Macro-Anatomical Investigations of the Cervicothoracic Sympathetic System in the Horse (Equus Ferrus Caballus)

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ABSTRACT
Twelve healthy adult horses (Equus ferrus caballus) were dissected to provide the anatomical description of bilaterally cervicothoracic sympathetic system macroscopically. On the left side, cervicothoracic sympathetic system was represented only by the caudal cervical ganglion, which located on the lateral surface of the esophagus cranial to the first rib. On the right side, cervicothoracic sympathetic system was represented by the caudal and middle cervical ganglion. The caudal cervical ganglion consisted of the fusion of the eighth cervical and the first three thoracic nerve ganglia. The caudal directed continued branch of left ansa subclavia gave off; a pericardial branch and then gave branch for ligamentum arteriosum. There was a special sympathetic–parasympathetic communicating branches; on the left side, there was only one branch that located on the lateral surface of the esophagus, while on the right side, there were four branches; two from the caudal cervical ganglion and two from the middle cervical ganglion. The most suitable site of ganglion block from both sides; the needle was placed medioventrally between the articulation of the first and second rib.

Key words: Horse; caudal cervical ganglion, sympathetic nerve, subclavian

1. INTRODUCTION
In all mammals, the autonomic nervous systems were consisted of nerves and ganglia that connected to the central nervous system on one side and to the viscera on the other side. The ganglia of the sympathetic chain in the cervical region are classically arranged into three bilaterally ganglia; cranial, middle and caudal cervical ganglion (Fioretto et al., 2003; Gabella, 2004; Rosse and Gaddum-Rosse, 1997). Occasionally, there is a vertebral ganglion on the vertebral nerve, (Rosse and Gaddum-Rosse, 1997).

The caudal cervical ganglion has been documented by many authors (Dyce et al., 2010; Evans and de Lahunta, 2013; Ozgel et al., 2009). The caudal cervical ganglion was considered as an important center of sympathetic innervations of cervical region, neck and forelimbs (Phillips et al., 1986), so there is clinically importance of the cervicothoracic ganglion block (Ackerman and Zhang, 2006; Marcer et al., 2011; Schürrmann et al., 2001).

The aim of the present study was to describe the dimensions, shape and location of the ganglia of the cervicothoracic sympathetic system bilaterally of horse and nerve branches originating from these ganglia, in addition to its relationship with the adjacent structures. As there is a little available data about the cervicothoracic sympathetic system in horse, this study provides a morphological basis for further research in comparative neuroanatomy and for future step, for new technique of block and surgical approach of cervicothoracic ganglion.

2. MATERIALS AND METHODS

2.1. Animals
Twelve healthy adult horses of both sexes (sexes and body weights were not recorded) were collected from the Edfina, Behera Governate to the local dissecting hall in the Faculty of Veterinary Medicine in Edfina, Behera Governate, Egypt for student teaching purpose. 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.

2.2. Animals preparation

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All horses had been received by intramuscular injection of acepromazine (0.05 mg/kg), and then followed after 10 minute by intramuscular injection of xylazine (0.2 mg/kg of body weight) and atropine (0.04 mg/kg). Then these horses were anesthetized by intravenous injection of ketamine (5.0 mg/kg) 10 minute after sedative injection. They were injected intravenously with 10 mm of heparin (1,000 IU) to suppress coagulation. Then horses 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 make fixation of these specimens, then after specimens had been stored for two weeks, both sides of each specimen were carefully dissected to observe; shape, location, and branches of the ganglia which share in the formation of the cervicothoracic sympathetic system bilaterally. The findings obtained were photographed by means of a digital camera (Cannon IXY 325, Japan). The measurements were carried out by utilizing digital calipers, in which "ml" mean millimeter while "cm" mean centimeter. The Quantitative results were expressed as mean ± SD.

3. RESULT

3.1. Macro-anatomical observation of the left side cervicothoracic sympathetic system

The left sided cervicothoracic sympathetic system is represented only by the caudal cervical ganglion. The caudal cervical ganglion was located on the lateral surface of esophagus, cranial to the level of the distal portion of the proximal half of the first rib. The caudal border of the indicated ganglion was located below the cranial border of the first rib, while its lateral surface was covered with the medial scalenus muscle. The dorsal one third of this ganglion was overlapped the groove between the longus colli muscle and esophagus (Fig.1).

The caudal cervical ganglion lies in the arterial triangular area, its apex caudally and its base cranially. This arterial triangular area is formed dorsally by the vertebral artery and ventrally by the left subclavian artery. The observed ganglion had an elongated satellite shape which compressed from its center (Fig.1: G). On the left side of the median plane, the shapes and the measurements of the cervicothoracic ganglion were shown in Table In ten examined horses, the caudal cervical ganglion was formed by the merger of the last (eighth) cervical (enter from the craniodorsal border of the caudal cervical ganglion) (Fig.1 and 2: a) and first three thoracic sympathetic ganglia (enter from the caudodorsal border of ganglion) (Fig.1, 2 and 3b) (Fig.1:*). But in the remaining two examined horse, the caudal cervical ganglion was formed by the fusion of the last cervical and the first two thoracic sympathetic ganglia.

3.2. Branches of the caudal cervical ganglion

The vertebral nerve

The vertebral nerve (Fig.1: Vn) had its origin from the craniodorsal angle of caudal cervical ganglion. The vertebral nerve was coursed in the craniodorsal direction on the lateral surface of longus colli muscle, then it passed along with the vertebral artery (Fig.1: Va) and vertebral vein under the transverse process of the seventh cervical vertebrae then enter through transverse foramen of the sixth cervical vertebrae.

3.3. The ansa subclavian nerve

In all examined horses, the nerves which originated from caudal cervical ganglion and surrounded the left subclavian artery were known as ansa subclavia (Fig.1, 2: As). Ansa subclavian was consisted of two nerves continued caudally as dorsal and ventral loop.

The ventral loop (Fig.1, 2 and 3: Av) had its origin from the caudoventral angle of the ganglion by three separated branches; the dorsal branch (2.5 ± 0.13 mm in width) is the thicker one (Fig.1, 2c) while the other two branches (middle and ventral) are similar to each other in width (1.2 ± 0.5 mm in width) (Fig.1, 2d), in which between the middle and ventral branches, the left cardiac nerve (Fig.1, 2: Lc) was originated from the ganglion. These three branches (dorsal thick one, and two thinner) were directed caudoventrally and then fused after their origin by 2.7 ± 0.17cm to form the common trunk of the ventral loop (5 ± 0.14mm in width), which coursed with the vagus nerve on the medial aspect of the curved part of the left subclavian artery. This common trunk of the ventral loop began to cross the ventral aspect of the left subclavian artery to join the dorsal loop on the lateral surface of left subclavian artery to form left ansa subclavia (Fig.1: As). The course of common nerve trunk of the ventral loop from its origin is parallel to the course of vagus nerve (Fig.1, 3: V).

The dorsal loop (3 ± 0.2mm in width) of the ansa subclavia nerve had its origin from the caudodorsal angle of ganglion below the level of first rib, and then directed caudally at the lateral surface of
the esophagus and at the medial surface of the vertebral artery, deep cervical artery and costocervical trunk. And then it deviated ventrally at the level of cranial border of the third rib and from caudal border of the costocervical trunk, and joined with the ventral loop at the lateral surface of the left subclavian artery. After this merger, there was a branch that continued directly caudal and this branch was 6 ± 0.16 mm in width (Fig. 3: DAs).

The dorsal loop gave three communicating branches (Fig. 1: +); the cranial one had its origin at the level of the first intercostal space and it was communicated with the first thoracic sympathetic nerve. While the middle one had its origin at the level of the caudal border of the second intercostal space and then it gave two branches after 3 ± 0.2 mm from its origin. The caudal one was originated at the origin of the third intercostal space and then it gave two branches after 4 ± 0.17 cm from its origin. It was observed that all branches separated from the dorsal loop were connected to sympathetic trunk.

The caudal directed continuation branch of the ansa subclavian (Fig. 3: DAs) was passed caudally to reach the pericardium at the level of the third intercostal space, then before penetrating the pericardium by 1.1 ± 0.15 cm and after its formation by 2 ± 0.11 cm gave off one small pericardial branch to the pericardium (Fig. 3: Pr), then the continued branch of the ansa subclavian penetrated the pericardium and gave two branches after its origin by 4.3 ± 0.22 cm; one branch for the ligamentum arteriosum and the other branch is the ventral cardiac branch.

The branch for ligamentum arteriosum (Fig. 3: ga) was branched after its origin by 2.1 ± 0.16 cm to give four small branches; three for ligamentum arteriosum and the most dorsal one to the aortic arch.

The ventral cardiac branch of the caudal directed continuation of the left ansa subclavian (Fig. 1: vb) was originated at the level of the origin of the brachiocephalic trunk, then directed ventrally, and then after its origin by 4 ± 0.2 cm and at the caudal border of the left auricle and cranial border of the aortic arch gave three branches; cranial, middle and caudal branches. The cranial one is the long one (8 ± 0.2 cm in length) then impeded in the cardiac musculature at the conus arteriosus while another two branches enter under the left atrium.

3.4. The sympathetic nerve

Sympathetic nerve (Fig. 1 and 2: S) had its origin from the cranioventral angle of the ganglion then coursed caudoventrally on the lateral surface of the esophagus. This nerve accompanying with the vagus nerve in the cervical region and named vagosympathetic trunk and covered with a sheath after 4 ± 0.2 cm from its origin (Fig. 1 and 2: VS).

3.5. The left cardiac nerve

Left cardiac nerve (Fig. 1 and 2: Lc) had its origin from the caudoventral angle of the cervicothoracic ganglion (without sharing in the formation of the ansa subclavia). Then it was coursed caudoventrally under the left subclavian artery to unite with the common right cardiac nerve (Fig. 2: CRc) after 8.8 ± 0.19 cm from its origin near the lateral surface of the trachea to form the common cardiac nerve (Fig. 2: CC) to share in the formation of the cardiac plexus.

3.6. The nerve to the brachiocephalic trunk

A small branch to the brachiocephalic trunk (Fig. 1, 2 and 3: bc) was originated from the ventral part of the caudal border of the cervicothoracic ganglion and dorsal to the origin of the left cardiac nerve by 1 ± 0.12 mm (without sharing in the formation of the ansa subclavian), then coursed caudoventrally parallel to the left cardiac nerve and attached to it with common sheath after its origin by 4 ± 0.15 cm then separated from the common sheath to supply the brachiocephalic trunk (Fig. 1: A).

3.7. The rami communicates

In all examined horses, rami communicates were originated from the cervicothoracic ganglion or its branches to join the brachial plexus. Eight of examined horses, had one ramus communicants from the cervicothoracic ganglion, whereas two horses, has one ramus communicates from vertebral nerve, another two horses from the dorsal loop of ansa subclavia.

3.8. The sympathetic-parasympathetic communicating branch

There is a sympathetic–parasympathetic communicating branch was located on the lateral surface of the esophagus. There is a cranial continuation of the ventral branch of the three branches (sharing in the formation of the ventral loop of ansa subclavian) originated from the caudoventral angle of the caudal cervical ganglion (Fig. 1 and 2: d’).
During the course of this cranial continued branch, it give a small branch to the left common carotid artery and carotid sheath (Fig.2: da) after its origin by 4.5 ± 0.16 cm while the main branch (Fig.2: db) is unit with a branch originated from the sympathetic nerve (Fig.2: S2) after its origin by 6.5 ± 0.15 cm to form a sympathetic-parasympathetic branch (Fig.2: SP) to the vagus nerve.
Figure 3: Photographs of the left cervicothoracic ganglion: views (I and II) to show the caudal directed branches of ganglion
A, brachiocephalic trunk; E, esophagus; G, cervicothoracic ganglion; M, longus colli muscle; T, trachea; V, vagus nerve; P, pericardium; Pr, pericardial branch; bc, brachiocephalic branch; b, common thoracic trunk of first, second, third thoracic sympathetic nerve; Ad, dorsal loop of ansa subclavian; Av, ventral loop of ansa subclavian; Ls, left subclavian artery; Va, vertebral artery; dc, deep cervical artery; cc, costocervical trunk artery; pb, reflected brachial plexus; DAs, caudal continuation of left ansa subclavia; vb, ventral cardiac branch of caudal continuation of left ansa subclavia; PT, pulmonary trunk; Cn, conus arteriosus; H, heart; Aa, aortic arch; TA, thoracic aorta; LA, left atrium; +, communicating branches of dorsal loop of ansa subclavian.

3.9. Anatomical observation of the cervicothoracic ganglion on the right side
In all examined horses; the right sided cervicothoracic sympathetic system is represented by two ganglia; the caudal and middle cervical ganglion. The caudal cervical ganglion (Fig.4:G) was situated at the level of the first rib, in which the dorsal half of the ganglion lies on the ventrolateral surface of the longus colli muscle, while the ventral half lies on the groove between the longus colli muscle and the trachea. The caudal part of the ganglion lies cranio medial to the origin of the deep cervical artery (Fig.4: dc), so become clear that this ganglion lies in the arterial triangular area, its apex ventrally and its base dorsally. This arterial triangular area was formed cranially by the vertebral artery and caudally by the deep cervical artery (Fig.4: Va, dc). The lateral surface of the ganglion was covered with the medial scalenus muscle as in left side. The shape of ganglion was stellate. On the right side of the median plane, the shapes and the measurements of the caudal cervical ganglion were shown in Table 1.

Middle cervical ganglion (Fig.4 and 5: k) was situated cranioventral to the caudal cervical ganglion and proceeding it by 1.7 ± 0.18 cm at the ventrolateral surface of the trachea and parallel to the vagus nerve which situated ventral to this ganglion. The middle cervical ganglion was communicated with the caudal cervical ganglion only by one main nerve trunk (which considered as the cranial loop of the ansa subclavia).

Middle cervical ganglion was lies in the arterial triangular area (apex caudally and base cranially). This arterial triangular area was formed by the vertebral artery dorsally and the right common carotid artery ventrally (Fig.4: Va, R.cart). The caudal part of the ganglion lies medial to the vertebral artery after 2 ± 0.2 cm form its origin. The shape of ganglion was star. On the right side of the median plane, the shapes and the measurements of the middle cervical ganglion were shown in Table 1.

Caudal cervical ganglion was formed by the merger of the last (eighth) cervical (enter from the dorsal border of the ganglion) (Fig.4: a) and the common sympathetic nerve trunk (enter from the caudodorsal border of ganglion) (Fig.4: b) of the first three thoracic sympathetic ganglia in all examined horses (Fig.4:*, except in two cadavers; the ganglion was formed by the union of the last cervical and the common sympathetic trunk of the first and second thoracic sympathetic ganglia.

3.10. Branches of the caudal cervical ganglion
The vertebral nerve
Vertebral nerve (Fig.4: Vn) had its origin at the craniodorsal angle of the caudal cervical ganglion.
As in left side, the nerve was coursed after its origin in the craniodorsal direction on the lateral surface of the longus colli muscle and medial to the medial scalenus muscle to reach the vertebral artery cranial to the first rib by 3 ± 0.1 cm then pass together under the transverse process of the seventh cervical vertebra then enter the transverse canal through the transverse foramen of the sixth cervical vertebra.

3.11. The cranial loop of ansa subclavian nerve
Ansae subclavia was formed by two loop; the cranial and the caudal loop. The caudal loop (Fig. 4: Ac) had its origin from the middle cervical ganglion while the cranial loop (Fig. 4:Ar) of 3.5 ± 0.18 cm in length and 9 ± 0.12 mm in width, was originated from the cranioventral angle of the caudal cervical ganglion, then directed cranioventrally from the lateral to the ventral surface of the trachea to enter from the caudodorsal angle of the middle cervical ganglion.

3.12. The right caudoventral cardiac nerve
On the lateral surface of the trachea, from the caudodorsal angle of the caudal cervical ganglion, the right caudoventral cardiac nerve (Fig. 4 and 5c) of 3.5 ± 0.16 mm in width was slightly directed caudoventrally then branched after its origin by 1.1 ± 0.1 cm into 3 branches; cranial, middle and caudal branch. The cranial one (Fig. 5:cr) was the shorter one (1.5 ± 0.15 cm in length and 1.5 ± 0.09 mm in width) which communicated with the right caudal cardiac nerve (Fig. 5: Rc). The middle one (Fig. 5cm) was the wider one (2 ± 0.14 mm in width); which directed caudoventrally and branched after its origin by 1.8 ± 0.1 cm to give the secondary branch (Fig. 5cml) to communicate with the right caudal cardiac nerve, while the main branch coursed caudoventrally to join with another branch from the right caudal cardiac nerve (Fig. 5:Rc1) to form the first sympathetic–parasympathetic communicating branch of the caudal cervical ganglion (Fig. 5:SP1) to communicate with the vagus nerve (Fig. 5:V). The caudal longer one is the second sympathetic–parasympathetic communicating branch of the caudal cervical ganglion (Fig. 5:SP2), which was directed ventrally to communicate with the vagus nerve after the previous sympathetic–parasympathetic communicating branch by 1 ± 0.08 cm.

3.13. Branches of the middle cervical ganglion
The sympathetic nerve
Sympathetic nerve (Fig. 4 and 5: S) had its origin from the craniodorsal angle of the middle cervical ganglion then coursed craniodorsally on the lateral surface of the trachea to form the vagsympathetic trunk with the vagus nerve (Fig. 4: V) at the distance of 5.5 ± 0.38 cm from its origin and after 6.5 ± 0.36 cm from the cranial border of the first rib and extend toward the head on the lateral surface of the trachea.

3.14. The tracheal nerve
Tracheal nerve (Fig. 4 and 5e) had its origin from the middle cervical ganglion by two branches; the main large branch (2 ± 0.1 mm in width) was originated from the cranial border of the middle cervical ganglion while the other small branch (1 ± 0.1 mm in width) was originated from the craniodorsal border of the middle cervical ganglion. After that, the two branches united to form the tracheal nerve, in which the first 1 ± 0.1 cm from the tracheal nerve was covered the initial part of the sympathetic nerve (Fig. 4 and 5: S, e).

Tracheal nerve was branched into the lateral and the medial branch after its origin by 2 ± 0.12 cm, then those two branches pass cranially on the ventral surface of the trachea under the right common carotid artery, in which the lateral one pass under the right common carotid artery after its origin by 5.5 ± 0.35 cm while the medial one pass under the right common carotid artery after its origin by 3 ± 0.24 cm.

3.15. The first sympathetic–parasympathetic communicating branch of the middle cervical ganglion
This branch (Fig. 5:SP3) had its origin from the ventral border of the ganglion and directed cranioventrally to communicate with the vagus nerve.

3.16. The caudal loop of ansa subclavian
The caudal loop of the ansa subclavian (3±0.12 mm in width) (Fig. 4, 5 and 6: Ac) had its origin from the cranioventral border of the middle cervical ganglion and directed caudoventrally, and then after its origin by 2±0.01 mm, this loop give the second sympathetic–parasympathetic communicating branch of the middle cervical ganglion (Fig. 5: SP4) to the vagus nerve, in which the distance between those two sympathetic–parasympathetic communicating branch reach to 1.8 ± 0.21 cm.
Then after that the caudal loop of ansa subclavian coursed under the right subclavian artery (Fig.4: Rs) with the vagus nerve (Fig.4: V), then this loop directed caudally on the ventral surface of trachea. Then during the course of the caudal loop of ansa subclavian (after its origin by 6.5 ± 0.34 cm), it was received the communicating branches from the ventral branch of the right caudal cardiac nerve (Fig.6: rv).

3.17. The right caudal cardiac nerve
Right caudal cardiac nerve (4 ± 0.08 mm in width) had its origin from the caudoventral angle of the middle cervical ganglion (Fig.4, 5 and 6: Rc) and directed caudally on the ventrolateral surface of trachea, below the level of caudal border of the first rib. The right caudal cardiac nerve was originated directly under the caudal border of the vertebral artery (Fig.4 and 5; Va) and after its coursing by 0.5±0.11 cm pass below the medial surface of the common trunk of deep cervical and costocervical arteries (Fig.4: x), then communicated with the cranial branch of the right caudoventral cardiac nerve (Fig.5:cr) after its origin by 3.8±0.2 cm.

After its origin by 5.3 ± 0.24 cm, it was divided into 3 branches on the ventral surface of trachea; dorsal, middle and ventral. The dorsal one (1 ± 0.04 mm in width) was directed caudally to join with the middle one after 3.7 ± 0.23 cm from its origin (Fig.4: rd), while the middle one (1 ± 0.02 mm in width) (Fig.4: rm) was joined with the dorsal one after its origin by 4 ± 0.42 cm then this common nerve trunk united to the caudal loop of ansa subclavian after 2±0.19 cm from its formation. The ventral one (1 ± 0.15 mm in width) was the shorter one (Fig.4: rv) which directed caudoventrally then divided into two branches after its origin by 1.3 ± 0.24 cm to communicate with the caudal loop of ansa subclavia, in which one branch proceeding to other by 2.3 ± 0.26 cm in the communication.

Then, the right caudal cardiac nerve with its all communicating branches was merger to form the cardiac plexus on the ventral surface of trachea, dorsal to the base of the heart and dorsal to the origin of the cranial vena cava, then the right caudal cardiac nerve united with the caudal loop of ansa subclavian to form the common right cardiac nerve (Fig.2:Ac, Rc, CRc), which communicated with the left cardiac nerve on the left side ventral to trachea to form the common cardiac nerve (Fig.2: CC).

The measurements of the all nerves originated from the ganglia of both sides were recorded in Table 2 and 3.

Clinical bilaterally approach to the caudal cervical ganglion in horse
To produce the caudal cervical ganglion blocks in horse from the right and left side, the most suitable site; the needle was placed medioventrally between the articulation of the first and second rib.

Figure 4: Photographs of the right caudal and middle cervical ganglion after reflection of the brachial plexus: view (I) with the presence of the right subclavian artery and its branches while view (II) after removal of the right subclavian artery and its branches: E, esophagus; G, caudal cervical ganglion; k, middle cervical ganglion; M, longus colli muscle; T, trachea; S, sympathetic nerve; V, vagus nerve; Ph, phrenic nerve; R.cart, right carotid artery; Rc, right caudal cardiac nerve of middle cervical ganglion; R1, first rib; R2, second rib; R3, third rib; a, last cervical sympathetic nerve; b, common thoracic trunk of first, second, third thoracic sympathetic nerves (*); c, caudal loop of ansa subclavius; e, tracheal nerve; Ar, Interganglionic branch; Ac, cranial loop of ansa subclavia; bp, reflected brachial plexus; Rs, right subclavian artery; Va, vertebral artery; Vn. Vertebral nerve; dc, deep cervical artery; cc, costocervical artery; x, common trunk of dc and cc ; CT, common trunk of deep cervical and costocervical artery; Jv, right jugular vein; cd.v., caudal vena cava.
Table 1: Shape and measurement values of the ganglion in both sides

<table>
<thead>
<tr>
<th>Side</th>
<th>Ganglion</th>
<th>Shape</th>
<th>Length (cm)</th>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left side</td>
<td>Caudal cervical ganglion</td>
<td>Elongated satellite shape and compressed from its center</td>
<td>3.1±0.12</td>
<td>8.9±0.3</td>
<td>15±1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>From middle part</td>
<td></td>
<td>At the middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>From branched (dorsal) apex and base (ventral) part</td>
<td>15±1.3</td>
<td>At apex</td>
<td>3.1±0.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22±1.8</td>
<td>At base</td>
<td>2.1±0.18</td>
</tr>
<tr>
<td>Right side</td>
<td>Caudal cervical ganglion</td>
<td>Stellate</td>
<td>1.3±0.12</td>
<td>10±1.3</td>
<td>1.12±0.1</td>
</tr>
<tr>
<td></td>
<td>Middle cervical ganglion</td>
<td>Star</td>
<td>1±0.1</td>
<td>10±1.3</td>
<td>1.12±0.1</td>
</tr>
</tbody>
</table>

Figure 5: Photographs of the right ventrolateral surface of the trachea: view (I) to clarify the branches of the ventral branch of the caudal cervical ganglion and view (II) to clarify the branches of the middle cervical ganglion: k, middle cervical ganglion; T, trachea; S, sympathetic nerve; V, vagus nerve; R.cart, right carotid artery; Rc, right cardiac nerve; Rc1, secondary branch of Rc; c, caudal loop of ansa subclavian; cr, cranial branch of c; cm, middle branch of c; cm1, secondary branch of cm; e, tracheal nerve; Ac, cranial loop of ansa subclavian; Va, a. vertebralis; SP1, first sympathetic-parasympathetic communicants; SP2, second sympathetic-parasympathetic communicants; SP3, third sympathetic-parasympathetic communicants; SP4, fourth sympathetic-parasympathetic communicants.

Figure 6: Photograph of the right ventrolateral surface of the trachea to demonstrate the branches of the ventral branch of the right cardiac nerve (Rc): T, trachea; S, sympathetic nerve; Rc, right cardiac nerve; Ac, cranial loop of ansa subclavian; V, vagus nerve; rd, dorsal branch of Rc; rm, middle branch of Rc; rv, ventral branch of Rc; Cd.v, caudal vena cava; Z, right azygus vein.
Table 2: The measurement values of the nerves in both sides

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Measurement (mm)</th>
<th>Left side</th>
<th>Right side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eighth cervical nerve</td>
<td>Width at its entrance from the craniodorsal border of the ganglion</td>
<td>3 ± 0.1</td>
<td>4 ± 0.14</td>
</tr>
<tr>
<td>First three thoracic sympathetic ganglia</td>
<td>Width at its entrance from the caudodorsal border of the ganglion</td>
<td>9.1 ± 0.15</td>
<td>7 ± 0.17</td>
</tr>
<tr>
<td>Vertebral nerve</td>
<td>Width at its origin from the ganglion</td>
<td>3 ± 0.0</td>
<td>3 ± 0.13</td>
</tr>
<tr>
<td>branch for ligamentum arteriosum</td>
<td>Width at its origin from the ganglion</td>
<td>2 ± 0.14</td>
<td>Not present</td>
</tr>
<tr>
<td>sympathetic nerve</td>
<td>Width at its origin</td>
<td>5 ± 0.2</td>
<td>3 ± 0.12</td>
</tr>
<tr>
<td>cardiac nerve</td>
<td>Width at its origin</td>
<td>3 ± 0.2</td>
<td>3.5 ± 0.16</td>
</tr>
<tr>
<td>branch to brachiocephalic trunk</td>
<td>Width at its origin</td>
<td>1 ± 0.1</td>
<td>Not present</td>
</tr>
</tbody>
</table>

Table 3: The measurement values of the sympathetic–parasympathetic communicating branches

<table>
<thead>
<tr>
<th>Side</th>
<th>Nerve</th>
<th>Width at their origin (mm)</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>a sympathetic-parasympathetic branch</td>
<td>0.5 ± 0.01</td>
<td>3.5 ± 0.16</td>
</tr>
<tr>
<td>Right</td>
<td>first sympathetic–parasympathetic communicating branch of the caudal cervical ganglion</td>
<td>2.5 ± 0.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>second sympathetic–parasympathetic communicating branch of the caudal cervical ganglion</td>
<td>1.5 ± 0.1</td>
<td>1.5 ± 0.12</td>
</tr>
<tr>
<td></td>
<td>First sympathetic–parasympathetic communicating branch of the middle cervical ganglion</td>
<td>1.5 ± 0.06</td>
<td>1.8 ± 0.08</td>
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<tr>
<td></td>
<td>second sympathetic–parasympathetic communicating branch of the middle cervical ganglion</td>
<td>1 ± 0.01</td>
<td>0.6 ± 0.017</td>
</tr>
</tbody>
</table>

4. DISCUSSION

Many authors were reported that the caudal cervical ganglion was situated bilaterally at the level of the first intercostal space (Evans and de Lahunta, 2013; Ozgel et al., 2009; Pather et al., 2006), but (Konig and Liebich, 2007) noted that the cervicothoracic ganglion lies medial to the first rib, while (Ozgel et al., 2009) reported that there is some variation in the position of the caudal cervical ganglion; in four donkey the location of ganglion at the first intercostal space bilaterally, while in one donkey, this ganglion was located at the level of the second intercostal space on the left side, while on the right side was situated in a wide area from the first and the second intercostal spaces. In the present study, the left caudal cervical ganglion was situated cranial to the level of the first rib, in which the caudal border of the ganglion was situated below the cranial border of the first rib, while the right caudal cervical ganglion was situated at the level of the first rib and the middle cervical ganglion was situated cranioventral to the caudal cervical ganglion and at the ventrolateral border of the trachea. (Hogan and Erickson, 1992; Raj, 1996) noted that the stellate ganglion lies in the front of the first rib and extended to the space between bodies of the seventh cervical vertebrae and the first thoracic vertebrae.

A cervicothoracic ganglion was located on the lateral surface of the longus colli muscle (Evans and de Lahunta, 2013; Ozgel et al., 2009; Phillips et al., 1986), but in the present investigation, the left caudal cervical ganglion was situated on the lateral surface of the esophagus and the dorsal border of the ganglion overlapped the groove between the longus colli muscle and the esophagus, while on the right side, the dorsal half of the caudal cervical ganglion was located on the ventrolateral surface of the longus colli muscle, while the ventral half hanged on the groove between the longus colli muscle and the trachea. In cat, the right stellate ganglion had its location over the base of the first rib, while the left stellate ganglion was located on the neck of the first and the second rib (Phillips et al., 1986).

Various shapes of the caudal cervical ganglion have been reported in many literatures (Hogan and Erickson, 1992; Kalsey et al., 2000; Marcer et al.,
2011; Pather et al., 2006); in donkeys (Ozgel et al., 2009), noted that there are five different shapes; star, spindle-like (fusiform), lunate, irregular and oval shapes, while (Pather et al., 2006) observed three different shapes; spindle, dumbbell, and an inverted ‘‘L’’ shape, but (Phillips et al., 1986) noted that the right middle cervical ganglion was spindle-shaped. In this investigation, the left caudal cervical ganglion wasstellate in shape and compressed from its center, while the right caudal cervical ganglion wasstellate and the middle cervical ganglion was star.

Interestingly, in the present study, there is a relation between the position of the caudal cervical ganglion with the head of the first rib and important arterial vessels in this region; in which the right caudal cervical ganglion lies under the first rib in the arterial triangular area, which bounded by: the vertebral artery cranially and the deep cervical artery caudally and the head of the first rib dorsally, while the right middle cervical ganglion lies in the arterial triangular area bounded by: the vertebral artery dorsally and the right common carotid artery ventrally. Moreover, the left caudal cervical ganglion was located in the arterial triangular area, which bounded by: the vertebral artery dorsally and the left subclavia artery ventrally. The presence of this triangular area was reported by (Katritsis et al., 1981).

Many previous published articles were described that, there are many morphological difference in the formation of the caudal cervical ganglion between different animals; in which the caudal cervical ganglion was formed by the coalescence of the last cervical and the first thoracic sympathetic nerves on both side (Dursun, 2000; Ozgel et al., 2009). In addition, (Ozgel et al., 2009) was observed that the caudal cervical ganglion was formed bilaterally by the coalescence of the last cervical and the first and the second thoracic sympathetic nerves in two donkeys, which agree with (Singh et al., 2005). In the present study, the bilaterally caudal cervical ganglion was formed by the coalescence of the last cervical and the first three thoracic sympathetic nerves, this result agree with (Evans and de Lahunta, 2010) in one cadaver on the right side, and also (Chung et al., 2002; Evans and de Lahunta, 2013) noted that the first four thoracic nerve may include in the formation of this ganglion. In human, the cervicothoracic ganglion was formed by the coalescence of the last two cervical, and generally the first thoracic nerve (Pather et al., 2006) and sometimes second (Kalsey et al., 2000) or additionally the third and the fourth thoracic sympathetic nerves (Arnci and Elhan, 1995).

The vertebral nerve was originated at different levels from the caudal cervical ganglion (Dursun, 2000; Kalsey et al., 2000). Our study is agree with (Ozgel et al., 2009), that on the both side, the vertebral nerve was originated from the craniodorsal angle of the caudal cervical ganglion, while (Ozgel et al., 2009) added that it may originated from the cranioventral aspect in one cadaver. Our study agrees with (Ozgel et al., 2009; Pather et al., 2006), that the caudal cervical ganglion gives a branch to the brachiocephalic trunk.

Cranial to the cervicothoracic ganglion, the sympathetic nerve was divided to ansa subclavian, around the subclavian artery (Evans and de Lahunta, 2010). In the present investigation, the left ansa subclavian was formed by the merger of the dorsal and ventral loops. The ventral loop had its origin from the caudoventral angle of the caudal cervical ganglion to merger with the dorsal loop on the lateral surface of the left subclavian artery, while the dorsal loop was originated from the caudal cervical ganglion at the caudodorsal angle below the level of first rib, while the right ansa subclavia was formed by; the cranial loop which originated from the cranioventral angle of the caudal cervical ganglion, then directed cranioventrally on the trachea to enter from the caudodorsal angle of the middle cervical ganglion, while the caudal loop had its origin from the cranioventral border of the right middle cervical ganglion and directed caudoventrally, then courses under the right subclavian artery with the vagus nerve then this loop directed caudally on the ventral surface of the trachea. (Ozgel et al., 2009), in all cadavers, the ansa subclavia loop was derived from the sympathetic ganglion, while in three cadavers, the ansa subclavia was formed by the union of two ventral branches ramify from the cranioventral and caudoventral aspects of the caudal cervical ganglion.

As noted in many literatures, in general the cardiac nerve was derived from the caudal cervical ganglion and contributed in the formation of the cardiac plexus (Kalsey et al., 2000; Ozgel et al., 2009). In the present study, the left cardiac nerve was derived from the caudoventral angle of the caudal cervical ganglion then courses caudoventrally under the left subclavian artery to unite with the right cardiac nerve near the lateral surface of trachea to form the common cardiac nerve which share in the formation of the cardiac plexus, while on the right side, the caudal cardiac nerve was derived from the caudoventral angle.
of the middle cervical ganglion then directed caudally on the ventrolateral surface of trachea, in addition to the caudoventral cardiac nerve which originated from the caudoventricle angle of the caudal cervical ganglion.

In the previous published review of literature, no publication was reporting the presence of the branch of the ligamentum arteriosum in the horse, except in this study, but (Ozgel et al., 2009) was reported it only in one donkey. Moreover, our study reported that there is a pericardial branch which not previously reported in any previous published literatures.

By the same token, a sympathetic–parasympathetic communications branches were not previously reported in any literature in the horse except in the present study on both side, but (Ozgel et al., 2009) was reported it on the right side in one donkey. Our findings indicate that, on the left side, there is only one sympathetic–parasympathetic communication branch on the lateral surface of the esophagus, while on the right side, there are four sympathetic–parasympathetic communications branches; two from the caudal cervical ganglion and two from the middle cervical ganglion.

Finally, our findings suggest the most suitable site to produce the bilaterally caudal cervical ganglion blocks, this site between the articulation of the first and the second rib, this suggestion is agree with that noted by (Skarda et al., 1986). In the past, the caudal cervical ganglion blocks was performed blindly by palpating the anterior tubercle of the transverse process of the sixth cervical vertebral but this method has a relatively high failure rate, but (Abdi et al., 2004; Feigl et al., 2007) noted that to produce the caudal cervical ganglion block, injecting either at the level sixth or seventh cervical vertebral.

5. CONCLUSION
In conclusion, the present study provides anomalous description to the bilateral cervicothoracic sympathetic system macroscopically. The left cervicothoracic sympathetic system was represented only by the caudal cervical ganglion, while the right cervicothoracic sympathetic system was represented by the caudal and middle cervical ganglion. The first record of that there is a branch for ligamentum arteriosum in horse which originated from the left subclavian nerve. The first record of that there are a special communicating branches called sympaticothetic–parasympathetic communicating branches. The most suitable site of ganglion blocks from both sides; the needle was placed medially between the articulation of the first and second rib.

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6. REFERENCES


