitalis palmaris communis III*.

Discussion

The morphology of brachial plexus has been investigated in a wide range of some species in terms of comparative anatomy and to contribute phylogenetic standards.^{8,10-16} At the same time, it has been notified that the constitution of the brachial plexus is different in some rodents. The brachial plexus is comprised of the ventral radices of C5th, C6th, C7th, C8th, T1st and T2nd spinal nerves in rat,¹⁷ chinchilla¹⁸ and guinea pigs¹⁹ as well as C4th, C5th, C6th, C7th, C8th, T1st and T2nd in Wistar rat;²⁰ but, in other studies, the constitution of brachial plexus was different in rat,² mouse,³ and mole rat⁷ comprising of the ventral radices of C5th, C6th, C7th, C8th and T1st spinal nerves. Similarly, in this study, the brachial plexus of vole is composed by *rami ventralis* of C5th, C6th, C7th, C8th and T1st spinal nerves as it was indicated in rodents (rat, mole rat and mouse). In general, the changes of composition, position and shape of brachial plexus depend on the relationship of muscle and nerve providing coordination of muscle movement.²¹

In this study, *n. subclavius*, *n. suprascapularis*, *nn. subscapulares*, *n. axillaris*, *n. musculocutaneus*, *n. thoracodorsalis*, *nn. pectoralis craniales*, *nn. pectoralis caudales*, *n. thoracicus lateralis*, *n. thoracicus longus*, *n. ulnaris*, *n. medianus* and *n. radialis* were found to be arising from the brachial plexus. According to the results, all nerves were found in vole brachial plexus as indicated in the literature.^{5,9} Also, *n. phrenicus* was found to consist of the ventral radices of C5th, C6th and C7th spinal nerves in chinchilla,¹⁸ the ventral radices of C5th - C6th in mole rat⁷ and New Zealand rabbit,²² innervating the diaphragm in these animals.^{7,18,22}

The brachial plexus in vole is consisted of three trunks similar to rat;²³ but, in rabbits,²² squirrels²⁴ and porcupine⁶ it is comprised of cranial and caudal trunks and in mole rat⁷ it is comprised of one trunk.

The *n. suprascapularis* emerged from *rami ventralis* of C5th and C6th spinal nerves in vole as well as in New Zealand rabbit,⁵ porcupines,⁶ chinchillas,¹⁸ and guinea pigs.¹⁹

Despite the fact that the *nn. subscapulares* sprang from ventral radices of C5th and C6th in porcupines,⁶ C5th - C6th (upper subscapular nerve) and C7th (lower subscapular nerve) in Wistar rat²⁰ and C7th in New Zealand rabbit,⁵ they sprang from C6th and C7th in vole. Like vole, this nerve dispersed in the *m. subscapularis* in chinchilla.¹⁸

While *n. axillaris* was consisted of the ventral radices of C7th and C8th in guinea pigs¹⁹ and C4th, C5th and C6th in Wistar rat,²⁰ the *n. axillaris* was consisted of the ventral radices of C6th and C7th spinal nerves in rat¹⁷ and chinchilla,¹⁸ similar to vole.

Tareq Mussa *et al.*,²² have emphasized that *nn. pectorales caudales* and *n. thoracicus lateralis* were comprised of the ventral radices of caudal trunk (C7th, C8th, T1st and T2nd) of brachial plexus. Also, *nn. pectorales caudales* arise from the caudal trunk in porcupines⁶ and from the ventral radix of T1st and T2nd spinal nerves in chinchilla.¹⁸ Aslan has reported that *n. thoracicus longus* springs from the ventral radix of C8th only in New Zealand rabbit.⁵ The *n. thoracicus lateralis* was originated from the ventral radices of C6th, C7th, C8th and T1st in rats¹⁷ and guinea pigs.¹⁹ But, in this study, *n. thoracicus lateralis*, *n. thoracicus longus* and *nn. pectorales caudales* were formed by the ventral radix of C8th and T1st spinal nerves in vole.

The *nn. pectorales craniales* were comprised of the ventral radix of the C7th, C8th, T1st and T2nd spinal nerves in chinchilla¹⁸ and C7th and C8th in New Zealand rabbit,⁵ but, in vole, they were formed only by the ventral radix of C6th spinal nerve.

The *n. thoracodorsalis* arose from the ventral radices of C6th and C7th spinal nerves in rat,¹⁷ from C8th spinal nerve in New Zealand rabbit⁵ and chinchilla¹⁸ and from C7th in Wistar rat.²⁰ Being different in vole, this nerve emerged

from the ventral radix of C7th and C8th. Similar to vole, this nerve innervated the *m. latissimus dorsi* in chinchilla¹⁸ and marten.⁸

The *n. radialis* arose from the ventral radix of C7th, C8th and T1st spinal nerves in New Zealand rabbit,⁵ like vole. It coursed from the medial level to *facies lateralis* of antebrachium and dispersed in the *m. anconeus*, *m. triceps brachii*, *m. brachialis*, *m. tensor fasciae antebrachii*, *m. supinators*, extensor muscles of carpus and digits, craniolateral skin of the antebrachium and dorsolateral surface of the digits.²⁵ In this study, the findings of the regions of innervating area of *n. radialis* were similar to the other rodents.²⁵

The common trunk of *n. medianus* and *n. ulnaris* reached to the *art. humeri* and at this joint, the *n. medianus* extended to the joint of olecranon and dispersed in flexor muscles. At the olecranon joint, *n. ulnaris* changed its course and innervated flexor and digit muscles and skin of the palmar and lateral faces of the digits.²⁵ In chinchilla,¹⁸ the *n. medianus* innervated the flexor muscles of the carpus and digits and the *n. ulnaris* dispersed in the *m. flexor carpi radialis*, *m. flexor carpi ulnaris* and *m. flexor digitorum*. In this study, as reported in the literature,²⁵ *n. medianus* and *n. ulnaris* extended to the *art. humeri* as a common trunk and the courses of *n. medianus* and *n. ulnaris* were similar. The *n. medianus* innervated the flexor muscles of the carpus and digits in vole, like the findings of literature.^{18,25}

The contribution of brachial plexus and its branches in some species is compared to the vole in Table 1. According to Table 1, it was seen that the contribution of *n. ulnaris* and *n. medianus* in vole was similar to the rat and guinea pig;²⁵ but, *n. radialis* contribution in vole was different from other species as indicated in Table 1.

Consequently, the nerves of the brachial plexus in the vole were dissected and the findings were recorded in this study. Also, the study had some limitations. The manipulation was difficult because the voles were too small.

Table 1. The contribution of brachial plexus and its branches in some species.

| Nerve | Vole | Rat | Chinchilla | Guinea pig | Red squirrel | Cavy |
|---------------------------------|---------------|-------------------------|-----------------------|---------------|-----------------------|----------------|
| Reference No. | Current study | 25 | 18 | 25 | 24 | 26 |
| Plexus brachialis | C5- C8, T1 | C5-C8, T1 | C5-C8, T1, T2 | C5-C8, T1, T2 | C5- C8 | C6-C8, T1, T2 |
| <i>N. subclavius</i> | C5, C6 | - | C5, C6 | - | - | - |
| <i>N. suprascapularis</i> | C5, C6 | C5, C6 | C5, C6 | C5, C6 | C5, C6 | C6, C7 |
| <i>Nn. subscapulares</i> | C6, C7 | C5, C6, C7 | C6, C7 | C5, C6, C7 | C5, C6 | C6, C7 |
| <i>N. axillaris</i> | C6, C7 | C6, C7 or C5, C6-C8, T1 | C6, C7 | C7, C8 | C5, C6 | C6, C7 |
| <i>N. thoracodorsalis</i> | C7, C8 | C6, C7 | C8 | C6, C7 | C7, C8 | C7, C8, T1, T2 |
| <i>N. thoracicus lateralis</i> | C8, T1 | C6-C8, T1 | T1, T2 | C6- C8, T1 | - | C7, C8, T1, T2 |
| <i>N. thoracicus longus</i> | C8, T1 | C6, C7, C8 | C6, C7 or C7 or C6-C8 | C7, C8, T1 | C7, C8 | C7, C8 |
| <i>Nn. pectorales craniales</i> | C6 | C5, C6 | C7, C8, T1, T2 | | C5 | C6, C7 |
| <i>Nn. pectorales caudales</i> | C8, T1 | C7 | T1, T2 | | C7, C8 (caudal trunk) | C7, C8 |
| <i>N. musculocutaneus</i> | C7, C8 | C5-C7 or C6, C7 | C7 | | C5 | C7, C8 |
| <i>N. radialis</i> | C7, C8, T1 | C6- C8 | C8, T1, T2 | | C7, C8 | C7, C8, T1, T2 |
| <i>N. ulnaris</i> | C7, C8, T1 | C7, C8, T1 | T1, T2 | C7, C8, T1 | C7, C8 | C7, C8, T1, T2 |
| <i>N. medianus</i> | C7, C8, T1 | C7, C8, T1 | C7, C8, T1 | C7, C8, T1 | C5, C7, C8 | C7, C8, T1, T2 |

C5, C6, C7, and C8: Ventral radices of 5th, 6th, 7th and 8th cervical spinal nerves, respectively; T1 and T2: Ventral radices of 1st and 2nd thoracic spinal nerves, respectively.

The nerves innervated the forelimb could be examined under a stereomicroscope; but, the nerves were very thin. So, the distal branches of the nerves could not be photographed with the reason of ruptures. Despite all limitations, it is thought that the findings will contribute to wild animal medicine and the brachial plexus formation in rodents.

Conflict of interest

No conflicting interests and no funding in connection with this paper are applicable.

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