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Macroanatomical Investigation of the Cervicothoracic Ganglion in Roe Deer, *Capreolus capreolus*

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Abstract.- The article provides anatomic information about cervicothoracic ganglion in roe deer. For this purpose 12 cervicothoracic ganglia obtained from the right and left sides of 6 mature roe deer weighing 18-25 kg of both sexes were investigated. Cervicothoracic ganglion was located at the first intercostal space and ventrolateral side of longus colli muscle. This ganglion which was in various forms such as triangle, spindle and reverse L and was in connection with eighth cervical (C8) and first two thoracal spinal (T1, T2) nerves by communicating branches (rami communicantes). In all roe deer, there were two communicating branches lying from ventral rami of first thoracal spinal nerve to cervicothoracic ganglion. The major nerves leaving from the cervicothoracic ganglion were vertebral nerve, two branches forming subclavian ansa (cranial and caudal branches) and thin nerve branches originating from the caudodorsal and caudoventral sides of ganglion. Caudal branch forming subclavian ansa gave nerve branches to vagus nerve. In totally four structures, middle cervical ganglion were detected on the place where cranial and caudal branches of subclavian ansa were combined**.** Nerve branches diverging from the caudodorsal and caudoventral sides of cervicothoracic ganglion, especially as the branch or branches reached to the base of heart, gave branches to the neighboring main vessels during its course. In some cadavers, the mentioned branch was seperated from the caudal branch of subclavian ansa. This branch passed the right side of aorta and joined to cardiac plexus. In conclusion, although differences were observed in the investigated materials, general form and locational of cervicothoracic ganglion and nerve branches seperating from this ganglion was similar to those of other ruminants and especially goat.

Keywords: Anatomy, cervicothoracic ganglion, roe deer.

INTRODUCTION

Cervicothoracic ganglion takes part in most caudal part of cervical division of the symphathetic system (Getty, 1975). This ganglion is formed as a result of combination of caudal cervical ganglion and first (Pather *et al.*, 2006), sometimes second (Getty, 1975), third (Dursun, 2000) or fourth (Tecirlioğlu, 1983) thoracic sympathetic ganglia and is named as cervicothoracic ganglion. This ganglion is also stated as stellate ganglion and situated in the first intercostal space in general; and its shape differs among species, even individuals (Getty, 1975; Pather *et al.*, 2006; Ozgel *et al.*, 2009). Nerve branches disperse from cervicothoracic ganglion to ventral rami of the eighth cervical (C8), the first (T1) and second (T2) thoracal spinal nerves or to brachial plexus (Dursun, 2000; Pather *et al.*, 2006; Ozgel *et al.*, 2009; Song *et al.*, 2010). Some nerve branches are also extended to ventral rami of the sixth (C6) and seventh (C7) cervical spinal nerves (Pather *et al.*, 2006; Song *et al.*, 2010). Besides these branches, caudal vertebral cardiac nerves are separated from this ganglion as well as cranial and caudal branches which form subclavian ansa and vertebral nerve (Getty, 1975; Dursun, 2000; Pather *et al.*, 2006; Ozgel *et al.*, 2009; Kawashima and Thorington 2011). With all these nerve branches radiated out from cervicothoracic ganglion are made innervation of the neck, forelimb and organs in the chest region (Getty, 1975; Tecirlioğlu, 1983; Janes *et al.*, 1986; Kawashima and Thorington 2011). Some sympathetic nerve fibers that do not make synapse on cervicothoracic ganglion extend to cranial cervical ganglion responsible for sympathetic innervations of the head (Getty, 1975; Tecirlioğlu, 1983). Therefore, topographic anatomy of this ganglion and the branches dispersed from it should be known well. Especially, this requirement becomes more significant in applications such as

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thoracoscopic sympathectomy (Daniel, 1996). There are some studies about the cranial cervical ganglion in roe deer (Kabak and Onuk 2010; Düzler *et al.*, 2015). Absence of anatomic literature about localization, shape of cervicothoracic ganglion and nerve branches dispersing from the ganglion in roe deer was evaluated as a deficiency. With this study, to present anatomical information about topographic anatomy of cervicothoracic ganglion and the relation of this ganglion with sympathetic and parasympathetic nerves course on the same region and also to reveal similarities and differences that may be associated with the subject among other ruminants.

MATERIALS AND METHODS

Six adult roe-deer which have weight of 18-25 kg and not taken into account of gender formed the material of this study. They were brought to our faculty surgery clinic with different reasons such as firearm injuries or traffic accident and could not be saved. Roe deer were perfused by formalin. And then costae on the thoracic cavity were removed and totally 12 cervicothoracic ganglia on both sides were investigated by dissection. The dimensions of these ganglia were measured by calipers compass (Mitutoyo, Tokyo, Japan). Photographs were taken using an Olympus C-5060 digital camera. Nomina Anatomica Veterinaria (2012) was used for anatomic denomination.

RESULTS

Cervicothoracic ganglion (Figs. 1,2-a) was situated at the level first intercostal space, on the surface of longus colli muscle, esophagus on the left side and trachea on the right side. The length, width and thickness measurements and shape of cervicothoracic ganglion was showed in Table I. It was observed that the shape of the ganglion was variable like triangle, spindle and reverse "L" (Figs. 1, 2). The cervicothoracic ganglion was formed by the coalescence of last cervical and first two thoracic sympathetic ganglia in all roe deer. The communicating branches (rami communicantes) which separated from cervicothoracic ganglion were participated into ventral rami of eighth cervical (C8) (Figs. 1,2-b) and the first (T1) (Figs. 1,2-c) and second (T2) (Figs. 1,2-d) thoracal spinal nerve. These branches (rami communicantes) were generally 1 branch to ventral ramus of C8 (2 branches in one cadaver, 3 branches in the other cadaver), 2 branches to ventral ramus of T1 (in all cadavers) and 1 branch to ventral ramus of T1 (2 branches on right side of one cadaver).

It was determined that vertebral nerve (Figs. 1,2-e) was originated from craniodorsal side of the ganglion; the cranial branch (Figs. 1,2-f) which formed subclavian ansa was separated from cranioventral side of the ganglion; 1 or 2 thin nerve branches were diverged from caudodorsal (Figs. 1,2-g) and caudoventral (Figs. 1,2-h) sides of the ganglion. Besides these, there were also nerve branches which dispersed from caudal branch (Figs. 1,2-f') of subclavian ansa and from ventral side of the ganglion. These branches were linked to vagus nerve.

It was seen that vertebral nerve which was dispersed from craniodorsal side of the ganglion as a branch in all cadavers progressed with vertebral artery (Figs. 1,2-va); it took part in transverse foramen by forming a perivascular plexus around this vessel as well.

One or two thin nerve branches from caudodorsal side of cervicothoracic ganglion were distributed to trachea and esophagus. One or two thin nerve branches were diverged from caudoventral side of cervicothoracic ganglion. It was observed that this branch or branches were terminated on aortic arch, on the ganglion which located on the right and caudal side of aortic arch or on the plexus (Fig. 1-i) which situated on the origin of brachiocephalic trunk. Nerve branches originated from plexus the mentioned above were distributed to right auricle (Fig. 1-i'), ascending aorta and pericardium (Fig. 1-i''), brachiocephalic trunk, initiation of pulmonary trunk (Fig. 1-i''') and ligamentum arteriosum (Fig. 1-i''''). It was observed that nerve fibers which separated from the ganglion on the caudal side of aortic arch were formed a plexus with nerve fibers participated from vagus nerve as well as sympathetic nerve fibers coming from cervicothoracic ganglion and thoracic ganglion. It was determined that nerve fibers which provide innervation of the heart were dispersed from this plexus.

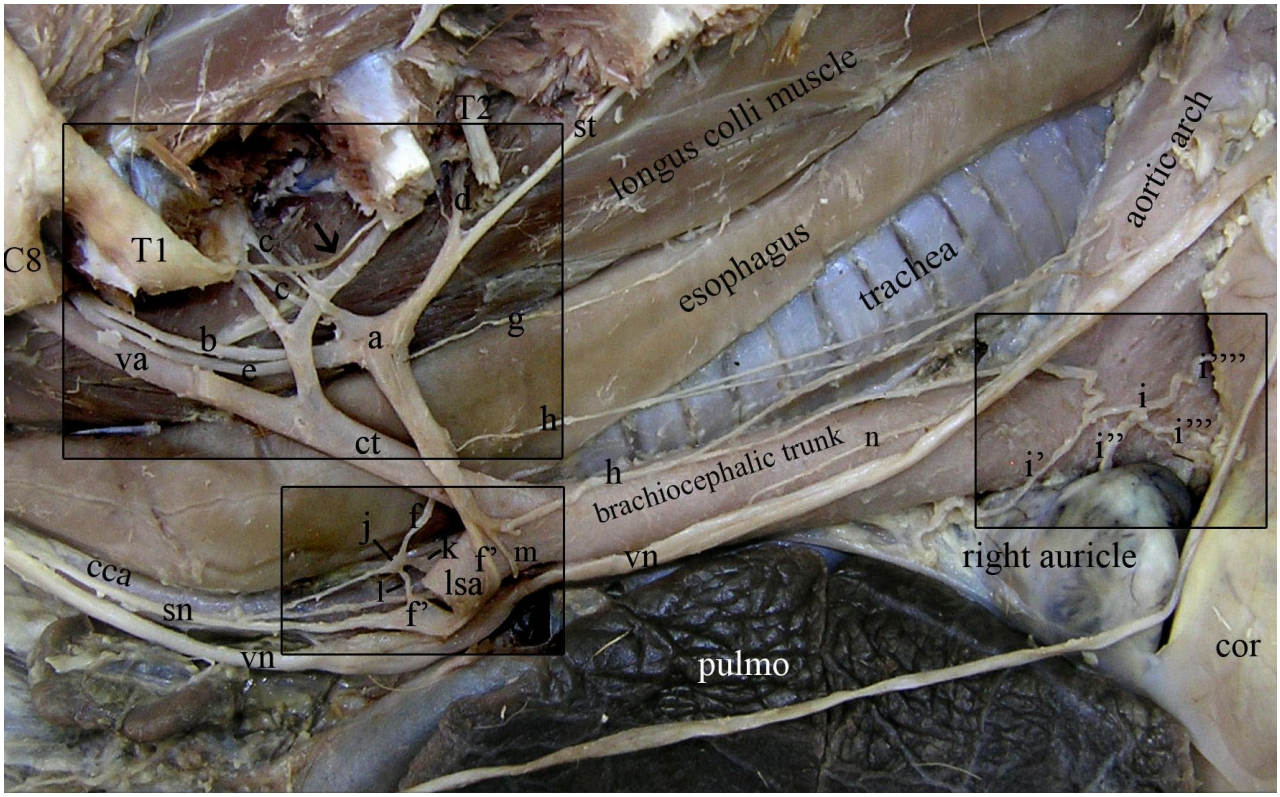


Fig. 1. View from left side of the cervicothoracic ganglion of roe deer.
a; cervicothoracic ganglion **b;** branch extended to C8 **c;** branches extended to T1 **d;** branch extended to T2 **e;** vertebral nerve **f;** cranial branch of subclavian ansa **f'**; caudal branch of subclavian ansa **g;** caudodorsal branch of cervicothoracic ganglion **h;** caudoventral branches of cervicothoracic ganglion **i;** branch that extended to brachiocephalic trunk and separating from caudoventral branch of cervicothoracic ganglion **i';** branch diverged to right auricula **i'';** branch extended to ascending aorta and pericardium **i''';** branch extended to initiation of pulmonary trunk **i'''';** branch separated to ligamentum arteriosum **j;** middle cervical ganglion **k:** branch separeted from middle cervical ganglion and participated into vagus nerve **l;** branch that separeted from middle cervical ganglion and extented to caudal branch of ansa **m;** branch that diverged from ventral side of cervicothoracic ganglion and participated into vagus nerve **n;** branch that started from vagus nerve and extended to aortic arch **sn;** sympathetic nerve **st;** sympathetic trunk **va;** vertebral artery **ct;** costocervical trunk **nv;** vagus nerve **lsa;** left subclavian artery **cca;** common carotid artery **C8;** ventral ramus of eighth cervical spinal nerve **T1**; ventral ramus of first thoracic spinal nerve **T2**; ventral ramus of second thoracic spinal nerve **arrow;** connections to branch between T1 and T2.

There were also different nerve branches diverging from cervicothoracic ganglion expect the mentioned above nerves. These nerves known as cranial and caudal branches of subclavian ansa were originated from cranioventral and ventral sides of cervicothoracic gangion, respectively. It was observed that caudal branch of subclavian ansa progressed through craniodorsal direction by covering subclavian artery on the right (Fig. 2-rsa) and left side (Figs. 1-lsa) and united with cranial branch of ansa which passes through medial side of costocervical trunk (Figs. 1,2-ct). These combined branches were formed sympathetic nerve (Figs. 1,2-sn). Middle cervical ganglion (Fig. 1-j) was encountered on the place where cranial and caudal branches of subclavian ansa combined. Both of these ganglia which were seen as four in total were on the right and two of them were on the left. It was determined that some branches ramified from middle cervical ganglion were connected with the vagus nerve (Figure 1-k) and caudal branch (Fig. 1-l) of the ansa. In addition to these branches, a branch (Fig. 1-m) diverged from ventral side of cervicothoracic ganglion was participated into vagus

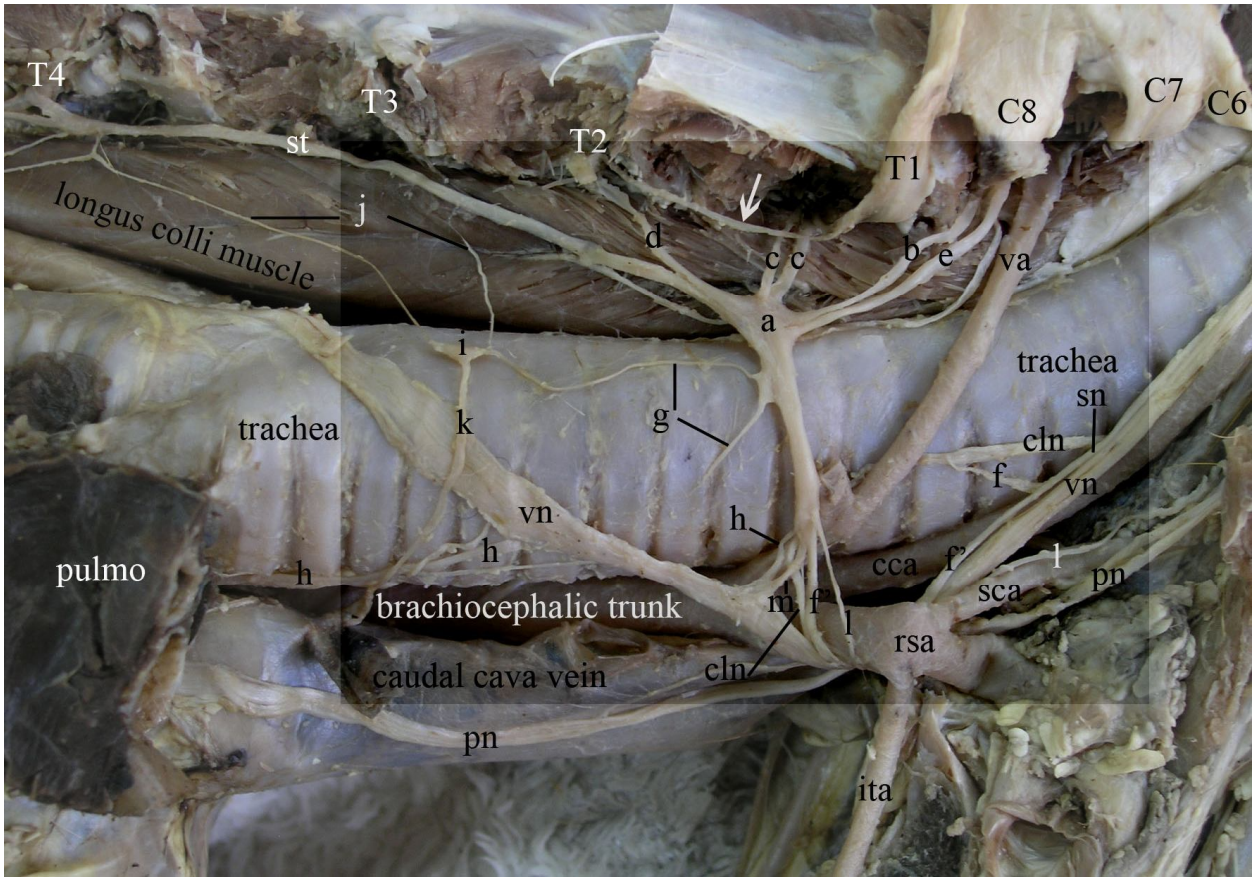


Fig. 2. View from right side of the cervicothoracic ganglion of roe deer.
a; cervicothoracic ganglion **b;** branch extended to C8 **c;** branches extended to T1 **d;** branch extended to T2 **e;** vertebral nerve **f;** cranial branch of subclavian ansa **f';** caudal branch of subclavian ansa **g;** caudodorsal branches of cervicothoracic ganglion **h;** caudoventral branch of cervicothoracic ganglion **i;** other ganglion **j;** branches coming from thirth and fourth thoracic ganglia **k;** branch diverged from other ganglion **l;** branch formed perivasculer plexus around right subclavian and superficial cervical arteries **sn;** sympathetic nerve **st;** sympathetic trunk **va;** vertebral artery **nv;** vagus nerve **cln;** caudal laryngeal nerve **rsa;** left subclavian artery **cca;** common carotid artery **sca;** superficial cervical artery **C8;** ventral ramus of eighth cervical spinal nerve **T1;** ventral ramus of first thoracic spinal nerve **T2;** ventral ramus of second thoracic spinal nerve **arrow;** connections to branch between T1 and T2.

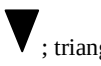
nerve and a branch (Fig. 1-n) which separated from vagus nerve was joined to plexus formed at the level aortic arch.

In one cadaver, two branches (Fig. 2-g) were diverged from center of cervicothoracic ganglion in right side. The dorsal branch of these branches was connected with another ganglion (Fig. 2-i) which was formed on the dorsal side of the trachea. It was observed that thin branches (Fig. 2-j) were extended from third and fourth thoracic ganglia to the mentioned ganglion. One branch (Fig. 2-k) diverged from ventral side of this ganglion was connected to vagus nerve (Figs. 1,2-vn). The ventral branch which was dispersed from middle level of cervicothoracic ganglion in the same cadaver was spread over trachea.

Generally 2 to 3 branches were originated from ventral side of cervicothoracic ganglion except caudal branch of subclavian ansa. From these branches, the one which was the thinnest (Fig. 2-l) on the cranial side was formed perivascular plexuses over right subclavian artery and their branches on right and left sides. It was detected that other branch or branches (Figs. 1,2-m) were connected with vagus nerve.

Table I.- The length, width and thickness measurements and shape of cervicothoracic ganglion in roe deer.

Cadaver Number		Length	Width	Thickness	Shape of ganglion
1	Right	12,30	2,92	1,8	
	Left	15,38	2,82	1,71	
2	Right	15,64	2,97	1,36	
	Left	19,78	2,58	1,35	
3	Right	16,36	1,51	0,73	
	Left	13,1	2,74	1,28	
4	Right	12,54	3,26	2,36	
	Left	14,83	2,25	1,75	
5	Right	16,45	2,9	1,49	
	Left	13,69	2,64	1,72	
6	Right	10,44	3,89	2,9	
	Left	10,6	3,86	2,11	
Average value	Right	13.95±2.5	2.9 ±0.78	1.77±0.76	
	Left	14.56±3.0	2.81±0.56	1.65±0.3	

 ; triangle, ; reverse L, ; oval

DISCUSSION

Cervicothoracic ganglion of roe deer was at the level first intercostal space, on the border of longus colli muscle and esophagus on the left side and on the border of longus colli muscle and trachea on the right side as reported in the literature (Getty, 1975; Tecirlioğlu, 1983; Dursun, 2000; Pather *et al.*, 2006; Ozgel *et al.*,2009). Ozgel *et al.* (2009) has stated in the donkey that the ganglion is at the level second intercostal space on the left side in one cadaver. In literature (Getty, 1975; Pather *et al.*, 2006; Ozgel *et al.*, 2009) have stated that the cervicothoracic ganglion consist of combination of caudal cervical ganglion and one or more thoracic ganglia. The caudal cervical ganglion has merged with the first in human (Pather *et al.*, 2006), first, second or sometimes third in donkey (Ozgel *et al.*, 2009) and first or second thoracic ganglia in ruminant (Getty, 1975). In this study, it was determined that caudal cervical ganglion combined with the first two thoracic ganglia constitute to cervicothoracic ganglion in all roe deer.

Although shape of cervicothoracic ganglion differs among species even according to right or left side of individuals and the shape is reported as oval, star, pear, semilunar and fusiform shaped in general (Getty, 1975; Kalsey *et al.*, 2000; Ozgel *et al.*, 2009). In roe deer, the ganglion was observed as triangle, spindle and reverse letter “L” in line as

reported by Pather *et al.* (2006).

While length, width and thickness measurements of cervicothoracic ganglion in human (Kalsey *et al.,* 2000) is reported as 20 x 10 x 3 mm, respectively, it has also specified that length of this ganglion is 16.51 mm and the width is 6.65 mm (Pather *et al.,* 2006). Ganglion size has reported in donkey (Ozgel *et al.,* 2009) as 26.5 x 9.5 x 2.7 mm on the right side and 26.5 x 11.3 x 2.3 mm on the left side. Length, width and thickness measurement of cervicothoracic ganglion of roe deer was detected as 13.95 x 2.9 x 1.77 mm on the right side and 14.56 x 2.81 x 1.65 mm on the left side. These measurement are similar to ganglion size of the goat among values reported by Getty (1975) for ox, sheep and goat.

Differences have stated in the literatures (Getty, 1975; Tecirlioğlu, 1983; Pospieszny and Bruzewicz, 1998; Dursun, 2000) about presence of middle cervical ganglion. In this study, the middle cervical ganglion was found as totally four numbers. Both of these ganglia were on the right and the other two were on the left side. We think that there is some confusion about nomenclature of this ganglion rather than its presence. In Nomina anatomicum veterinaria (2012), three ganglions (cranial, middle and caudal vertebral ganglia) on the cervical region have mentioned and denomination has performed complying with this nomina in many literatures (Janes *et al.,* 1986; Pospieszny and Bruzewicz, 1998; Pather *et al.,* 2006; Ozgel *et al.,* 2009). However, Getty (1975) and Kalsey *et al*. (2000) has expressed that intermediate and vertebral ganglions are on sympathetic trunk except these three ganglions on the cervical regions. In the goat, same researcher (Getty, 1975) has specified that middle vertebral ganglion has located after vertebral ganglion and vertebral ganglion is on the combination point of two branches of subclavian ansa. In respect of the localization reported, we think that the ganglion that we report as middle vertebral ganglion in roe deer is same as the ganglion reported by Getty (1975) as vertebral ganglion in goat. However, our nomenclature was done pursuant to nomina anatomicum. The ganglion which has reported by Getty (1975) as middle cervical ganglion in goat has not been seen macroscopically in roe deer.

It has reported in the literature (Getty, 1975; Kalsey *et al.,* 2000; Pather *et al.,* 2006; Ozgel *et al.,* 2009) that nerve branches radiated out from cervicothoracic ganglion are the vertebral nerve, cranial and caudal branches that form subclavian ansa, caudal vertebral cardiac nerves. These branches were observed in the roe deer as well. Apart from these nerve branches, although presence of a nerve branch joined from the ganglion to brachial plexus has mentioned in human (Pather *et al.,* 2006; Song *et al.,* 2010) and donkey (Ozgel *et al.,* 2009), such a branch was not observed in roe deer.

It has stated that cervicothoracic ganglion has formed by the coalescence of last cervical (C8) first (Pather *et al.,* 2006), sometimes second (Getty, 1975), third (Ozgel *et al.,* 2009) or fourth (Tecirlioğlu, 1983) thoracic ganglia. In all roe deer observed, this ganglion was created by combining last cervical and first two thoracic sympathetic ganglia. The communicating branches (ramus communicantes) which has diverged from cervicothoracic ganglion and extended to ventral rami of cervical and thoracic spinal nerves are one number in the literature (Getty, 1975; Kalsey *et al.,* 2000; Pather *et al.,* 2006; Ozgel *et al.,* 2009). While the branch that was extended to ventral rami of cervical and second thoracal spinal nerves was generally one number, the branch that was extended to ventral ramus of first thoracic spinal nerve was observed as two numbers in all roe deer. Other all branches such as cranial and caudal branches that formed subclavian ansa and thin branches forming perivascular plexuses over their branches and right and left subclavian arteries were comply with the literature (Getty, 1975; Kalsey *et al.,* 2000; Pather *et al.,* 2006; Ozgel *et al.,* 2009).

On the left side, one branch or two branches ramified from caudodorsal side of cervicothoracic ganglion have formed plexus on trachea and esophagus (Kalsey *et al.,* 2000; Pather *et al.,* 2006). Additionally, one branch or two branches (caudal vertebral cardiac nerves) dispersed from caudoventral side of this ganglion have constituted a plexus on aortic arch in the same side (Getty, 1975; Pather *et al.,* 2006). The forming plexus and the distribution of the branches originating from plexus on the aortic arch were similar to literature (Pather

et al., 2006; Ozgel *et al.,* 2009). It was determined that a branch (caudal vertebral cardiac nerves) which has extended from caudoventral side of the ganglion on the right side was also participated into cardiac plexus in this study. One branch (caudal cervical cardiac nerves) dispersed from middle cervical ganglion was participated into the plexus shaped on aortic arch level in two roe deer and on the left side. These branches participating to plexus above mentioned was similar with the literatures (Getty, 1975; Kalsey *et al.,* 2000). Besides, it was observed that branches diverged from caudal branch of the ansa are participate into this plexus and vagus nerve. This situation was complying with the literature (Getty, 1975; Ozgel *et al.,* 2009).

Consequently, shape, size, localization, nerve branches dispersed from the ganglion and relation of these nerve branches with surrounding organs and vessels were determined in detail in the roe deer. It was detected that localization and shape of cervicothoracic ganglion of the roe deer was similar with domestic ruminantia and ganglion size was similar with goat. In addition to these similarities, the differences that were specific to the roe deer were present. These different were detected as two communicating branches (ramus communicantes) separated from first thoracic spinal segment in all roe deer, thin nerve branches originated from the both right and left ganglia connected to vagus nerve and the presence another ganglion formed on trachea and right side in one roe deer. We think that findings obtained will contribute to anatomy literature and provide a resource to researches who will work about the subject in roe deer.

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