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Original Research Article

Surgical anatomy of cervical sympathetic trunk: a cadaveric study

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ABSTRACT

Background: Cervical sympathetic trunk (CST) is at risk of injury during surgical procedures of cervical spine and may result in Horner's syndrome. The purpose of present study was to clearly describe the surgical anatomy of CST with respect to the surrounding structures and to analyse the anatomical variations.
Methods: In this cross-sectional study, 50 cervical sympathetic chains were studied by bilateral neck dissections of 25 formalin fixed human cadavers from the Department of Anatomy, Government medical college Thrissur.
Results: Cervical sympathetic chain was found inside the carotid sheath in 1 (2%) side of neck. Superior cervical ganglion (SCG) was consistently seen in all sympathetic chains. Middle cervical ganglion (MCG) was present in 27 (54%) chains studied; vertebral ganglion (VG) was present in 33 (66%) chains. Inferior cervical ganglion (ICG) was present in 38 (76%) CSTs. In case of stellate ganglion (SG), it was present in 12 (24%) chains. The most common type of CST was type 1 consisting of SCG, VG and ICG (17, 34%). Out of 25 cadavers studied, sympathetic chain appeared similar on right and left sides in 14 cadavers.
Conclusions: This study concludes that variations occur in cervical sympathetic chain with regard to occurrence and measurements of its ganglia. Our study also emphasizes the need for awareness of the CST's anatomy during cervical surgical procedures to prevent inadvertent injury to it.

Keywords: Cervical sympathetic chain, Cervical sympathetic trunk, Cervical sympathetic ganglia, Stellate ganglion, Sympathetic chain, Sympathetic trunk

INTRODUCTION

Cervical part of sympathetic chain differs from other parts of sympathetic trunk in having only three ganglia corresponding to 8 cervical spinal segments and in the absence of white rami communicantes. The cervical sympathetic chain, though important surgically and functionally, anatomical details have not been well documented.

Cervical part of sympathetic chain lies behind the carotid sheath and in front of prevertebral fascia. It extends from the base of skull up to the level of the neck of 1st rib, where it continues as the thoracic chain. Initially the number of sympathetic ganglia corresponds with the number of spinal nerves. Later the upper four fuse to form superior cervical ganglion, 5th and 6th fuse to form middle and 7th and 8th join to form inferior cervical ganglion. Sometimes inferior cervical and first thoracic ganglia fuse to form a cervicothoracic or stellate ganglion.[1] The three ganglia apart from communicating with each other through alternate channels like ansa subclavia, communicate with other important nerve trunk in the deep strata of neck like the vagus, phrenic and recurrent laryngeal nerves.

The development of the cervical sympathetic ganglia may get arrested at some stage and this leads to marked individual variations of the cervical sympathetic trunk in newborn, infants and adults. Based on this concept, Laubmann classified the cervical sympathetic chain to five types according to the number and position of ganglia.[2] Telford in 1935 noted the marked variability of the sympathetic trunk in the cervical region and stated that no two chains are alike in pattern.[3]

Cervical and cervico-thoracic sympathectomies have become an emerging surgical procedure in treatment of patients with post-traumatic stress disorder, sympathetic reflex dystrophy, facial pain, epilepsies, Raynaud's syndrome etc. Cervical spine surgeries, retropharyngeal and para pharyngeal procedures also need the anatomic knowledge of cervical sympathetic chain.

Anatomic variations in the position and pattern of CST were reported in a few studies only. To overcome the above limitation, the present study was undertaken. The purpose of this study was to determine the length, position, pattern and linear relationships of right and left sympathetic trunks and to analyse the variations. The ultimate goal was to delineate anatomy of CST and there-by minimize the chances of CST injury during surgical interventions of neck region.

METHODS

We conducted a cross-sectional study in the department of anatomy, Government medical college Thrissur, Kerala over a period of 1.5 years from December 2016 to May 2018 on cadavers preserved for undergraduate medical education. All 25 cadavers used were males, belonging to Central Kerala, their age may be ranging from 25-60 years as most were unidentified bodies. 50 cervical sympathetic chains were studied by bilateral neck dissection of 25 adult cadavers. Sample size was worked out based on the result from the available literature on the prevalence of increased frequency of vertebral ganglion. The formula used was,[4]

$N=\frac{4pq}{l^2}$.

Inclusion criteria

All adult cadavers of normal gross morphology of neck were included in the study.

Exclusion criteria

Cadavers with difficult exposure of cervical sympathetic chain were excluded.

Ethical considerations

Institutional research board (IRB) approval was obtained before starting the study.

Study procedure

The cervical sympathetic chain was dissected out from the base of skull to neck of second rib as per instructions in Cunningham's practical manual of anatomy. The CST were traced superiorly and inferiorly to locate superior, middle and inferior sympathetic ganglia. Various parameters like size, shape, location of all cervical ganglia, the presence of accessory ganglia and their relations with adjacent structures were noted. All findings were photographed, and the data were documented.

Statistical analysis

Master chart was prepared in Microsoft office excel 2007 worksheet and statistical analysis done using SSPS software version 20.

RESULTS

Gross anatomical parameters of 50 human cervical sympathetic chains were studied in 25 cadavers. All 25 cadavers used were males, belonging to Central Kerala their age may be ranging from 25-60 years as most were unidentified bodies.

Table 1: Different patterns of CST observed.

Types	Patterns
Type 1	SCG-VG-ICG
Type 2	SCG-MCG-ICG
Type 3	SCG-MCG-VG-ICG
Type 4	SCG-MCG.VG-ICG
Type 5	SCG-VG-SG
Type 6	SCG-MCG-SG
Type 7	SCG-MCG-VG-SG

SCG-superior cervical ganglion, middle cervical ganglion, VG-vertebral ganglion, ICG-inferior cervical ganglion, SG-stellate ganglion.

Position of cervical sympathetic chain

A ganglionated cord was observed in all the cadavers studied. The cervical sympathetic chain was seen lying over the longus colli muscle extending from base of skull to neck of first rib. In 49 specimens, the CST was lying over the alar fascia and in 1 chain it was seen inside the carotid sheath.

The mean length of the sympathetic chain was found to be 7.68 cm with a standard deviation of 0.726 cm. The range of length varied from 5.8 cm to 9 cm.

The mean distance of sympathetic chain from the medial border of longus colli muscle at the level of C3 vertebral body was 1.25 cm and C7 vertebral body was 1.236 cm.

Superior cervical sympathetic ganglion

SCG was found in all 50 cervical sympathetic chains studied. The average length of SCG was 26.5 mm. The vertebral level of SCG coincided most frequently with the transverse process of 2nd and 3rd cervical vertebrae (56%). In 6 sides of neck, it was seen over 1st and 2nd vertebrae (12%). In 9 chains, it extended up to 3rd cervical vertebra (18%) and in 7 chains, it extended up to 4th vertebra (14%). Shape of SCG was fusiform in 90% chains and was oval in 10% chains (Figure 1).[5]

Table 2: Types of CST on right and left sides.

Type of chains	Sides		Total
	Right	Left	
	N (%)	N (%)	N (%)
1	9 (18)	8 (16)	17 (34)
2	6 (12)	6 (12)	12 (24)
3	3 (6)	4 (8)	7 (14)
4	0 (0)	2 (2)	2 (4)
5	3 (6)	3 (6)	6 (12)
6	3 (6)	2 (4)	5 (10)
7	1 (2)	0 (0)	1 (2)

Table 3: Percentage distribution of cervical ganglia observed in present study compared with that of other researchers.

Name of investigator	Year of study	No. of CSTs	SCG (%)	MCG (%)	VG (%)	ICG/SG (%)
Kiray	2005	12	100	33.33	33.33	100
Civelek	2008	30	100	74	-	-
Cannon	2009	20	100	48	8	100
Yin	2015	32	100	43.75	12.5	100
Present study	2018	25	100	54	66	100

SCG-superior cervical ganglion, MCG- Middle Cervical Ganglion, VG-vertebral ganglion, ICG-inferior cervical ganglion, SG-stellate ganglion.

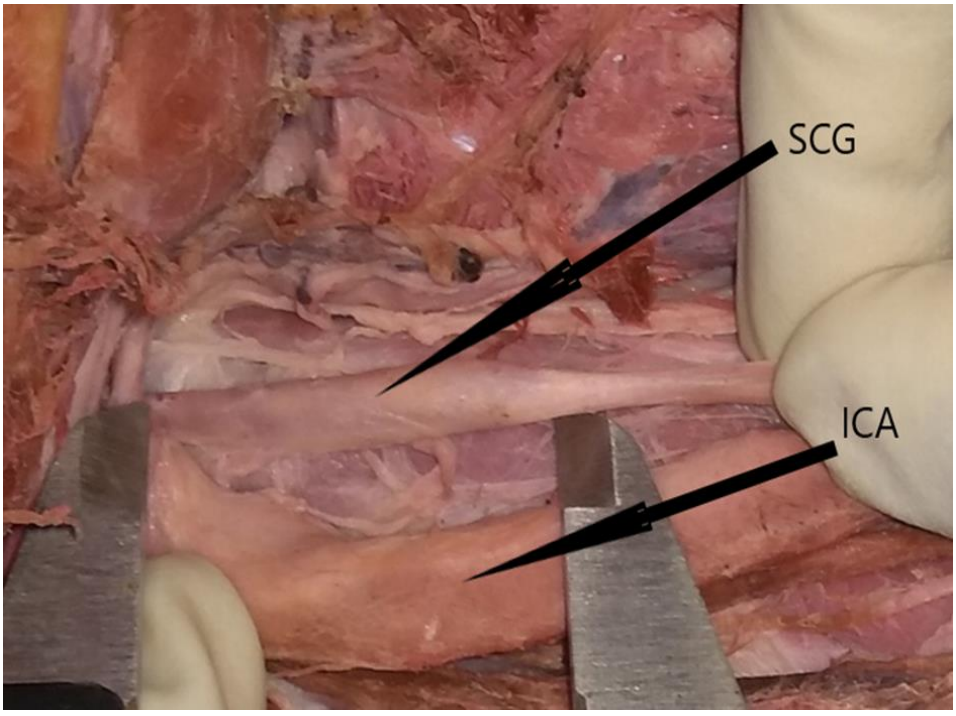

Figure 1: SCG of fusiform shape (SCG-superior cervical ganglion, ICA-internal carotid artery).

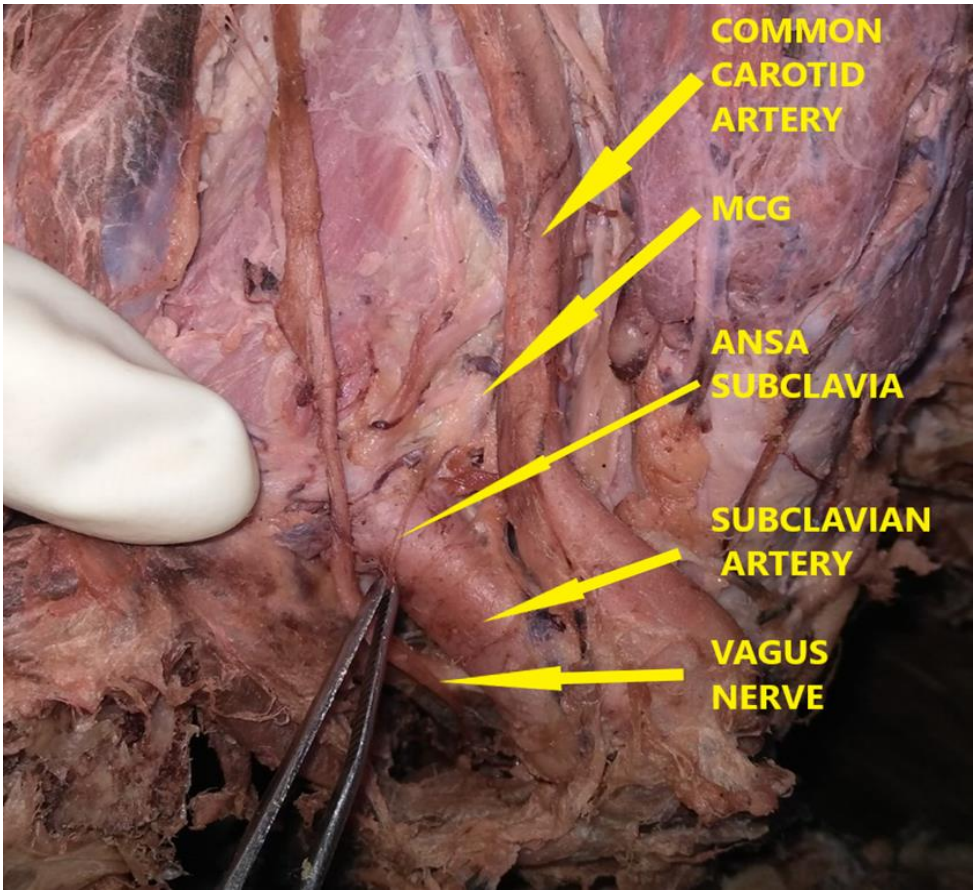

Figure 2: MCG-middle cervical ganglion.

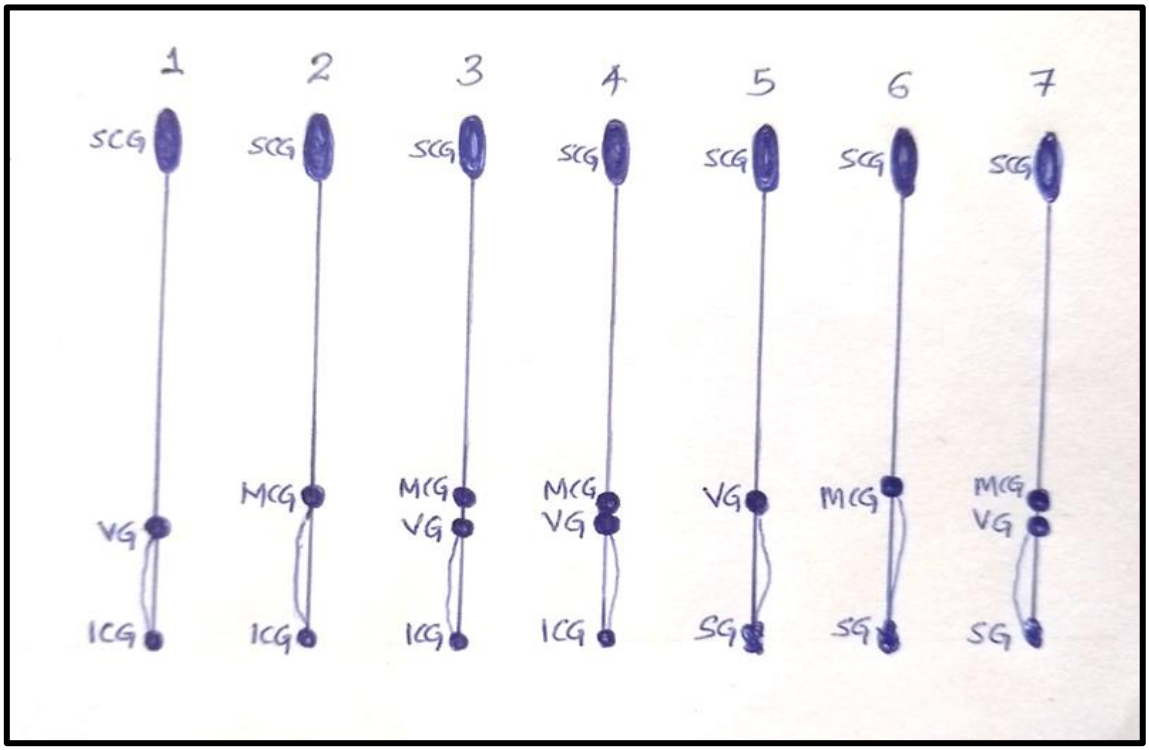

Figure 3: Different patterns of CST observed.

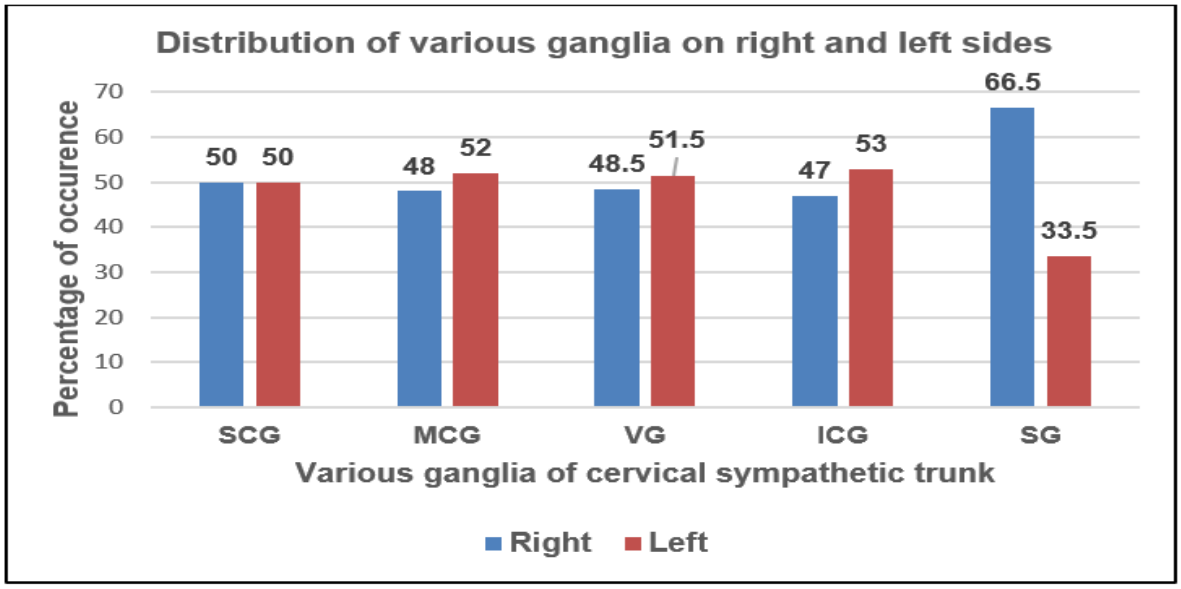

Figure 4: Distribution of various ganglia on right and left sides.

MCG

MCG was seen only in 27 chains. 13 were on right side and 14 were on left side. The mean length of MCG was 5.7 mm (Figure 2). Most frequently, MCG was located at the level of 6th cervical vertebral body (11 CSTs). In 8 CSTs it was seen at the level of C5. It was seen at the level of C5-C6 and C6-C7 in 3 CSTs each. Only in one chain, MCG was found at the level of C7 vertebra. The shape of MCG varied between oval (17) irregular (4) fusiform (4) and round (2). It was closely related to Inferior thyroid artery (ITA) in all CSTs. Among the 27 MCGs observed, 52% (14) were posterior, 22% (6) were anterior, 15% (4) were superior and 11% (3) were inferior to the ITA.

VG

The VG was present in 33 CST studied. 16 were on right side and 17 were on left side. The average length was 8.87 mm. In 20 CSTs it was seen at the level of C7 vertebra and in 13 CSTs, it was seen at the level of C6 vertebra. The shape was irregular and in all CSTs, it was closely related to vertebral artery.

MCG and VG

MCG and VG did not co-exist in majority of the chains. Only in 10 CSTs both MCG and VG co-existed. There was an apparent fusion of MCG and VG in two chains.

ICG

The ICG was present in 38 chains (76%) with an average length of 7.68 mm. 18 were on the right side and 20 were on the left side. ICG was seen at different vertebral levels namely C7 vertebra (24), C7 1st rib (6), 1st rib (6) and C6-C7 vertebra (2).

SG

SG was present in 24% (12) chains, where no separate ICG was seen, of which 8 were on right and 4 on left side. Its average length was 18.3 mm and mostly over transverse process of 7th cervical vertebra.

Different patterns of CST observed

Cervical sympathetic chains varied in their length and presence or absence of the ganglia. CST of the right and left sides also varied in a cadaver. Arbitrarily classified seven different types of CST were observed in the present study as shown in Table 1 and Figure 3. Different patterns of CST observed. The most common pattern of CST was found to be type 1 with SCG, VG and ICG (17, 34%). Type 2 CST was found in 12 (24%), type 3 in 7 (14%), type 4 in 2 (4%), type 5 in 6 (12%), type 6 in 5 (10%) and type 7 in 1 (2%) (Table 2).

Cervical sympathetic chain on right and left sides

Cervical sympathetic chains on right and left sides were similar in 14 cadavers studied. But in 11 cadavers, the type of chain was different between right and left sides. The distribution of ganglia on right and left side is shown in Figure 4. Upon statistical analysis, there was no significant difference between the distribution of type of chain and side of the cadaver, that is, type of chain was comparable in right and left side of the cadaver (p=0.881) (Table 2).

Results of the study indicated the importance of the awareness of the variations by the surgeons to avoid chances of injury to CST during surgical interventions of neck.

DISCUSSION

We dissected 50 human sympathetic chains in 25 adult cadavers to study their length, position and pattern. Also, the variations were analysed on right and left sides. In the present study, SCG appeared in all CSTs. MCG was present in 27 (54%) chains studied, 13 were on right side and 14 were on left side, VG was present in 33 (66%) chains studied, 16 were on right side and 17 were on left side. ICG was present on 38 (76%) chains, 18 were on right side and 20 were on left side and in case of SG, it was present in 12 (24 %) chains, 8 on right and 4 on left side.

The frequency of occurrence of SG on right side was twice more than left which was not reported in any of the previous studies. The study revealed wide variations in the position and pattern of CSTs bilaterally.

Position of cervical sympathetic chain

The cervical sympathetic trunk extended from the base of skull to the neck of the first rib to continue as thoracic part. It had a straight course in the neck lying behind the carotid sheath and in front of prevertebral fascia.[1,4-6] In our study, the CST was lying in the alar fascia over the longus colli muscle behind the carotid sheath in 98% CSTs studied. In one specimen (2%), CST was found to be inside the carotid sheath. The CST can pass within the posterior wall of the carotid sheath. A CST in this location was reported by Lyons et al in 16.7% of their specimens.[7]

The mean length of the sympathetic chain was found to be 7.68 cm with a standard deviation of 0.726 mm. The average distance of CST from the medial border of ipsilateral longus colli muscle at the level of C3 and C7 was obtained as 12.5±3.41 mm and 12.36±3.998 mm respectively. Ebraheim et al 2000 and Kiray et al 2005 measured the average distance of CST from the medial border of ipsilateral longus coli muscle at the level of C3 as 17.2 mm and C7 as 12.4 mm.[8,9] Also, Saylam had reported that CST converge medially.[5]

SCG

SCG was a constant finding in all CSTs studied. This was consistent with previous studies.[5,10-14] No variation in its number was obtained in the present study.

The length of SCG was ranging from 1.6 cm to 4.2 cm. In one case it was 4.2 cm long. 6.5 cm long SCG was noticed by Kalsey et al.[15] It was noted that the average length ranged from 2.5 to 4 cm, in earlier studies of Civelek et al and Kalsey et al.[6,15]

Internal carotid nerve arising from the upper pole of SCG and extending to the cranial cavity along with the internal carotid artery was noted in all CSTs and was relatable to findings of Kuntz.[16]

Kalsey et al 2000 and Hoffman 1957 reported that the shape of SCG as fusiform.[15,17] In the present study, SCG was fusiform in shape in 45 CSTs and oval in shape in 5 CSTs. Gray described the SCG, as the largest of all sympathetic ganglia.[18] According to Fazliogullari et al, SCG served as a landmark for locating cervical sympathetic trunk in the neck.[14]

In majority of CSTs, SCG was seen over the transverse process of 2nd and 3rd cervical vertebrae. Civelek et al 2000 reported a case of SCG extending from transverse process of C1 to C4.[6]

MCG

The MCG was present only in 54% CSTs. Sheehan et al mentioned absence of MCG in CST.[4,16,19] Though Laubmann et al observed the fused SCG and MCG named as medio-superior cervical ganglion, we didn't spot it.[2,20]

The MCG was closely related to inferior thyroid artery, either superior, inferior, anterior or posterior. This relation was reported in earlier works by Sheehan et al and Kuntz.[4,15,16]

Kasley et al mentioned the shape of MCG as oval in 54.3% CSTs studied. In the present study 63% of the MCG were oval in shape.[15]

The position of MCG was found to be lying over the transverse process of C6 vertebra in 11 (40.7%) of CSTs. It was on the transverse process of C5 vertebrae in 8 (29%) of CSTs. In 4 CSTs, it was on C4-C5 level, in 3 CSTs, it was on C5-C6 level and in 1 CST, it was at C7 level. The previous studies have reported the frequent absence of MCG and if present lied at the level of 6th cervical vertebra in close relation with inferior thyroid artery.[10,15,21]

VG

VG was present in 66% CSTs and more frequent than MCG which was an increased incidence than that reported in the previous studies. Sheehan et al reported the increased frequency of VG than MCG in their works.[4,21] An apparent fusion between VG and MCG was mentioned in earlier study done by Laubmann et al in 2% chains, known as medio-vertebral cervical ganglion which was also seen in the present study in 4% chains.[2,20]

VG was seen closely related to 1st part of vertebral artery anteriorly or antero medially. This finding was consistent with that of previous study of Becker et al and Wrete.[10,20]

The vertebral level of VG was at C7 level in 60.60% chains and at C6 level in 39.4% chains. Becker et al noted C7 vertebral level as the frequent location in 87.7% chains studied.[10]

Relation between VG and MCG

Occurrence of MCG and VG varied in the chains studied. Only MCG was present in 17 (34%) CSTs studied; only VG was present in 23 (46 %) CSTs. Both the MCG and VG co-existed in 10 CSTs (20%). We couldn't find any CSTs with the absence of both MCG and VG.

Woolard et al 1933 had suggested that VG merely represented a detached portion of either MCG.[22] Gray's anatomy also mentioned that the VG was considered as a detached part of MCG.[23] In the present study, MCG and VG were approximately equal in size ranging from 0.5 to 1 cm in length. It was noted that the size of VG was constant irrespective of presence or absence of MCG. The size of MCG also, was constant irrespective of the presence or absence of VG. With these observations, VG could be considered as a frequent entity within CST.

A medio-vertebral ganglion was found in only 2 CSTs and both were present on the left sided CSTs. Co-relation between length of MCG and VG were statistically analysed and found that there was a relation between length of MCG and VG. But this relation was negative and was not statistically significant.

ICG

ICG was present in 76% of CSTs. It was a small irregular ganglion. In majority of CSTs, it was seen on the transverse process of 7th cervical vertebra. In all CSTs it was present dorsal to the subclavian artery. These findings were similar to that of Kuntz.[16]

SG

The SG was seen lying ventral to the neck of 1st rib as an irregular mass with constrictions. It appeared to be extending up to the neck of 2nd rib. Stellate ganglion was present in 24% CSTs, where no separate ICG was seen. Kalsey et al and Wrete et al reported the presence of SG more than that of ICG.[15,20,24] But according to Sheehan et al and White et al the incidence of SG was less.[4,10,21]

The ganglionated mass was extended down up to the neck of 2nd rib in 3 CSTs. But none of them were fused with 2nd thoracic ganglion. Kalsey et al and Woollard et al had observed such type of SG in their studies.[15,22,24] Percentage distribution of cervical ganglia in our study was compared with that of other researchers in Table 3.

Different patterns of CST and distribution of ganglia on right and left sides

In the present study, chains with SCG, VG and ICG were the commonest (type I, 34%). According to Laubmann, the commonest type was chain with SCG, MCG and VG.[2]

The types of chain present on right and left sides in a cadaver were observed. Out of 25 cadavers studied, 14 cadavers had similar type of CST on both sides (56%) and in 11 CSTs, it varied. According to Zhang et al, 16% cadavers had bilaterally similar cadavers.[25]

According to the statistical analysis of the present study, there was no significant difference between the distribution of type of chain and side of the cadaver, type of chain was comparable in right and left side of the cadaver ($p=0.881$).

According to Yin et al 2015 SCG was consistently present, the MCG, ICG and SG were absent in some cadavers and no significant difference was noticed between CST of right and left sides.[13] In our study, presence of SG was more on right side (66.66 %). The increased presence of SG was not mentioned in any of the previous studies. Regarding distribution of various ganglia on both sides, no significant differences were found between the left and right side ($p>0.05$).

Limitations

As the study subjects were of male sex and included unidentified dead bodies received by the department, correlation with age and sex was not done in our study.

CONCLUSION

Our cross-sectional study of 50 cervical sympathetic chains throws light towards its varied anatomy with regard to size, shape, occurrence, pattern and vertebral level of ganglia within it. The SCG was consistently present in all 50 chains. We noticed more frequent presence of the VG compared to middle cervical ganglion. SG when occurred was more frequent on right side. Detailed knowledge of the anatomy and variations of CST is a pre-requisite while performing cervical spine surgeries, SG block, and other emerging surgical procedures of neck. Awareness of the variations of CST equips the surgeon to identify and preserve it during surgical interventions of neck, thus reducing CST injury.

Recommendations

The authors suggest that the study of CST should be correlated to age and sex of the cadaver and to conduct the study on fresh cadavers within 24 hours of post-mortem for accurate measurements.

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