Original Article



A Study on Thoracic Splanchnic Nerves: Anatomo-surgical Appraisal

Abstract

Introduction: The thoracic splanchnic nerves greater, lesser, and least are derived from medial branches of the lower seven thoracic sympathetic ganglia; they carry preganglionic fibers, pierce the diaphragmatic crura, and supply the abdominal viscera through coeliac and aorticorenal plexus. These splanchnic nerves carry pain conducting visceral afferent fibers from the upper abdominal organs, including the pancreas. The origin of the splanchnic nerves from different roots may have a significant role in clinical presentation of patients than the normal or absence of consecutive nerve roots. Material and Methods: The study was done on 26 formalin-fixed cadavers (52 sides) from the Chettinad Hospital and Research Institute, Chennai, and University College of Medical Sciences, Delhi. The endothoracic tissue and the parietal pleura in the paravertebral region were carefully removed from the 1st rib to 12th rib (costodiaphragmatic recess). The thoracic sympathetic chain and its medial branches were traced from its origin to medial arcuate ligament. Any variations in the origin, formation, and communication of the splanchnic nerves were noted and photographed. Results: The origins of splanchnic nerves were bilaterally asymmetrical in most of the cases. The greater splanchnic nerve (GSN) was always present, whereas lesser splanchnic nerve and least splanchnic nerve were found to be absent in 40% and 80% cases, respectively. The GSN showed great variability both in the level of its origin and in the pattern of its formation. In the present study, four different patterns of GSN origin were observed in addition to normal. Discussion and Conclusion: Significant differences were noted in the formation and communication between the thoracic splanchnic nerves. The patterns in the formation were not only different from cadaver to cadaver but also were bilaterally asymmetrical.

Keywords: Chronic abdominal pain, splanchnic nerves, splanchnicectomy, sympathectomy

Introduction

The lateral most content of the posterior mediastinum is the thoracic sympathetic chain, a continuation of the cervical sympathetic chain. It lies posterior to the costal pleura. There are typically 11 thoracic ganglia; the branches from the upper five are very small and supplies minute filaments to the thoracic aorta and its branches. Whereas, the lower six to eight ganglia gives origin to the three splanchnic or visceral nerves which give a rich supply to the abdominal viscera. The splanchnic nerves carry preganglionic fibers, pierce the diaphragmatic crura, and supply the abdominal viscera through coeliac plexus.^[1]

The greater splanchnic nerves (GSNs) were formed by nerve branches from the T5 to T9 sympathetic ganglia. The highest contribution of the sympathetic chain leading to the formation of GSN is documented as the T4 or T5

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These splanchnic

ganglia.^[4]

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ganglia.^[2] The most caudal contribution

leading to its formation could be as low as

the T12 ganglion.^[3] It descends through the

posterior mediastinum and pierces the crura

of the diaphragm on either side to terminate

The lesser splanchnic nerves (LSNs) were

formed by nerve branches from T10 to

T11 sympathetic ganglia and also from the

trunk between them and descend through

the posterior mediastinum along with the

GSNs, pierce the crura of the diaphragm

to ultimately join the aorticorenal ganglion.

Edwards and Baker found the origin of

the LSN from the T9 to T12 sympathetic

The least splanchnic nerves (ISNs)

composed of nerve branches from the

T11 to T12 thoracic sympathetic ganglion

or only T12. It pierces the crura of the

conducting visceral afferent fibers from

nerves carry

pain

diaphragm to end in the renal plexus.

finally in the coeliac ganglion.

N. Esakkiammal, W. M. S. Johnson¹, Mariappan Senthiappan Arathi², Rajasundaram Archana¹

Research Scholar in Anatomy, BIHER, ¹Department of Anatomy, Sree Balaji Medical College and Hospital, BIHER, ²Department of Anatomy, Chettinad Hospital and Research Institute, Chennai, Tamil Nadu, India

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Address for correspondence: Dr. Rajasundaram Archana, Department of Anatomy, Sree Balaji Medical College and Hospital, # 7 Works Road, Chrompet, Chennai - 600 044, Tamil Nadu, India. E-mail: archana09@yahoo.com



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pancreas. They also carry visceral efferent fibers to these organs.^[5] The origin of the splanchnic nerves from different roots may have a significant role in clinical presentation of patients than the normal or absence of consecutive nerve roots.^[6]

These splanchnic nerves may have intermediate splanchnic ganglia (ISG) that represents embryonic displaced cells of neural origin from the primordia of sympathetic trunk ganglia. Intermediate ganglia, present on the thoracic splanchnic nerves, is connected to aortic plexuses and could be functioning as a residual pathway for pain transmission after sympathectomies.^[7]

Splanchnicectomy, the surgical interruption of these nerves, has been shown to be an effective treatment in the control of abdominal pain due to chronic pancreatitis, cancer of the pancreas, or any other upper abdominal viscera.^[6] The outcome of these procedures can be unpredictable and is, in part, dependent on the exact knowledge of the variations in the origin of GSNs, LSNs, and ISNs.^[6,8-10] Variation in the formation of splanchnic nerves is enormous, therefore, the present study was done to help the surgeons to be aware of all kinds of variations preoperatively so as to prevent uneven degrees of symptom relief.

Material and Methods

The present study was done in the Department of Anatomy, Chettinad Hospital and Research Institute, Chennai, and University College of Medical Sciences, Delhi, on 26 formalin-fixed cadavers. The anterior thoracic wall of each of the cadaver was reflected the lungs and heart were removed to expose posterior mediastinum. Then, the endothoracic tissue and the parietal pleura in the paravertebral region were carefully removed from the 1st rib to 12th rib (costo-diaphragmatic recess). The thoracic sympathetic chain was traced from its origin to medial arcuate ligament. Variations in the origin, formation, and communication of splanchnic nerves were noted and photographed.

Results

Variations in the origin, formation, and communication of splanchnic nerves were studied in 26 formalin-fixed cadavers (52 sides). The origins of splanchnic nerves were bilaterally asymmetrical in most of the cases. The GSNs were always present, whereas LSNs and ISN were found to be absent in 40% and 80% cases, respectively.

The GSNs showed great variability both in the level of its origin and in the pattern of its formation. Normally, the GSN originates from the T5 to T9 thoracic sympathetic ganglia. In the present study, the origin of GSN was found to be normal in 20.8% of cases. In addition, four other different patterns of GSNs origin were observed [Table 1]. In this study, the most common pattern of origin of GSNs was from T6 to T10 ganglia [Figure 1], and the incidence

was 36.2% which was more than the normal pattern of origin.

The incidence of GSN, LSN, and ISN was compared with other authors and tabulated [Table 2].

The LSNs take origin from T10 to T11 thoracic sympathetic ganglia. In the present study, the origin of LSN was found to be normal in 24.5% of cases. In addition, in 36.2% of cases, the LSNs originated from T11 to T12 ganglia [Figure 2]. In 40% of cases, the LSNs were absent.

With respect to ISN, in the present study, it was absent in 80% of cases. In 20% of cases, it originated from T12 thoracic sympathetic ganglia [Figure 1]. No variations were observed in the origin of the ISN.

ISG can be observed only on the trunk of GSN whenever present. Unilateral ISG was observed on the main trunk of GSN in one specimen in the present study [Figure 3].

Intersplanchnic connections may occur between GSN and LSN or between LSN and ISN. In the present study, intersplanchnic connection was observed bilaterally between GSN and LSN in one specimen [Figure 2].

Discussion

Splanchnicectomy is an effective method of management for chronic abdominal pain. The inconsistent results of splanchnicectomy may be due to anatomical variations in the pattern of splanchnic nerves. Clinically, the morphology of origin of splanchnic nerves is of greater significance. The origins of splanchnic nerves were bilaterally asymmetrical

Table 1: Different patterns of origin of greater splanchnic nerve (n=52)		
Origin	Incidence %	
$\overline{T_5-T_9}$	24.5	
$T_6 - T_9$	14.8	
$T_{6}^{-}-T_{10}^{-}$	36.2	
T ₆ -T ₁₁	12.7	
T ₇ -T ₁₀	11.8	

Table 2: Comparative report of the incidence of splanchnic nerves by various authors with the present study

Author and year	GSN %	LSN %	ISN %
Edwards and Baker et al. (1940)	100	94	17
De Sousa et al. (1955)	100	100	80
Jit and Mukerjee et al. (1960)	100	86	37
Naidoo et al. (2001)	100	92.1	55.2
Gest and Hildebrandt (2009)	100	100	57
Dayal and Manjunath (2014)	100	95.45	67.5
Present study	100	60	20

GSN: Greater splanchnic nerve, LSN: Lesser splanchnic nerve, ISN: Least splanchnic nerve

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Figure 1: Photograph of the dissection of the origin of splanchnic nerves. Origin of greater splanchnic nerves from T6 to T10 ganglia and the origin of least splanchnic nerves from T12 to ganglia. SG – Stellate Ganglion, TG – Thoracic Ganglion

in most of the cases. The GSNs were always present, while LSN and ISN were inconsistent.^[6]

Groen *et al.* studied the formation of GSNs in fetuses and found ten different patterns, of which formation from T5 to T10 sympathetic ganglia was the most common pattern.^[11] Reed observed 58 different patterns of formation of the GSNs, of which the most common was from T6 to T9.^[12] Swayamjothi *et al.* observed the similar pattern of formation GSN in 20% of cases.^[13] In the present study, four different patterns of formation of GSNs were observed, the most common was from T6 to T10 ganglia (36.2%) [Table 1].

In the current study, the highest origin of nerve branch in the formation of GSN was from T5 and the lowest was from T7. The highest root of origin in the formation



Figure 2: Photograph of the dissection of the origin of splanchnic nerves and intersplanchnic connections: Origin of lesser splanchnic nerves from T11 toT12 ganglia. Intersplanchnic connections between greater splanchnic nerve and lesser splanchnic nerve. SG – Stellate ganglion, TG – Thoracic ganglion

of GSN was from T3 ganglion in the study conducted by Dayal and Manjunath (2014).^[14] Reed and Swayamjothi *et al.* observed highest nerve root from the T4 ganglion and lowest from T8 to T11, respectively.^[12,13] Stone and Chauvin reported that highest root contributing to the formation of GSN was from T4 or T5 and T6 was seen in the study of Groen *et al.*^[11,15] Lowest thoracic ganglia contributing to the formation of GSN was from T11 according to Groen *et al.* and T12 according to Hollinshead.^[3,11] The surgeons should be aware of variations, as the origin of nerve branch for GSN may arise from T3 to T6 sympathetic ganglia and the lowest from T7 to T12 so as to avoid inconsistent results with respect to pain management.

The incidence of LSN is variable [Table 2]. LSN was present in 60% of the sides in the present study. The most common origin of LSN was from T10 to T11 ganglia (47%) according to Jit and Mukerjee and Groen *et al.*^[11,16] According to the study of Naidoo *et al.*, LSN most

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Figure 3: Photograph of the dissection of intermediate splanchnic ganglia: Origin of intermediate splanchnic ganglia from the main trunk of greater splanchnic nerve. TG – Thoracic ganglion

Table 3: Comparison of incidence of intermediate				
splanchnic ganglia as observed in various studies with				
the present study				

Study	Incidence of ISG (%)
Toni and Frignani et al. ^[19]	45
Jit and Mukerjee et al.[16]	39
Naidoo <i>et al.</i> [6]	39
Present study	4.3
	1.

ISG: Intermediate splanchnic ganglia

commonly arose from T11 to T12 ganglia (55.2% cases).^[6] In about 36% of cases, T11 to T12 ganglia contributed to the formation of LSN in the present study.

ISN was absent in 43%, 32.95%, and 43% of cases according to Naidoo *et al.*, Dayal and Manjunath, and Gest and Hildebrandt, respectively.^[6,14,17] Absence of ISN varies from 1.7% to 83% of cases.^[18] In the present study, ISN was absent in 80% of cases. In the remaining 20% of cases, it originated from T12 to thoracic sympathetic ganglion.

The incidence percentage of GSN in the present study is in accordance with the previous studies (100%). The lowest incidence of LSN was observed in the present study (60%) as compared to previous studies. Incidence percentage of ISN is higher in previous studies as compared to the

present study [Table 2]. The presence of ISN in the current study (20%) is more or less equal to the Edwards and Baker study (17%).^[4] The inconsistent results of splanchnicectomy could be due to the anatomical variations in the splanchnic neural pattern.

Naidoo *et al.* reported that whenever ISG is present, it is found only in the trunk of GSN.^[6] Medial collateral branches from these ISG joined with the plexus around esophagus and aorta. In the present study, the ISG was present in 4.3% of the cases out of the 26 cadavers dissected. Jit and Mukerjee and Naidoo et al reported 39% incidence of ISG in their study; Toni and Frignani on the other hand reported an incidence of 45% cases out of 40 observed.^[6,16,19] The incidence of ISG was less in the present study as compared to the previous reports by various authors [Table 3].

Recurrent pain following splanchnicectomy in patients could be due to medial collateral branches of ISG which provides an alternate neural pathway through aortic and esophageal plexuses to the upper part of thoracic sympathetic chain. The surgeons must also be aware of intersplanchnic connections to avoid the recurrence of symptoms postoperatively.

In the present study, intersplanchnic connection was observed between GSN and LSN bilaterally only in one cadaver, that is, 8.3%. Naidoo *et al.* (2001) reported that the intersplanchnic connection may occur between the GSN and LSN or between LSN and ISN; according to their study, the intersplanchnic connections between the GSN and LSN was in 38% of cases.^[6] Dayal and Manjunath observed intersplanchnic connection between GSN and LSN in 9% of cases, that is, four sides of adult cadavers and two sides of fetal specimen.^[14] Intersplanchnic connection was less in the current study (8.3%) in comparison to the study of Naidoo *et al.* (38%) and more or less equal to Dayal and Manjunath study (9%).^[6,14]

Conclusion

Splanchnicectomy is the treatment of choice for chronic abdominal pain such as chronic pancreatitis, carcinoma of the pancreas, liver, gall bladder, and stomach. In the present study, different patterns in the origin, formation, and communications of splanchnic nerves were observed. Surgically, the knowledge of anatomical variations in the splanchnic neural pattern is of utmost importance to prevent the unsuccessful outcome of splanchnicectomy. ISG was observed in two specimens in the trunk of GSN in the present study. In patients where the recurrence of pain occurs following splanchnicectomy, the cause could be medial collateral branches of ISG providing an alternate neural pathway through aortic and esophageal plexuses to the upper part of thoracic sympathetic chain. Thus, splanchnicectomies are dependent on the detailed knowledge of the anatomy of these nerves and their variations.

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Conflicts of interest

There are no conflicts of interest.

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