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

Abstract

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) 5th, 6th, 7th and 8th and thoracic (T) 1st spinal nerves. Also, the brachial plexus was consisted of three trunks including cranial (C5th and C6th), medial (C7th) and caudal (C8th and T1st) trunks. Nervus (n.) subclaviius, 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 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.

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. subclaviius, 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).

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. cutaneous 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).
The **n. thoracicus lateralis** was made up of the ventral radicles 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 C8th 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 palmaris 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 the **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.) carpaee**. 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. carpeae**.

The **n. medianus** was comprised of the ventral radices of C7th, C8th and T1st 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; 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](image)

**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 ventrales** 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. subclavious, 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 rat2 and New Zealand rabbit,22 innervating the diaphragm in these animals.7,10,22

The brachial plexus in vole is consisted of three trunks similar to rat;23 but, in rabbits,24 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 C5<sup>th</sup> and C6<sup>th</sup> spinal nerves in vole as well as in New Zealand rabbit, porcupines, chinchillas, and guinea pigs. 

Despite the fact that the *nn. subscapulares* sprang from ventral radices of C5<sup>th</sup> and C6<sup>th</sup> in porcupines, C5<sup>th</sup> - C6<sup>th</sup> (upper subscapular nerve) and C7<sup>th</sup> (lower subscapular nerve) in Wistar rat and C7<sup>th</sup> in New Zealand rabbit, they sprang from C6<sup>th</sup> and C7<sup>th</sup> in vole. Like vole, this nerve dispersed in the *m. subscapularis* in chinchilla.

While *n. axillaris* was consisted of the ventral radices of C7<sup>th</sup> and C8<sup>th</sup> in guinea pigs and C4<sup>th</sup>, C5<sup>th</sup> and C6<sup>th</sup> in Wistar rat, the *n. axillaris* was consisted of the ventral radices of C6<sup>th</sup> and C7<sup>th</sup> spinal nerves in rat and chinchilla, similar to vole.

Tareq Mussa et al. have emphasized that *nn. pectorales caudales* and *n. thoracicus lateralis* were comprised of the ventral radices of caudal trunk (C7<sup>th</sup>, C8<sup>th</sup>, T1<sup>st</sup> and T2<sup>nd</sup>) of brachial plexus. Also, *nn. pectorales caudales* arise from the caudal trunk in porcupines and from the ventral radix of T1<sup>st</sup> and T2<sup>nd</sup> spinal nerves in chinchilla. Aslan has reported that *n. thoracicus longus* springs from the ventral radix of C8<sup>th</sup> only in New Zealand rabbit. The *n. thoracicus lateralis* was originated from the ventral radices of C6<sup>th</sup>, C7<sup>th</sup>, C8<sup>th</sup> and T1<sup>st</sup> in rats and guinea pigs. But, in this study, *n. thoracicus lateralis, n. thoracicus longus* and *nn. pectorales caudales* were formed by the ventral radix of C8<sup>th</sup> and T1<sup>st</sup> spinal nerves in vole.

The *nn. pectorales craniales* were comprised of the ventral radix of the C7<sup>th</sup>, C8<sup>th</sup>, T1<sup>st</sup> and T2<sup>nd</sup> spinal nerves in chinchilla and C7<sup>th</sup> and C8<sup>th</sup> in New Zealand rabbit, but, in vole, they were formed only by the ventral radix of C6<sup>th</sup> spinal nerve.

The *n. thoracodorsalis* arose from the ventral radices of C6<sup>th</sup> and C7<sup>th</sup> spinal nerves in rat from C8<sup>th</sup> spinal nerve in New Zealand rabbit and chinchilla and from C7<sup>th</sup> in Wistar rat. Being different in vole, this nerve emerged from the ventral radix of C7<sup>th</sup> and C8<sup>th</sup>. Similar to vole, this nerve innervated the *m. latissimus dorsi* in chinchilla and marten.

The *n. radialis* arose from the ventral radix of C7<sup>th</sup>, C8<sup>th</sup> and T1<sup>st</sup> spinal nerves in New Zealand rabbit like vole. It coursed from the medial level to *facies lateralis* of antebrachium and dispersed in the *m. anconeus, m. triceps brachi, m. brachialis, m. tensor fascia antebrachii, m. supinators*, extensor muscles of carpus and digits, cranialateral skin of the antebrachium and dorsolateral surface of the digits. In this study, the findings of the regions of innervating area of *n. radialis* were similar to the other rodents.

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. In chinchilla, 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, *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.

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, 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 |
|------------------------|-----------------|------------------|------------|------------|--------------|------|
| Plexus brachialis      | C5-C8, T1       | C5-C8, T1, T2    | C5-C8, T1, T2 | C5-C8, T1, T2 | C5-C8       | C6-C8, T1, T2 |
| N. subclavius          | C5, C6          | -                | C5, C6     | C5, C6     | -            | -    |
| N. suprascapularis     | C5, C6          | C5, C6           | C5, C6     | C5, C6     | C5, C6       | C6, C7 |
| Nn. subscapulares      | C6, C7          | C5, C6, C7       | C6, C7     | C5, C6, C7 | C5, C6       | C6, C7 |
| N. axillaris           | C6, C7          | C6, C7 or C5, C6-C8, T1 | C6, C7     | C7, C8     | C5, C6       | C6, C7 |
| N. thoracodorsalis     | C7, C8          | C6, C7           | C8         | C6, C7     | C7, C8       | C7, C8, T1, T2 |
| N. thoracicus lateralis| C8, T1          | C6-C8, T1        | T1, T2     | C6-C8, T1  | -            | C7, C8, T1, T2 |
| N. thoracicus longus   | C8, T1          | C6, C7, C8       | C6, C7 or C7 or C6-C8 | C7, C8, T1, T2 | C7, C8      | C7, C8 |
| Nn. pectorales craniales| C6              | C5, C6           | C7, C8, T1, T2 | C5         | C6          | C7, C6 |
| Nn. pectorales caudales| C8, T1          | C7               | T1, T2     | C7, C8 (caudal trunk) | C7         | C8 |
| N. musculocutaneus     | C7, C8          | C5-C7 or C6-C7   | C7         | C5         | C7, C8       | C7, C8 |
| N. radialis            | C7, C8, T1      | C6-C8            | C8, T1, T2 | C7, C8     | C7, C8, T1, T2 | C7, C8, C8, T1, T2 |
| N. ulnaris             | C7, C8, T1      | C7, C8, T1       | T1, T2     | C7, C8, T1 | C7, C8       | C7, C8, T1, T2 |
| N. medianus            | C7, C8, T1      | C7, C8, T1       | C7, C8, T1 | C5, C7, C8 | C7, C8, T1, T2 | C7, C8, C8, T1, T2 |

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

References

1. Yiğit N, Çolak E, Sözen M, et al. Rodents of Turkey [Turkish]. Ankara, Turkey: Meteksan Publishing House 2006; 154.
2. Uzun A, Cengiz N, Kavakli A, et al. Morphological and microscopical examination of the rat brachial plexus [Turkish]. Turk J Vet Anim Sci 2001; 25(3): 397-402.
3. Cook MJ. The anatomy of the laboratory mouse. London, UK: Academic Press; 1965; 20-143.
4. König HE, Liebich HC. Veterinary anatomy of domestic mammals. Textbook and colour atlas. 6th ed. Stuttgart, Germany: Shattauer, 2014; 542.
5. Aslan K. The comparative macroanatomical investigation on the brachial plexus of the native cat (Felis domestica) and White New Zealand Rabbit (Oryctolagus cuniculus) [Turkish]. Istanbul Univ Vet Fak Derg 1994; 20: 197-208.
6. Aydin A. Nerves originating from brachial plexus in the porcupine (Hystrix cristata). Vet Med – Czeh 2004; 49(4): 123-128.
7. Aydin A, Karan M. The spinal nerves forming the brachial plexus in mole rats (Spalax leucodon). Vet Med (Praha) 2012; 57(8): 430-433.
8. Demiraslan Y, Aykut M, Özgül Ö. Macroanatomical characteristics of plexus brachialis and its branches in martens (Martes foina). Turk J Vet Anim Sci 2015; 39(6): 693-698.
9. Nomina anatomica veterinaria. International committee on veterinary gross anatomical nomenclature (ICVGAN). Ghent, Belgium: World Association of Veterinary Anatomists (WAVA). 2017; 118-148.
10. Santos-Sousa CA, Gomes MS, Da Cruz De Carvalho N, et al. Origin and antimeric distribution of brachial plexus nerves in Macaca mulatta (Zimmermann, 1780) (Primates: Cercopithecidae). Ital J Zool (Modena) 2016; 83(4): 469-481.
11. Aydin A. Brachial plexus of the porcupine (Hystrix cristata). Vet Med – Czech 2003; 48(10): 301-304.
12. Mohiuddin M, Rahman ML, Alim MA, et al. Macro anatomical investigation of brachial plexus of the White New Zealand Rabbit (Oryctolagus cuniculus). Int J Nat Sci 2011; 1(3): 74-76.
13. Özdemir V, Bahar S, Tiprardamaz S. Subgross and morphometric formation of the brachial plexus in Balb/c mice. Indian Vet J 2005; 18: 1193-1195.
14. Santos AP, Suaid CA, Fazan VPS, et al. Microscopic anatomy of brachial plexus branches in Wistar rats. Anat Rec (Hoboken) 2007; 290(5): 477-485.
15. Mencalha R, Sousa CA, Costa O, et al. Ultrasound and gross anatomy of the brachial plexus and major nerves of the forelimb. An anesthetic approach using the domestic rabbit (Oryctolagus cuniculus) as an experimental model. Acta Cir Bras 2016; 31(4): 218-226.
16. Reichert P, Kielbowicz Z, Dziękiewicz P, et al. The rabbit brachial plexus as a model for nerve repair surgery - histomorphometric analysis. Anat Rec (Hoboken) 2015; 298(2): 444-454.
17. Greene EC. Anatomy of the rat. Transactions of the American Philosophical Society. New York, USA: Hafner Pub 1935; 115-177.
18. Çevik-Demirkarakağ, Özdemir V, Demirkan I, et al. Gross morphological features of plexus brachialis in the chinchilla (Chinchilla lanigera). J Afr Vet Assoc 2007; 78(1): 21-24.
19. Cooper G, Schiller AL. Anatomy of the guinea pig. Massachusetts, USA: Harvard University Press 1975; 155-205.
20. Angélica -Almeida M, Casal D, Mafra M, et al. Brachial plexus morphology and vascular supply in the Wistar rat. Acta Med Port 2013; 26(3): 243-350.
21. Miller RA, Detwiler SR. Comparative studies upon the origin and development of the brachial plexus. Anat Rec 1936; 65(3): 273-292.
22. Tareq Mussa MD, Bhownik S, Liaquat Ali MD, et al. Origin and distribution of brachial plexus of white New Zealand rabbit (Oryctolagus cuniculus). Malays J Vet Res (Putrajaya) 2016; 7(1): 53-64.
23. Bertelli JA, Mira JC, Gilbert A, et al. Anatomical basis of rat brachial plexus reconstruction. Surg Radiol Anat 1992; 14(1): 85-86.
24. Aydin A. The spinal nerves that constitute the brachial plexus in the red squirrel (Sciurus vulgaris). Vet Med (Praha) 2011; 56(8): 405-408.
25. Martinez-Pereira MA, Maria Zancan D. Comparative anatomy of the peripheral nerves. In: Tubbs RS, Rizk E, Shoa MA, et al. (Eds). Nerves and Nerve Injuries: Vol 1: History, Embryology, Anatomy, Imaging and Diagnostics.1st ed. Oxford, UK: Academic Press 2015; 62-65.
26. Araujo JRHN, Oliveira GB, Silva AVN, et al. Origin and distribution of the brachial plexus in the Spix's yellow-toothed cavy (Galea spixii Wagler, 1831) (Rodentia caviidae). Vet Med (Praha) 2016; 61(6): 337-343.