Lack of knowledge of the anatomy of the cervical sympathetic trunk (CST) may complicate surgical procedures on the cervical spine. This study aims to define linear and angular relations of the CST with respect to consistent structures around it, including the number and size of the cervical ganglia, the distances between the CST and the longus colli muscle and the anterior tubercles of the transverse processes of cervical vertebrae. Morphometric parameters of the 24 CSTs of 12 adults were measured on both sides. The CST had superior, middle, and inferior (or cervicothoracic) ganglia in 20.8% of specimens; superior and inferior (or cervicothoracic) ganglia in 45.8%; superior, middle, vertebral, inferior, or cervicothoracic ganglia in 12.5%, and superior, vertebral, inferior or cervicothoracic ganglia in 20.8% of specimens. The superior ganglion was observed in all specimens, the middle ganglion and vertebral ganglion were each observed in 33.3%. There was no difference between the number of superior and vertebral ganglia between the right and left sides. The average distance between the CST and the medial border of the ipsilateral longus colli muscle (LCM) was 17.2 mm at C3 and 12.4 mm at C7. As the CSTs converged caudally, the LCMs diverged. The average distance between the anterior tubercles of transverse processes of the cervical vertebrae and the lateral borders of the ipsilateral CST was 3.4 mm at C4, 3.2 mm at C5, and 3.9 mm at C6. The presence of a vertebral ganglion and variations, such as the localization of the CST within the carotid sheath, are important. The anatomical landmarks described should assist the spinal surgeon to avoid injury of the CST. Clin. Anat. 18:179–185, 2005.

Key words: anatomy; cervical spine; cervical sympathetic trunk; spinal surgery

INTRODUCTION

The anterior approach to the subaxial cervical spine is used commonly in the surgical treatment of several diseases, including cervical disc herniation, cervical spondylitic myelopathy, and disease of cervical vertebral bodies caused by tumour, infection, or trauma. An anterior approach to the cervical spine carries a variety of neurovascular risks (Robinson et al., 1962; Cloward, 1971; Hankinson and Wilson, 1975; Tew and Mayfield, 1976; Bertalanffy and Eggert, 1989; Saunders, 1991; Johnston and Crockard, 1995; Ebraheim et al., 2000; Lu et al., 2000). One of these risks is injury to the cervical sympathetic trunk (CST). Although the risk is as low as 0.2–4% in the common approaches to the anterior cervical spine (Hankinson and Wilson, 1975; Tew and Mayfield, 1976; Johnston and Crockard, 1995), the risk seems to be higher for recently favored lateral approaches to the subaxial cervical spine (George et al., 1999) in patients undergoing oblique corpectomy or anterior transforaminal cervical discectomy. This study describes the number and size of the cervical ganglia and measure the distances of the sympathetic trunk from the longus colli muscle (LCM) and the anterior tubercles of transverse processes of cervical vertebrae. The LCM and anterior tubercles are consistent in their presence and easy to identify during both anterior and anterolateral approaches to the cervical spine. It is hoped that the CST distances determined from these structures will assist surgeons and avoid damage to the CST.

MATERIALS AND METHODS

This study was carried out on 24 CSTs of 12 formaldehyde-fixed human cadavers of height 1.57–1.80 m (mean = 1.68 m). The necks were positioned in ex-
tension. Dissection started with an incision along the anterior border of the sternocleidomastoid muscle from the angle of the mandible to the jugular notch. The platysma muscle was cut away and the sternocleidomastoid muscle was transected and its superior and inferior portions reflected rostrally and caudally respectively. The omohyoid muscle was incised and the connective tissues beneath the deep fascia were dissected. The exposed neurovascular complex was identified and the carotid arteries and internal jugular vein were retracted medially, exposing the LCM and the CST. The cervical ganglia, the main sympathetic trunk, and their branches were dissected from the upper cervical to the upper thoracic regions. Romanes (1981) described the sympathetic trunk dividing into smaller bundles in the lower neck. When this occurred we regarded the largest bundle as the main trunk.

After opening the fascia of the LCM, the muscle and the anterior aspects of the intervertebral discs and vertebral bodies of C2–C7 were exposed. The following parameters of the anatomy of the CST were measured.

**Ganglion Organization**

We measured the distances between the superior ganglion (SG) and middle ganglion (MG), the SG and inferior ganglion (IG) or cervicothoracic ganglion (CTG), the SG and vertebral ganglion (VG), the MG and IG or CTG, and between the MG and VG, on the right and left sides.

**Morphometric Analysis of the Ganglia of the CST**

We measured the width, length, and thickness of the right and left SG, MG, IG or CTG, and VG, as well as the width of the CST at the level of C6.

**Relationship Between the CST and Consistent Structures**

Our findings of the relationship between the CST and consistent structures included:

1. The distance between the medial border of LCM and the ipsilateral CST or medial border of the ganglion at the C2–3, C3–4, C4–5, C5–6, and C6–7 intervertebral disc levels on the right and the left sides.
2. The distance between the medial border of the LCM and the ipsilateral CST or medial border of the ganglion at the anterior mid-level of C3, C4, C5, C6, and C7 vertebral bodies on the right and the left sides.
3. The distance between the lateral borders of the ipsilateral CST or the ganglion and the anterior tubercles of transverse processes of C2, C3, C4, C5, and C6 vertebrae on the right and the left sides.
4. The midline-CST angle on the right and the left sides.
5. The relationship between the vertebral artery (VA) and the ipsilateral CST or lateral border of the CTG on the right and the left sides.

**Distances and Angle Between the Medial Borders of Right and Left LCMs**

The distances between the medial borders of the right and left LCMs at the levels of the intervertebral discs and at the anterior mid-levels of the vertebral bodies of C3–C7 vertebrae. The angle between the medial borders of the right and left sides. The measurements were carried out using a Vernier caliper sensitive to 0.1 mm and a goniometer. The statistical analysis was carried out using Mann-Whitney U-tests; \( P < 0.05 \) was accepted as significant.

**RESULTS**

**Ganglion Organization**

The CST consisted of a main trunk and 2–4 ganglia. There were two ganglia (SG and IG or CTG) in 45.8% of specimens (Fig. 1), three ganglia (SG, MG, and IG or CTG) in 20.8% of specimens (Fig. 2), three ganglia (SG, VG, IG or CTG) in 20.8%, and four ganglia (SG, MG, VG and IG or CTG) in 12.5% of specimens. When the organization of the ganglia on the right and left sides were compared, no differences between the numbers of SG and VG on the right and left sides were found (Table 1). The SG was observed in all specimens (100%) on both sides. The MG was observed in five of 12 specimens and three of 12 specimens on the right and left sides, respectively. The IG was observed in three and two specimens on the right and left sides, respectively. The CTG was observed in nine and 10 necks on the right and left sides, respectively.

The following distances between the right and left ganglia were recorded: between the right and left SG was 56.0 ± 3.2 mm (mean ± SD); between the right and left MG was 49.5 ± 2.7 mm; between the right and left CTG was 45.4 ± 2.6 mm.

The distance between the ipsilateral SG and MG was 67.3 ± 4.0 mm and 57.0 ± 12.4 mm on the right and left sides, respectively. The distance between the ipsilateral SG and IG/CTG was 83.0 ± 11.2 mm and 86.6 ± 10.1 mm on the right and left sides, respectively. The distance between the ipsilateral MG and IG/CTG was 14.8 ± 3.2 mm and 18.1 ± 3.8 mm on the right and left sides, respectively (Table 2).
Morphometric Analysis of the CST and the Ganglia of the CST

The CST was 2.2 ± 0.7 mm in diameter at the level of the C6 vertebral body.

The SG was observed in all specimens. It was located at the level of C2–3 transverse process in 75% of specimens (18 dissections), and at the level of C1–2 transverse process in 25% of specimens (6 dissections). The length of the SG was 27.6 ± 4.6 mm, the width 8.2 ± 1.4 mm, and the thickness was 3.2 ± 0.8 mm (Table 3). The distance between the SG and the anterior tubercle of the transverse process of C2 was 3.0 ± 1.5 mm. There were no significant statistical differences between the data for the right and left ganglia.

The MG was present in eight of 24 specimens. The MG was detected on both sides in only three specimens. When present, the MG was located at the level of the C6 transverse process in three specimens, and at the level of C6–7 intervertebral disc in five specimens. Fibers entering and exiting from the MG lay on the inferior thyroid artery. The mean length of the MG was 9.7 ± 3.4 mm, the mean width was 5.0 ± 1.1 mm, and the mean thickness was 2.1 ± 2.8 mm. There were no significant differences in the data for the right and left ganglia.

TABLE 1. Number of Ganglia on the Right and Left Sides

<table>
<thead>
<tr>
<th>Ganglion</th>
<th>Right</th>
<th>Left</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG</td>
<td>12 (100%, 100%)</td>
<td>12 (100%, 100%)</td>
<td>24 (100%)</td>
</tr>
<tr>
<td>MG</td>
<td>5 (41.7%, 62.5%)</td>
<td>3 (25%, 37.5%)</td>
<td>8 (33.3%)</td>
</tr>
<tr>
<td>IG</td>
<td>3 (25%, 60%)</td>
<td>2 (16.7%, 40%)</td>
<td>5 (20.8%)</td>
</tr>
<tr>
<td>CTG</td>
<td>9 (75%, 47.4%)</td>
<td>10 (83.3%, 52.6%)</td>
<td>19 (79.2%)</td>
</tr>
<tr>
<td>VG</td>
<td>4 (33.3%, 50%)</td>
<td>4 (33.3%, 50%)</td>
<td>8 (33.3%)</td>
</tr>
</tbody>
</table>

*The first percentage shows the percentage of specimens showing the ganglion, and the second percentage shows the distribution of the particular ganglia between the right and left sides. SG, superior ganglion; MG, middle ganglion; VG, vertebral ganglion; IG, inferior ganglion; CTG, cervicothoracic ganglion.
The IG or CTG were present in all specimens. An IG was present in five specimens. It was at C7 in one specimen and at the C7-T1 intervertebral disc level in four specimens. Its length was 11.3 ± 3.1 mm, its width 6.4 ± 1.9 mm, and its thickness was 3.1 ± 1.1 mm.

In 79.2% of specimens (19 dissections) the inferior ganglion joined with the first thoracic sympathetic ganglion and formed the CTG. The upper pole of the CTG was located at the level of the C7 transverse process in 63.2% of specimens (12 of 19 examples). In 36.8% of specimens (7 of 19 examples) it was located between the first rib and the C7 transverse process. The upper pole of CTG was located medial to vertebral artery (VA) in 68.4% of specimens (13 of 19 examples), posterior to VA in four of 19 specimens, and was located lateral to VA in two of 19 specimens. The mean distance between the superior pole of CTG and the origin of the VA was 12.2 mm. The mean length of the CTG was 20.6 ± 5.6 mm, the mean width was 8.3 ± 2.3 mm, and the mean thickness was 3.9 ± 1.3 mm. No statistically significant differences were found between the right and left CTG.

In eight specimens (33.3%) a fourth ganglion, a vertebral ganglion (VG), was observed anteromedial to the VA (Fig. 3). The VG is linked to SG and CTG through the CST. The fibers exiting this ganglion descended to join to the ansa subclavia, and with C5 and C6 nerve roots. The VG is the smallest ganglion of the CST. The VG was 6.5 ± 2.8 mm in length, 3.9 ± 1.5 mm in width, and 2.3 ± 0.2 mm in thickness.

<table>
<thead>
<tr>
<th>Table 2: Distance Between Ganglia (mm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG-MG</td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
<tr>
<td>Mean</td>
</tr>
</tbody>
</table>

*SG, superior ganglion; MG, middle ganglion; IG, inferior ganglion; CTG, cervicothoracic ganglion.

<table>
<thead>
<tr>
<th>Table 3: Length, Width, and Thickness (mm) of the CST Ganglia*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>SG</td>
</tr>
<tr>
<td>MG</td>
</tr>
<tr>
<td>IG</td>
</tr>
<tr>
<td>CTG</td>
</tr>
<tr>
<td>VG</td>
</tr>
</tbody>
</table>

*SG, superior ganglion; MG, middle ganglion; VG, vertebral ganglion; IG, inferior ganglion; CTG, cervicothoracic ganglion.

Relationship Between the CST and Consistent Structures

The distance between the medial border of CST and the medial border of LCM was 17.4 ± 2.8 mm, 17.0 ± 3.0 mm, 15.5 ± 3.7 mm, 13.7 ± 2.8 mm, 12.4 ± 2.8 mm, and 11.8 ± 3.6 mm, at the levels of the C2–3,
C3–4, C4–5, C5–6, C6–7, and C7-T1 intervertebral discs respectively. The measurements were 17.2 ± 2.7 mm, 16.0 ± 2.9 mm, 14.6 ± 2.8 mm, 13.3 ± 2.8 mm, and 12.4 ± 3.4 mm at the levels of the C3, C4, C5, C6, and C7 vertebrae, respectively (Table 5). Anterior vertebral muscles lay between the anterior tubercles and the CST.

The CST was located anterior to the anterior tubercle of transverse process. The distance between the anterior tubercle of the transverse process and the lateral border of the CST was 3.0 ± 1.5 mm, 3.2 ± 1.6 mm, 3.4 ± 1.9 mm, 3.2 ± 1.5 mm, and 3.9 ± 1.4 mm at the levels of the C2, C3, C4, C5, and C6 vertebrae, respectively (Table 5). Anterior vertebral muscles lay between the anterior tubercles and the CST.

The angle between the CST and the midline was 10.5° ± 1.6° and 11.5° ± 3.0° on the right and left sides, respectively. The CST converged toward midline as the spine was descended. There was no statistical difference between the right and left CST-midline angles.

The CST passed within posterior wall of the carotid sheath on both sides of one cadaver. In this case, the CST was adherent to sheath.

Distances and Angle Between the Medial Borders of Right and Left LCMs

The distance between medial borders of LCM was 5.1 ± 1.8 mm, 7.6 ± 2.3 mm, 10.4 ± 3.3 mm, 13.4 ± 3.2 mm, and 15.3 ± 3.2 mm at the levels of the C2–3, C3–4, C4–5, C5–6, and C6–7 intervertebral discs, respectively. The measurements were 6.0 ± 2.0 mm, 8.9 ± 3.3 mm, 12.3 ± 3.2 mm, 14.0 ± 3.1 mm, and 16.1 ± 3.3 mm at the levels of the vertebral bodies of C3, C4, C5, C6, and C7, respectively. The mean angle between the right and left LCM was 17.0°, and the two muscles diverged from each other as they passed inferiorly.

DISCUSSION

The anterior approach to the cervical spine is a common procedure in spinal surgery. It requires the lateral retraction of the carotid arteries, and dissection of the LCM to expose the anterior aspects of the cervical vertebrae. An anterolateral approach, however, is used for anterior foraminal cervical discectomies and oblique cervical corpectomies (Verbiest, 1968; Jung et al., 1974; Hakuba, 1976; Lesoin et al., 1987; Jho, 1996; George et al., 1999; Özer et al., 1999). Such an approach requires greater retraction of the longus colli and longus capitis muscles. The latter approach has a greater risk of CST injury. George et al. (1999) reported that, after oblique corpectomy, 57% of patients had temporary and 9% had residual Horner’s syndrome. Regardless of the approach used, such an injury may result in transient or permanent Horner’s syndrome. Reducing such a risk necessitates a clear understanding of the morphometric and regional anatomy of the CST. This study has defined the anatomy and location of the CST and its ganglia with respect to relatively constant landmarks, including the LCM, VA, cervical intervertebral discs, bodies of cervical vertebrae, and anterior tubercles of their transverse processes.

The CST is 2.2 ± 0.7 mm in diameter at the level of C6 vertebra where the transverse process is an important surgical landmark. The diameter at this site was reported to be 3–4 mm by Lyons and Mills (1998), and 2.7 ± 0.6 mm by Ebraheim et al. (2000).

The CST is located anterior to the transverse processes. The distances between the anterior tubercles of the transverse processes and the lateral border of the CST are relatively consistent, with values between 3.0 ± 1.5 mm and 3.9 ± 1.4 mm. The distance between the anterior tubercle of the transverse process of C6 and the lateral border of the CST (3.9 ± 1.4 mm) should also be kept in mind for anterior percutaneous sympathectomy procedures.

The CST passes over the LCM (Williams et al., 1995). As observed in one specimen (8.3%), however, the CST can pass within the posterior wall of the carotid sheath. A CST in this location was reported by Lyons and Mills (1998) in 16.7% of their specimens. Such a variation may cause a stretching injury of the CST during lateral retraction of the carotid artery, even during the anterior approach to the cervical spine.

The linear and angular relationships between the CST and the LCM are of great interest. Whereas the right and left CSTs converge as the spine is descended, the LCMs diverge. The CST-midline angle was reported to be 10.0° ± 3.7° and 10.7° ± 4.0° on the right and left respectively (Ebraheim et al., 2000). The same angle was measured as 10.5° ± 1.6° on the right side and 11.5° ± 3.0° on the left side in the present series. This angle should be kept in mind during anterior approaches to the cervical spine.

A comparison of distances between the medial border of the LCM and the medial border of the CST at

### TABLE 5. Distances Between Anterior Tubercles of Transverse Processes and Lateral Border of the CST (mm)

<table>
<thead>
<tr>
<th></th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>3.1</td>
<td>3.3</td>
<td>3.7</td>
<td>3.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Left</td>
<td>3.0</td>
<td>3.1</td>
<td>3.4</td>
<td>3.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Mean</td>
<td>3.0</td>
<td>3.2</td>
<td>3.4</td>
<td>3.2</td>
<td>3.9</td>
</tr>
</tbody>
</table>

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the C3 and C7 levels reflects the aforementioned angular relationship clearly (17.0 ± 3.1 mm vs. 11.8 ± 3.2 mm on the left side; and 17.3 ± 2.4 mm vs. 12.9 ± 3.6 mm on the right side). The distance between the medial border of LCM and the medial border of the CST may range from 8.4–21.2 mm. The results presented are consistent with those reported by Ebraheim et al. (2000). These linear and angular relationships explain the vulnerable position of the CST, particularly during anterior and anterolateral surgery in the lower cervical spine.

The number of ganglia in the CST varies. There were three classic ganglia (SG, MG, and IG) in 20.8%, two ganglia in 45.8%, four ganglia in 12.5%, and another combination of three ganglia in 20.8% of the specimens. Katritsis et al. (1983) reported three ganglia in 20.8% of the specimens. Katritsis et al. (1983) reported three ganglia in 20.8% of cases, two ganglia in 45.8%, four ganglia in 12.5%, and another combination of three ganglia in 20.8% of the specimens. Katritsis et al. (1983) reported three ganglia in 20.8%, two ganglia in 45.8%, four ganglia in 12.5%, and another combination of three ganglia in 20.8% of the specimens.

The findings of this study may be useful for identifying the CST and its ganglia during anterior and anterolateral surgical approaches to the cervical spine. The short distance between the medial border of the LCM and CST in the lower cervical spine should be borne in mind during routine discectomy and corpectomy in this region.
REFERENCES


