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Cervicothoracic sympathetic system in the dog: new insights by the gross morphological description of each ganglia with their branches in each side

M.M.A. Abumandour et al., Cervicothoracic sympathetic system in dog

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ABSTRACT

Much published data exists on the mention of the position of cervicothoracic ganglion, but a little published research has been done on the cervicothoracic system of dog. Herein, we illustrated topographical position, shape of each ganglia of cervicothoracic system to determine the distribution of nerves dispersing from them in two sides; left and right. Our work designed on the usage of ten healthy adult dogs. Left cervicothoracic sympathetic system represented by the presence of two ganglia; caudal and middle ganglion, while the right system represented by the presence of three ganglia; caudal, middle cervical and small accessory ganglia. Left caudal cervical ganglion was elongated triangular, while the right one was elongated spindle in shape. Left caudal cervical ganglion located on lateral surface of longus colli muscle, at first intercostal space, while the right one located at the level of second rib. Left middle cervical ganglion was

ovoid in shape and located at first intercostal space, while the right one located at the level of second rib. There are two nerve trunks were forming ansa subclavian trunk in both sides. There are three sympathetic-parasympathetic communicating branches in both sides. Our study recorded the first observation of left pericardial branch in dog, which originated from the caudal angle of middle cervical ganglion. There was a small ganglion located on the lateral surface of trachea at the level of first rib.

Key words: caudal cervical ganglion, middle cervical ganglion, accessory cervical ganglion, Ansa subclavian, dog

INTRODUCTION

The accumulating body of evidence recorded that the autonomic sympathetic nervous system is formed from nerves and ganglions (1). Furthermore, several reports described that the ganglia make communication between the central nervous system from one side to the viscera on the other side of the body. In the cervical region, the ganglia of the sympathetic chain classified into three bilaterally situated ganglia; cranial, middle, and caudal cervical ganglion (1-5). Sometimes, another ganglia may be present on the vertebral nerve named a vertebral ganglion (2).

The caudal cervical or the stellate ganglion was described previously in many published articles in different animals (1, 4, 6-9). Moreover as recorded in several reports the cervicothoracic system with its all nerves give an autonomic sympathetic innervation of the forelimb, cervical region, and the organs included in the chest region (4, 10, 11).

There were several published anatomical books mentioned the position of the cervicothoracic ganglia in the dog. However, to date, a scanty report recorded the cervicothoracic ganglia in the Baladi dogs. The current investigation was prepared to illustrate the cervicothoracic system and describing the topographical position, shape of the caudal and middle cervical ganglion in each side and their relationship with the surrounding structures and the nerves dispersing from them. Finally, the obtained data were compared to those reported in other animal species.

MATERIALS AND METHODS

Animals

Ten healthy adult dogs of both sexes (sexes and body weights were not recorded) were collected from the Kafrelsheikh Governorate and transported to the anatomical lab of the anatomy and embryology department of the Faculty of Veterinary Medicine, Alexandria University, Egypt to make the anatomical studies. The dog considered the famous canine species. The Baladi dog is the famous dog in Egyptian street. The dog was belongs to *carnivore* order, *Canidae* family, *canis* genus, *canis iupus* species, and *canis iupus familiaris* (Linnaeus, 1758) subspecies (12, 13).

This study followed the guidelines for the care and use of laboratory animals and the animal welfare and Ethics Committee of the Faculty of Veterinary Medicine, Alexandria University according the Egyptian's laws, approved it, in which adequate measures were taken to minimize pain or discomfort.

Preparation of animals

The collected dogs were received by injection of acepromazine (0.05 mg/kg/IM), and after 10 minutes were injected by the xylazine (0.2 mg/kg of body weight/IM) and atropine (0.04 mg/kg). All dogs were well bled via a cannula placed in the common carotid artery, then the cannula was subsequently used as an inflow port for injection of 10% formalin solution through the common carotid artery to made fixation of these specimens, then after specimens had been stored for two weeks to complete the fixation process. The anatomical dissection technique was carried in both sides of all dogs to describe the topographical position, shape, and branches of the ganglia. The dissected dogs were photographed by means of a digital camera (Canon IXY 325, Japan). The measurements were carried out by utilizing digital calipers. The Quantitative results were expressed as mean \pm SD. The anatomical terms followed the Nomina Anatomica Veterinaria (14).

RESULTS

Anatomical description of the left cervicothoracic sympathetic system

The left cervicothoracic sympathetic system was represented by the presence of the two ganglia: the caudal (cervicothoracic) and the middle cervical ganglion (**Figs.1-5/G and M**), in addition to one or more thoracic ganglia. The caudal cervical (cervicothoracic) ganglion was elongated triangular in shape with its apex ventrally and located on the lateral surface of the longus colli muscle, at the first intercostal space. The cranial $\frac{1}{4}$ of the examined ganglion was crossed laterally by the first thoracic spinal nerve of the brachial plexus and the costocervical artery (**Figs.1 and 2**).

In all examined dogs, the formation of the caudal cervical ganglion (cervicothoracic) achieved by the union of the last (eighth) cervical sympathetic nerve and the first two thoracic sympathetic ganglia. There were several rami communicantes received by the caudal cervical ganglion, which were originated from the eight cervical and the first two thoracic spinal segments. These rami communicantes originated from the first two thoracic spinal segments were united with the sympathetic trunk to combined with the caudal cervical ganglion at its caudodorsal angle (**Figs.1-5/b and c**). The ramus communicans named the eight cervical spinal segments was combined with the caudal cervical ganglion at its craniodorsal border (**Figs.1-5/a**).

Middle cervical ganglion (**Figs.1-5/M**) was ovoid or may spindle in shape in some cases. It was located slightly at the same level of the caudal cervical ganglion, at the first intercostal space or by at the level of the second rib (two cases). Its dorsal $\frac{1}{4}$ was covered laterally by the left subclavian artery before its bifurcation into, common carotid, internal thoracic and the axillary arteries. The middle cervical ganglion was communicated with the caudal cervical ganglion by the two nerve trunks forming the left ansa subclavian. After it left the vagosympathetic nerve trunk, the cervical part of the sympathetic nerve trunk was combined with the middle cervical ganglion at its cranial angle.

Branches dispersing from the left caudal cervical ganglion

The vertebral nerve

The vertebral nerve (**Fig.1 and 2/Vn**) was a large nerve that originated from the cranial angle of the triangular caudal cervical ganglion. Then, it passed in the craniodorsal direction on the lateral surface of the longus colli muscle and covered laterally by the last cervical and the first thoracic spinal nerve. During its course, it is corresponding with the vertebral artery and vein

(Figs.1-3/Va, Vv), after that, they passed under the transverse process of the seventh cervical vertebrae and enter the transverse foramen of the sixth cervical vertebrae.

The ansa subclavian nerve

The ansa subclavian nerve was the nerve dispersing from the caudal cervical ganglion and wrapped around the left subclavian artery. The left ansa subclavian was consisted of two nerve trunks originated from the caudoventral angle of the caudal cervical ganglion and named: the lateral small branch and the medial large branch (Figs.1-5/Ad, Av).

The lateral small branch (Figs.1-5/Ad) was directed oblique ventrally and pass on the lateral surface of the left subclavian artery, and then fused with the medial large branch of the ansa subclavian nerve and enter the middle cervical ganglion as one nerve trunk from its dorsal arch and embedded directly in the body of the middle cervical ganglion (Figs.1-4/CAV). While the medial large branch of the ansa subclavian nerve passed medially to the left subclavian artery and on the lateral surface of the esophagus (Figs.1-5/Ad, Av) until they it united with the lateral ones forming the common trunk that embedded directly in the body of the middle cervical ganglion.

The nerve to the brachiocephalic trunk

It was the smaller branch dispersing from the caudoventral border of the caudal cervical ganglion near to its caudoventral angle, and then directed caudoventrally to the medial surface of the brachiocephalic and the left subclavian artery (Figs.1-5/br).

The rami communicants

There were two rami communicants were combined to the first thoracic spinal nerve to share in the formation of the brachial plexus. These two rami communicants were originated from the craniodorsal border of the caudal cervical ganglion. These two rami communicants were described as: a short and long one (Figs.1-3/Bbr and Bbr1). In two cases of the examined dogs, there was only one ramus communicans to the first thoracic spinal nerve.

Branches dispersing from the middle cervical ganglion

Cardiac nerves

There were two or three cardiac nerves originated from the ventral and medial surface of the middle cervical ganglion. These cardiac nerves coursed ventrally or slightly caudoventrally to combine with other cardiac nerves forming a cardiac plexus (**Figs. 1-5/mc and Cp**).

The sympathetic-parasympathetic communicating branch

There were three a sympathetic–parasympathetic communicating branches to joined with the vagus nerve; two shorts ventrally and one long caudally directed branches. The two shorts ventrally directed branches were originated from the ventral arch of the ovoid shaped middle cervical ganglion to join the vagus nerve (**Figs. 1-5/1 and 2**), and these two nerves reached to 5 ml in the length and 2 ml in breadth and 1 ml in the thickness.

The long caudally directed branch measured about 5 cm in length and 2 ml in breadth and 1.5 ml in the thickness and originated from the caudal angle of the middle cervical ganglion together with the pericardial branch (**Figs. 1-5/3 and Pr**), and then directed caudally for 5 cm and unit with the vagus nerve before the origin of the recurrent laryngeal nerve from the vagus nerve by 1 cm (**Fig.4/3, V and Rc**), except in one case, it united with the vagus nerve after the origin of the recurrent laryngeal nerve by 1.5 cm

Pericardial branch

It was originated from the caudal angle of the middle cervical ganglion together with the long caudally directed branch of the sympathetic–parasympathetic communicating branches (**Figs.1-4/3 and Pr**), and then directed caudoventrally to reach the pericardium above the left auricle, then it penetrates the pericardium to reach the wall of the left auricle (**Fig.5/Pr, pi and La**).

Anatomical description of the right cervicothoracic sympathetic system

The right cervicothoracic sympathetic system was represented by the presence of the two sympathetic ganglia: the caudal (cervicothoracic) and the middle cervical ganglion (**Figs.6-10/G and M**). The caudal cervical ganglion was elongated spindle in shape and located at the level of the second rib on the lateral surface of the longus colli muscle (**Figs.6-10/G and Lm**), while the

cranial $\frac{1}{4}$ of the ganglion was located in the groove between the longus colli muscle and the trachea (**Figs.6-10/G, Lm and T**). The cranial $\frac{1}{2}$ of the examined ganglion was covered laterally by the second and third thoracic spinal nerve of the brachial plexus (**Figs. 6-10/G, Bp and R2**).

The right caudal cervical ganglion was located in the cranial $\frac{1}{4}$ of the quadrilateral venous area. This quadrilateral area formed from; vertebral veins cranially, the right vena azygous caudally, and the cranial vena cava ventrally, and the vertebral column dorsally (**Figs. 7I and 8I/G, Vv, VCr and Vb**).

In all examined dogs, the formation of the caudal cervical ganglion achieved by the union of the last (eighth) cervical sympathetic nerve and the first two thoracic sympathetic ganglia. There were several rami communicants received by the caudal cervical ganglion, which were originated from the eight cervical and the first two thoracic spinal segments. These rami communicants originated from the first two thoracic spinal segments were united with the sympathetic trunk to combine with the caudal cervical ganglion at its craniodorsal angle (**Figs.6-10/b and c**). The ramus communicans named eight cervical spinal segments was combined with the caudal cervical ganglion at its craniodorsal border (**Figs. 6-10/a**).

Middle cervical ganglion (**Figs.6-10/M**) was ovoid in shape, and it was located at the same level of at the caudal cervical ganglion, at the level of the second rib, nearly at the ventrolateral surface of the trachea. The middle cervical ganglion was located on the lateral surface of the right subclavian artery and its caudal $\frac{1}{4}$ was covered laterally by the vertebral vein (**Figs.6-10/Rs, Vv**). The middle cervical ganglion was communicated with the caudal cervical ganglion by the two-nerve loop trunk named the ansa subclavia; the lateral and the medial nerve loop trunk (**Figs.6-10/Ad, Av**). Furthermore, the middle cervical ganglion was communicated with the accessory small ganglion by the cranially directed nerve branch originated from the cranial angle of the middle cervical ganglion (**Figs.6-10/S1**).

Branches of the right caudal cervical ganglion

The vertebral nerve

The vertebral nerve (**Figs. 6 and 7/Vn**) was originated from the cranial part of the craniodorsal border of the caudal cervical (cervicothoracic) ganglion. Then, it passed under the last cervical spinal nerve in the craniodorsal direction. During its course, it is corresponding with

the vertebral artery and vein (**Fig. 7/Va-VV**). After that, they passed under the transverse process of the seventh cervical vertebrae and enter the transverse foramen of the sixth cervical vertebrae.

The ansa subclavian nerve

The nerve loop trunk named the ansa subclavia consists of two nerve loop: the lateral and the medial nerve trunk loop. The lateral nerve loop of the ansa subclavia (**Figs.6-10/Ad**) was originated from the cranial part of the caudoventral border of the caudal cervical ganglion and caudal to the origin of the medial nerve loop of the ansa subclavia by 0.3 cm, and then it directed ventrally on the lateral surface of the trachea to enter the dorsal arch of the middle cervical ganglion.

The medial nerve loop of the ansa subclavia (**Figs.6-10/Av**) was originated from the cranial part of the caudoventral border of the caudal cervical ganglion, and then it directed ventrally directly on the lateral surface of the trachea and pass under the right subclavian artery to join with the middle cervical ganglion at its medial surface. This nerve loop measured about 3.5 cm in length and 0.1 cm in width.

The cranioventrally directed nerve

This nerve was originated from the cranial part of the caudoventral border of the caudal cervical ganglion (**Figs. 6-10/cdm**), and then it directed cranioventrally on the lateral surface of the trachea and joined with the sympathetic nerve trunk before its union with the middle cervical ganglion forming a small sympathetic ganglion (**Figs.6-10/sg**). The cranioventrally directed nerve measured about 4.5 cm in length and 0.3 cm in width and give before its sharing in the formation of the small sympathetic ganglia by 1 cm a caudoventrally directed cardiac branch (**Figs.6-10/cv**) of 4 cm length to share in the cardiac plexus formation with other cardiac branches originated from the ansa subclavia and the middle cervical ganglion.

The ramus communicans

There was only one ramus communicans was combined to the last cervical spinal nerve which sharing in the formation of the brachial plexus (**Figs.6-10/Bbr**). This ramus communicans was originated from the craniodorsal angle of the caudal cervical ganglion.

Muscular branch

There was only one muscular branch was originated from the craniodorsal angle of the caudal cervical ganglion (**Figs.6-10/mr**). This branch was directed craniodorsally in corresponding with the vertebral nerve and ramus communicans was combined to the last cervical spinal nerve, in which these three branches had the same origin from the craniodorsal angle of the caudal cervical ganglion.

Branches of the middle cervical ganglion

The sympathetic–parasympathetic communicating branch of the middle cervical ganglion

There were two smalls sympathetic–parasympathetic communicating branches of 0.7 cm in the length (**Figs.6 and 10/1, 2**), which were originated from the middle cervical ganglion and directed ventrally to join with the vagus nerve.

The caudal cardiac nerve

There were two or three cardiac nerves originated from the ventral and medial surface of the middle cervical ganglion (**Figs.6-10/mc**). These cardiac nerves coursed slightly caudoventrally to combine with other cardiac nerves originated from the lateral loop of ansa subclavia, cranioventrally directed nerve and small ganglia to form a cardiac plexus (**Figs.6-10/CP**).

Anatomical description of the accessory small ganglion

There was a small ganglion located on the lateral surface of the trachea at the level of the first rib and cranial to the middle cervical ganglion by 1.2 cm (**Figs.6-10/sg**). This ganglion formed from the union of the cranial sympathetic branch originated from the cranial angle of the middle cervical ganglion with the cranioventrally directed nerve that originated from the caudal cervical ganglion (**Figs.6-10/cdm, S1**). The sympathetic nerve trunk was joining with the cranial angle of the accessory small ganglion.

Branches of the accessory small ganglion

The sympathetic–parasympathetic communicating branch of accessory small ganglion

This was a small ventrally directed branch of 1cm in the length that originated from the ventral border of the accessory small ganglion to join the vagus nerve (**Figs. 6 and 10/3**).

The caudoventrally directed cardiac branch

This was a small caudoventrally directed branch that originated from the caudal angle of the accessory small ganglion to share in the formation of the cardiac plexus (**Figs. 6 and 10/sc**).

DISCUSSION

The present study clarified that, the Baladi dog had some anatomical variations in the position of the ganglia forming the cervicothoracic system in two sides; the left caudal cervical ganglion was located at the first intercostal space on the lateral surface of the longus colli muscle, while the right caudal cervical ganglion located at the level of the second rib. This variation in the position of the ganglia forming the cervicothoracic system was reported previously by **(6)** in the donkey in which; the left and right caudal cervical ganglia of the four examined donkey was located at the first intercostal space, but in one examined donkey, the left one was situated at the level of second intercostal space, and in the area between the first and second intercostal spaces on right side. In the horse **(4)** reported that the location of the left caudal cervical ganglion is cranial to the level of the first rib, but the right examined ganglion located at the level of the first rib. However, there are numerous articles noted that the left and right caudal cervical ganglion located at the level of first intercostal space **(6, 9, 15, 16)**, while in the domestic animals **König and Liebich [17]** observed that the cervicothoracic ganglion located at the level of the first rib.

The previous published articles reported the presence of the some anatomical variations about the presence the middle cervical ganglion **(1, 11, 17)**. The current work observed the presence of the middle cervical ganglion in both side, this results similar to that noted by **(6)** in the donkey, while in the horse **(4)** observed that the middle cervical ganglion present on the right side and absent in the left side.

The current work agree with that noted by many authors that, the caudal cervical ganglion situated on the lateral surface of the longus colli muscle **(6, 9, 10)**, however in the horse **(4)** reported that the left-sided caudal cervical ganglion located on the lateral surface of the esophagus, while the right-sided caudal cervical ganglion located on the ventrolateral surface of the longus colli muscle and trachea. In the roe deer **(16)** noted that the caudal cervical ganglion located on the border of the longus colli muscle.

There are various appearance of the caudal cervical ganglion were observed in the numerous published articles (4-6, 10, 15, 18, 19). The current study reported that, the left caudal cervical ganglion was elongated triangular in shape with its apex ventrally, while the right is elongated spindle in shape. The general appearance of the caudal cervical ganglion is a spindle-shape or star shape, similar to that observed by (1, 4, 6, 9, 11, 15, 16). In the donkey, there were five different appearance of the caudal cervical ganglion; fusiform, star, oval, lunate, and irregular appearance **Ozgel, Duzler [6]**, but there were three different appearance were noted by (15, 16). In the horse (4) reported that the left caudal cervical ganglion was stellate in shape and compressed from its center, while the right caudal cervical ganglion was stellate and middle cervical ganglion was star.

There some published anatomical articles described the formation of the caudal cervical ganglion and observed some variations between the different animals. The caudal cervical ganglion consisted of union of the last (eighth) cervical and the first thoracic sympathetic nerves (6, 20), While, the present study noted that the examined caudal cervical ganglion consisted of the union of the last (eighth) cervical and first two thoracic sympathetic nerves, this results similar to this observed in roe deer and donkey (6, 16). While, it was consisted of the union of the last (eighth) cervical and first three thoracic sympathetic nerves as reported in the; dog (21) and in horse (4). Moreover, (9, 22) reported that the caudal cervical ganglion consisted of the union of the last (eighth) cervical and first four thoracic sympathetic nerves. However, in the human (15) reported that, the caudal cervical ganglion consisted of the union of the last two cervical and the first thoracic sympathetic nerve, and in some times the second (5) or occasionally the third and the fourth thoracic sympathetic nerves (23).

The present study observed that, the left caudal cervical ganglion gave the following branches: the vertebral nerve, the two branches forming the ansa subclavia, the nerve to the brachiocephalic trunk, muscular branches, and the ramus communicans to the first thoracic spinal nerve. However, the previous literatures (4-6, 15) reported that the caudal cervical ganglion gave the following branches; the vertebral nerve, the two branches forming the ansa subclavia, and the caudal cardiac nerve. The rami communicants joined to the brachial plexus was also reported by (4, 6, 15).

There are some minor variations in the origin of the vertebral nerve from the caudal cervical ganglion (5, 20). The present study observed that the left vertebral nerve originated from the

cranial angle of the left caudal cervical ganglion, while the right vertebral nerve was originated from the cranial part of the craniodorsal border of the caudal cervical ganglion. (4, 6) observed that the vertebral nerve radiating from the craniodorsal angle of the caudal cervical ganglion.

The cardiac nerves were derived from the caudal cervical ganglion and sharing in the cardiac plexus formation (4-6). In the present study, the cardiac nerves were originated directly from the caudal and middle cervical ganglion, in addition to there were some cardiac nerves was originated from ansa subclavia, accessory cervical ganglion.

The present study records the first record of the presence of the pericardial branch in the dog that originated from the caudal angle of the middle cervical ganglion, and then penetrated the pericardium to reach the wall of the left auricle. The pericardial branch reported only previously in the horse (4).

The present study records the first record of the sympathetic–parasympathetic communications branches, in which in the left side, there were three a sympathetic–parasympathetic communicating branches that originated from the middle cervical ganglion to joined with the vagus nerve, while in the right side there were there sympathetic–parasympathetic communicating branches to join the vagus nerve; two branches was originated from the middle cervical ganglion, in addition to only one sympathetic–parasympathetic communications branch originated from the accessory cervical ganglion. The sympathetic–parasympathetic communications branch were previous reported only by; (6) in one donkey on the right side and (4) in both sides of all examined horse.

In the current work, there was a right small ganglion in addition to the other three cervical ganglia: the cranial, the middle and the caudal. The right small ganglion named the accessory cervical ganglion in the right side only and absent on the left. This right accessory ganglion was located on the lateral surface of the trachea at the level of the first rib. This ganglion formed from the union of the cranial sympathetic branch originated from the cranial angle of the middle cervical ganglion with the cranioventrally directed nerve originated from the caudal cervical ganglion. in the roe deer (16) observed the presence of the two accessory ganglion one on each side, the left one located at the origin of the brachiocephalic trunk from the aortic arch while, the right one was located on the dorsal side of the trachea.

Compliance with Ethical standard

The authors confirmed that the article do not contain any studies with human participants.

This study followed the guidelines for the care and use of laboratory animals and the animal welfare and Ethics Committee of the Faculty of Veterinary Medicine, Alexandria University according the Egyptian's laws, approved it, in which adequate measures were taken to minimize pain or discomfort.

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Conflict of Interest: The authors declare that there are no conflicts of interest

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Figure legends

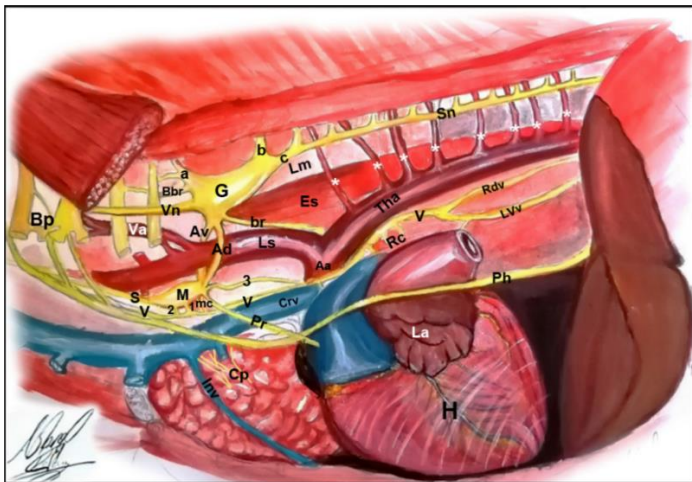


Figure 1. Illustrated image to describe the left cervicothoracic system of dog; G — left cervicothoracic ganglia; M — middle cervical ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglion; br — the nerve to brachiocephalic trunk; Bbr — ramus communicans combined to the thoracic spinal nerve to share in the formation of the brachial plexus; Ad — lateral small Ansa subclavian nerve; Av — medial large Ansa subclavian nerve; Pr — pericardial branch; 3 — the long caudally directed sympathetic-parasympathetic communicating branch; mc — cardiac nerves; Aa — aortic arch; Ls — left subclavian artery; Tha — thoracic aorta; white star refer to the intercostal arteries; Es — esophagus; Lm — longus colli muscle; Va — vertebral artery; Vn — vertebral nerve; Sn — sympathetic nerve; Inv — internal thoracic vein; V — vagus nerve; Ldv — left dorsal vagus nerve; Lvv — left ventral vagus nerve; Ph — phrenic nerve; H — heart; La — left atrium; Crv — cranial vena cavae.

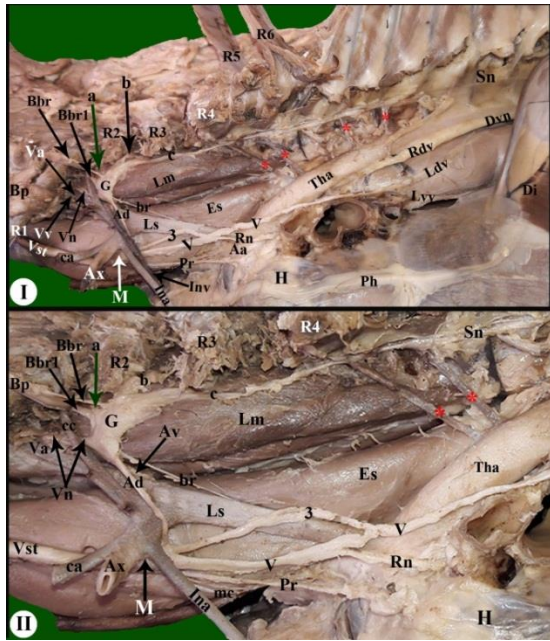


Figure 2. Gross anatomical photographs of the lateral macroscopic appearance of left cervicothoracic ganglion after the cranial reflection of first rib (R1), removal of succeeding three ribs (R2-R4), and the reflection of fifth and sixth ribs (R5 and R6), and the elevation of brachial plexus (Bp): View (I) with the presence of left subclavian vein and its branches while view (II) after removal of left subclavian vein and its branches; G — left cervicothoracic ganglia; M — middle cervical ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglion; br — the nerve to brachiocephalic trunk; Bbr — a long ramus communicans combined to the first thoracic spinal nerve to share in the formation of the brachial plexus; Bbr1 — short ramus communicans combined to the first thoracic spinal nerve to share in the formation of the brachial plexus; Ad — lateral small ansa subclavian nerve; Av — medial large ansa subclavian nerve; Pr — pericardial branch; 3 — the long caudally directed sympathetic-parasympathetic communicating branch; mc — cardiac nerves; Aa — aortic arch; Ls — left subclavian artery; Tha — thoracic aorta; Es — esophagus; Lm — longus colli muscle; cc — costocervical artery; Va — vertebral artery; Vv — vertebral vein; Vn — vertebral nerve; ca — common carotid artery; Vst — vgosympathetic trunk; Sn — sympathetic nerve; Ax — axillary artery; Ina — internal thoracic artery; Inv — internal thoracic vein; red star — intercostal arteries; V — vagus nerve; Ldv — left dorsal vagus nerve; Rdv — left dorsal vagus nerve; Lvv — left ventral vagus nerve; Dvn — dorsal vagal nerve trunk; Di — diaphragm; Ph — phrenic nerve; H — heart; Rn — recurrent laryngeal nerve.

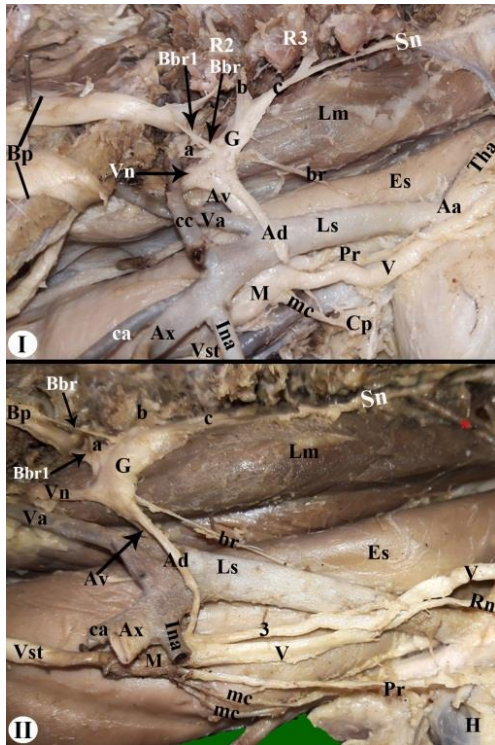


Figure 3. Gross anatomical photographs of lateral macroscopic appearance of the left cervicothoracic ganglion after the removal of first four ribs (R1-R4), and the elevation of brachial plexus (Bp); G — left cervicothoracic ganglia; M — middle cervical ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglion; br — nerve to brachiocephalic trunk; Bbr — a long ramus communicans combined to the first thoracic spinal nerve to share in the formation of the brachial plexus; Bbr1 — short ramus communicans combined to the first thoracic spinal nerve to share in the formation of the brachial plexus; br — nerve to the brachiocephalic trunk; Ad — lateral small ansa subclavian nerve; Av — medial large ansa subclavian nerve; Pr — pericardial branch; 3 — the long caudally directed sympathetic-parasympathetic communicating branch; mc — cardiac nerves; Cp — cardiac plexus; Aa — aortic arch; Ls — left subclavian artery; Tha — thoracic aorta; Es — esophagus; Lm — longus colli muscle; cc — costocervical artery; Va — vertebral artery; Vn — vertebral nerve; ca — common carotid artery; Vst — vagosympathetic trunk; Sn — sympathetic nerve; Ax — axillary artery; Ina — internal thoracic artery; red star — intercostal artery; V — vagus nerve; H — heart; Rn — recurrent laryngeal nerve.

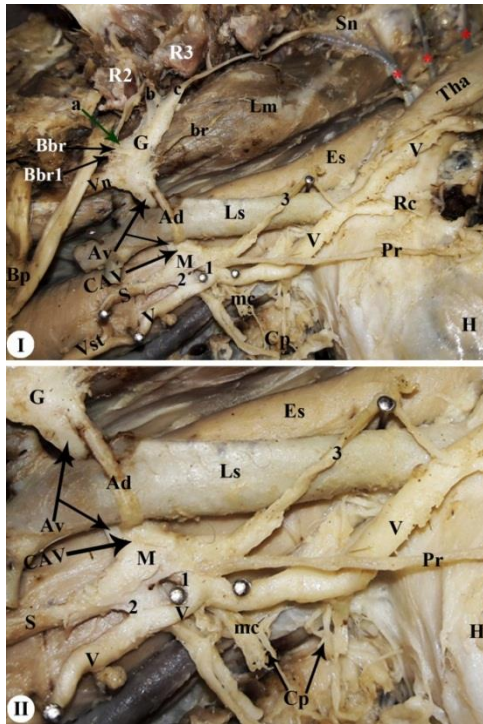


Figure 4. Gross anatomical photographs of lateral macroscopic appearance of the left cervicothoracic ganglion after the removal of first four ribs (R1-R4), and the elevation of brachial plexus (Bp); G — left cervicothoracic ganglion; M — middle cervical ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglion; br — the nerve to brachiocephalic trunk; Bbr — a long ramus communicans combined to the first thoracic spinal nerve to share in the formation of the brachial plexus; Bbr1 — short ramus communicans combined to the first thoracic spinal nerve to share in the formation of the brachial plexus; Ad — lateral small ansa subclavian nerve; Av — medial large Ansa subclavian nerve; CAV — common Ansa subclavian nerve; Vn — vertebral nerve; Pr — pericardial branch; 1 and 2 — represent the two-short sympathetic-parasympathetic communicating branch; 3 — the long caudally directed sympathetic-parasympathetic communicating branch; mc — cardiac nerves; Cp — cardiac plexus; Ls — left subclavian artery; Tha — thoracic aorta; Es — esophagus; Lm — longus colli muscle; Vst — vagosympathetic trunk; S — sympathetic trunk; Sn — sympathetic nerve; red star — intercostal arteries; V — vagus nerve; H — heart; Rn — recurrent laryngeal nerve.

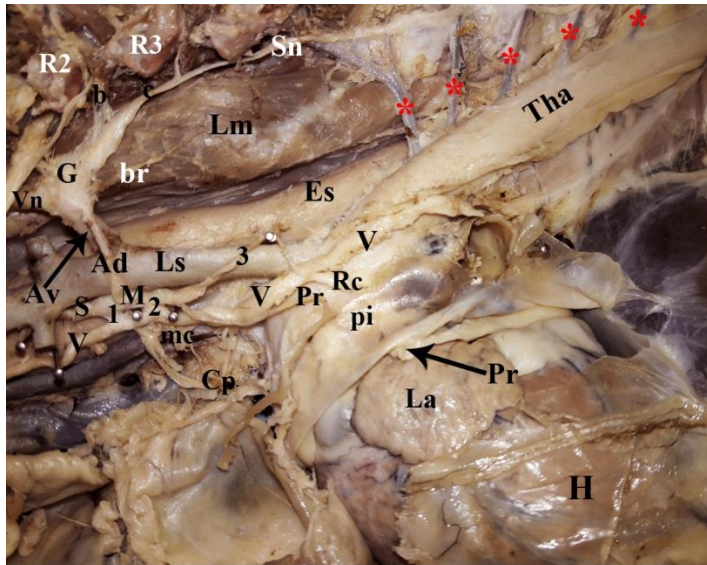


Figure 5. Gross anatomical photographs of lateral macroscopic appearance of the left cervicothoracic ganglion; G — left cervicothoracic ganglion; M — middle cervical ganglion; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglion; br — the nerve to brachiocephalic trunk; Ad — lateral small ansa subclavian nerve; Av — medial large ansa subclavian nerve; Vn — vertebral nerve; Pr — pericardial branch; 1 and 2 — represent the two-short sympathetic-parasympathetic communicating branch; 3 — the long caudally directed sympathetic-parasympathetic communicating branch; mc — cardiac nerves; Cp — cardiac plexus; Ls — left subclavian artery; Tha — thoracic aorta; Es — esophagus; Lm — longus colli muscle; Sn — sympathetic nerve; red star — intercostal arteries; V — vagus nerve; H — heart; Rn — recurrent laryngeal nerve; pi — pericardium; La — left atrium.

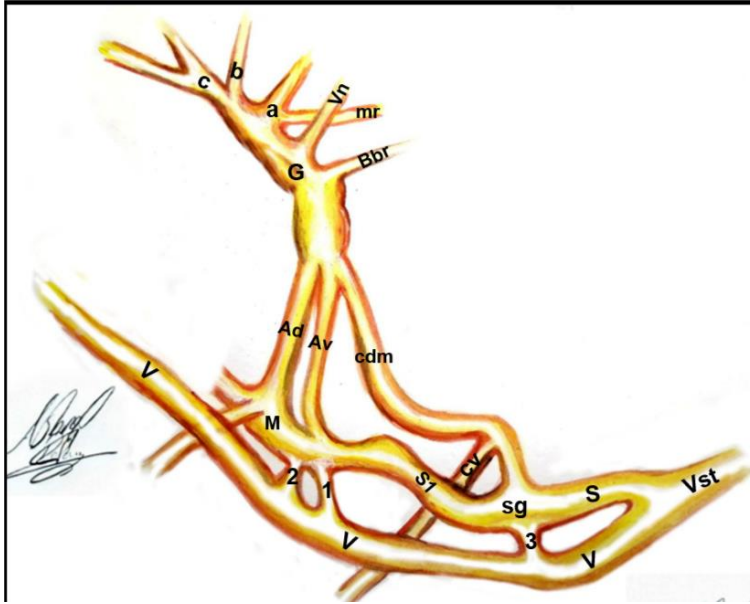


Figure 6. illustrated image to describe the right cervicothoracic system of dog; G — right cervicothoracic ganglion; M — middle cervical ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglia; c — second thoracic sympathetic ganglia; mr — muscular branch from right cervicothoracic ganglia; Bbr — the ramus communicans combined to the last cervical spinal nerve to share in the formation of the brachial plexus; Ad — lateral small Ansa subclavian nerve; Av — medial large Ansa subclavian nerve; cdm — the cranioventrally directed nerve; Vn — vertebral nerve; Cr — the caudal cardiac nerve; V — vagus nerve; Vst — vagosympathetic trunk; Sn — sympathetic nerve; S1 — communicating sympathetic branch between the middle and the small ganglia; sg — small ganglion; cv — caudoventrally directed branch from the cranioventrally directed nerve.

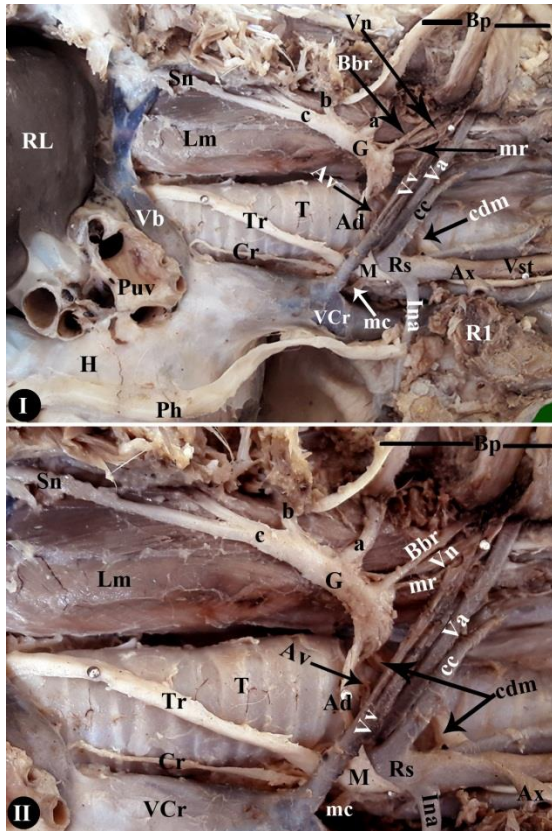


Figure 7. Gross anatomical photographs of lateral macroscopic appearance of the right cervicothoracic ganglion after the elevation of the brachial plexus (Bp); G — right cervicothoracic ganglion; M — middle cervical ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglia; c — second thoracic sympathetic ganglia; mr — muscular branch from right cervicothoracic ganglia; Bbr — the ramus communicans combined to the last cervical spinal nerve to share in the formation of the brachial plexus; Ad — lateral small ansa subclavian nerve; Av — medial large ansa subclavian nerve; cdm — the cranioventrally directed nerve; Vn — vertebral nerve; Cr — the caudal cardiac nerve; mc — cardiac nerves; Rs — right subclavian artery; Ax — axillary artery; Ina — internal thoracic artery; cc — costocervical trunk; Lm — longus colli muscle; Vst — vagosympathetic trunk; Sn — sympathetic nerve; Vv — vertebral vein; Va — vertebral artery; Sn — sympathetic nerve; VCr — cranial vena cavae; H — heart; Ph — phrenic nerve; T — trachea; Vb — azygos vein; RL — right lung; Puv — pulmonary veins; R1 — first rib.

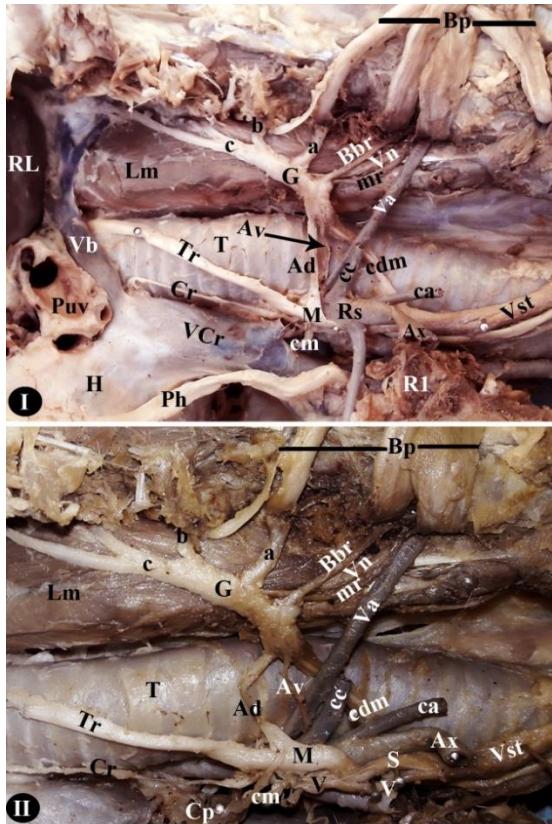


Figure 8. Gross anatomical photographs of lateral macroscopic appearance of the right cervicothoracic ganglion after the elevation of the brachial plexus (Bp); G — right cervicothoracic ganglia; M — middle cervical ganglia; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglia; c — second thoracic sympathetic ganglia; mr — muscular branch from right cervicothoracic ganglia; Bbr — the ramus communicans combined to the last cervical spinal nerve to share in the formation of the brachial plexus; Ad — lateral small Ansa subclavian nerve; Av — medial large Ansa subclavian nerve; cdm — the cranioventrally directed nerve; Vn — vertebral nerve; Cr — the caudal cardiac nerve; cm — cardiac nerves; Cp — cardiac plexus; Rs — right subclavian artery; ca — common carotid artery; Ax — axillary artery; Ina — internal thoracic artery; cc — costocervical trunk; Lm — longus colli muscle; Vst — vagosympathetic trunk; V — vagus nerve; S — sympathetic nerve trunk; Sn — sympathetic nerve; Vv — vertebral vein; Va — vertebral artery; Sn — sympathetic nerve; VCr — cranial vena cavae; H — heart; Ph — phrenic nerve; T — trachea; Vb — azygos vein; RL — right lung; Puv — pulmonary veins; R1 — first rib.

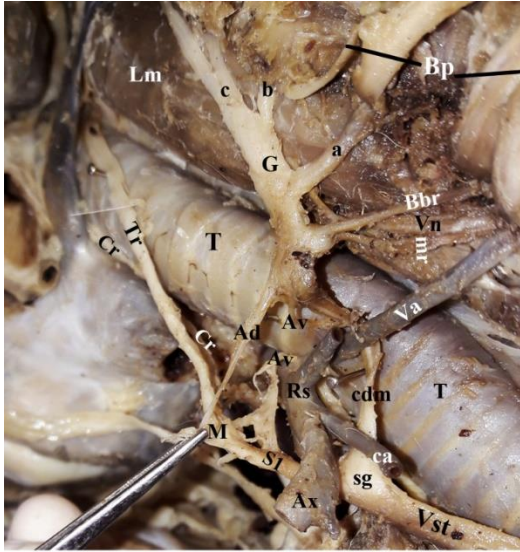


Figure 9. Gross anatomical photographs of the cranial macroscopic view of the right cervicothoracic ganglion after the elevation of the brachial plexus (Bp); G — right cervicothoracic ganglion; M — middle cervical ganglion; sg — small ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglia; mr — muscular branch from right cervicothoracic ganglia; Bbr — the ramus communicans combined to the last cervical spinal nerve to share in the formation of the brachial plexus; Ad — lateral small Ansa subclavian nerve; Av — medial large Ansa subclavian nerve; cdm — the cranioventrally directed nerve; Vn — vertebral nerve; Cr — the caudal cardiac nerve; mc — cardiac nerves; S1 — communicating sympathetic branch between the middle and the small ganglia; Rs — right subclavian artery; ca — common carotid artery; Ax — axillary artery; Ina — internal thoracic artery; cc — costocervical trunk; Lm — longus colli muscle; Vst — vagosympathetic trunk; V — vagus nerve; Va — vertebral artery; S — sympathetic nerve trunk; Sn — sympathetic nerve; T — trachea.

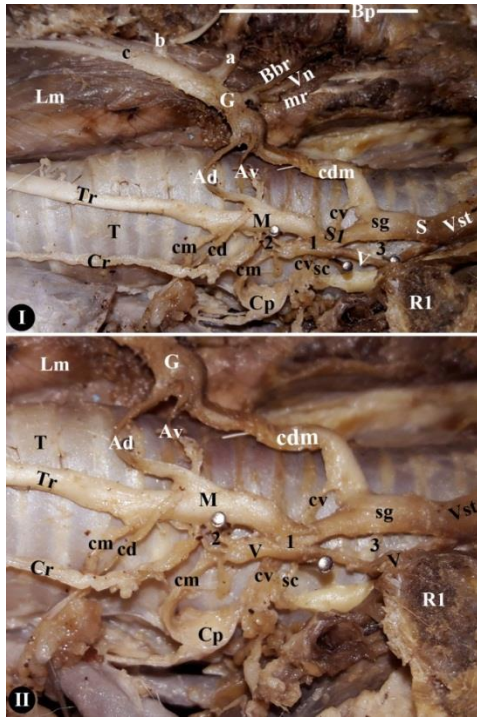


Figure 10. Gross anatomical photographs of lateral macroscopic appearance of the right cervicothoracic ganglion after elevation of brachial plexus (Bp); G — right cervicothoracic ganglion; M — middle cervical ganglion; sg — small ganglion; a — last (eighth) cervical sympathetic nerve; b — first thoracic sympathetic ganglion; c — second thoracic sympathetic ganglion; mr — muscular branch from right cervicothoracic ganglion; Bbr — the ramus communicans combined to the last cervical spinal nerve to share in the formation of the brachial plexus; Ad — lateral small ansa subclavian nerve; Av — medial large Ansa subclavian nerve; cdm — the cranioventrally directed nerve; Vn — vertebral nerve; Cr — the caudal cardiac nerve; mc — cardiac nerves; Cp — cardiac plexus; 1 and 2 — the two small sympathetic-parasympathetic communicating branches which originated from the middle cervical ganglion and directed ventrally to join with the vagus nerve; 3 — the sympathetic-parasympathetic communicating branch of the accessory small ganglion; cv — caudoventrally directed branch from the cranioventrally directed nerve; sc — the ventrally directed cardiac nerve from the small ganglia; S1 — communicating sympathetic branch between the middle and the small ganglia; Lm — longus colli muscle; Vst — vagosympathetic trunk; V — vagus nerve; S — sympathetic nerve trunk; Sn — sympathetic nerve; Sn — sympathetic nerve; VCr — cranial vena cavae; T — trachea; Bbr — the ramus communicans combined to the last cervical spinal nerve to share in the formation of the brachial plexus.