

# A Morphological study of the Intermediate Splanchnic Ganglion

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## ABSTRACT

**Introduction:** Intermediate ganglia are located outside the sympathetic trunk on the rami communicantes, splanchnic nerves, sympathetic branches or spinal nerves. Splanchnic ganglion of the greater splanchnic nerve was first described by Lobstein in 1823. These ganglia give off medial branches to the aortic coat, celiac plexus, superior mesenteric plexus, renal plexus or oesophageal plexuses. Splanchnic nerves with intermediate ganglia are neural structures with synaptic relay and not just conduction pathways.

**Aim:** To study the incidence and structure of the intermediate ganglion in relation to thoracic splanchnic nerves and its connections in cadavers.

**Materials and Methods:** Study design consisted of 50 cadavers of either sex, between 45 and 70 years of age, embalmed by conventional method for undergraduate Anatomy classes. After the removal of thoracic and abdominal viscera, the diaphragm was cut close to posterior abdominal wall and the parietal pleurae were carefully stripped off the posterior thoracic wall. Thoracic splanchnic nerves were defined and traced to the sympathetic trunk. Size, location,

branches and microanatomy of the intermediate ganglion, if any, present on the thoracic splanchnic nerves were studied.

**Results:** Intermediate splanchnic ganglia were observed macroscopically on the greater splanchnic nerve in 52% of the right and left sides of 50 cadavers examined. Bilateral presence of ganglia was seen in 13 cadavers. The trunk of the greater splanchnic nerve was thickened in 12 specimens where a macroscopic ganglion was not appreciated. Microanatomy of the intermediate ganglion, studied by haematoxylin and eosin stain, demonstrated a structure similar to that of sympathetic ganglion. Presence of macroscopic ganglion and nerve thickening was not observed in lesser or least splanchnic nerves.

**Conclusion:** Present study demonstrates the location of the intermediate splanchnic ganglia and its medial branches which communicates with aortic plexus. Intermediate splanchnic ganglia connected to aortic plexuses could act as a residual pathway after sympathectomies. Thus, denervation of the medial branches may also be needed in future to have complete pain relief after sympathectomies.

**Keywords:** Greater splanchnic nerve, Splanchnicectomy, Sympathectomy, Thoracic Splanchnic nerves

## INTRODUCTION

Ganglion that is located outside the sympathetic trunk, on the rami communicantes, splanchnic nerves, spinal nerves or sympathetic branches, is regarded as intermediate ganglion [1]. Splanchnic ganglion of the greater splanchnic nerve was first described by Lobstein in 1823 [2]. These ganglia give off numerous medial branches to the aortic coat, and sometimes to the celiac plexus, superior mesenteric plexus, renal plexus or oesophageal plexuses [3,4]. Intermediate splanchnic ganglion situated on the thoracic splanchnic nerves are considered as neural structures with synaptic relay and not just conduction pathways [5].

Abdominal pain is the major clinical problem that affects the quality of life in patients suffering from chronic pancreatitis

and carcinoma of pancreas. Surgical denervation of splanchnic nerves through minimal access thoracoscopic surgery has highly reduced the morbidity in these patients but with inconsistent results. Intermediate ganglia present on the thoracic splanchnic nerves are connected to aortic plexuses and could be functioning as a residual pathway for pain transmission after sympathectomies [1,5]. The present cadaveric study in South Indians aims to identify the incidence, morphology, connections and microanatomy of the intermediate splanchnic ganglion.

## MATERIAL AND METHODS

Present study was a descriptive observational study done during the period of June 2011 to April 2017 in the department of Anatomy in Aarupadaiveedu Medical College affiliated

to Vinayaka Missions University, Salem, with the approval of ethical committee. Study sample included 50 cadavers of either sex, between 45 and 70 years of age, which were available for dissection during the above period. The present study is limited to adult cadavers. The foetal specimens have not been included. The cadavers with congenital deformity of thoracic wall, pleural adhesions or tissue damage due to flawed dissection were excluded from the study. After the removal of the thoracic and abdominal viscera for undergraduate teaching, the diaphragm was cut close to the posterior abdominal wall. The parietal pleurae were carefully stripped off the posterior thoracic wall to expose the thoracic sympathetic trunks and their medial branches. Thoracic splanchnic nerves were defined and traced to the sympathetic trunk. Intermediate splanchnic ganglion, if any, present on the splanchnic nerves were studied with regard to their location, size, and connections. Length and width of the ganglion was measured by digital Vernier caliper. Microanatomy of the intermediate splanchnic ganglion was studied by examining 4 $\mu$  thick sections of paraffin embedded tissue stained with haematoxylin and eosin. Microanatomy of the thickened greater splanchnic nerve was studied in few specimens. Statistical analysis was done for the data obtained with SPSS 19.

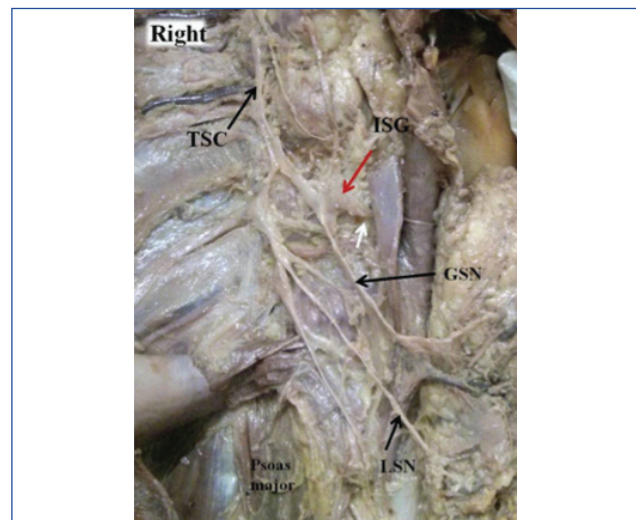
### Observations

Intermediate Splanchnic Ganglion (ISG) was observed in 52% (Right side-29; left side-23) of the specimens [Table/Fig-1]. Bilateral presence was found in 13 cadavers (Female-5; male-8). No statistically significant differences were found in the occurrence of ISG in male and female cadavers ( $p$ -value=0.468) or left and right sides ( $p$ -value=0.23). These ganglia were observed only on the Greater Splanchnic Nerve (GSN) and gave off medial branches which terminated in aortic plexuses [Table/Fig-2]. There were no communications between the branches of ISG and other splanchnic nerves. ISG were elliptical, round or linear in shape. Size of the ganglion ranged from 0.31x0.23 cm to 2.73x0.21 cm.

ISG were located at the level of T10, T11 or T12 thoracic vertebrae, on the GSN. In four specimens, ganglion was present in one of the roots of the GSN, at the level of T8, T9, T10 and T11 vertebrae [Table/Fig-3]. Thickening of the GSN at one or more points along the nerve was observed in 12 of the 48 specimens in which the macroscopic splanchnic ganglia was not appreciated [Table/Fig-4]. ISG were not observed on the lesser or least thoracic splanchnic nerves.

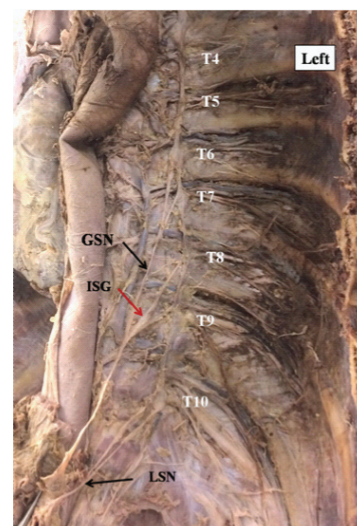
Sample	Intermediate Splanchnic ganglion		
	Right	Left	Total
Female (n=38 sides)	9	9	18
Male (n=62 sides)	20	14	34
Total	29	23	52

**[Table/Fig-1]:** Incidence of the intermediate splanchnic ganglion in the present study



**[Table/Fig-2]:** Intermediate splanchnic ganglion (ISG) with medial collateral branch (white arrow).

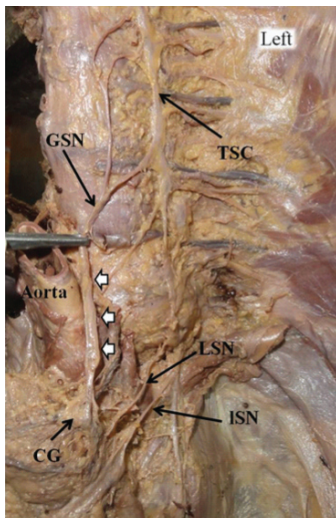
GSN: Greater splanchnic nerve; TSC: Thoracic sympathetic chain; LSN: Lesser splanchnic nerve



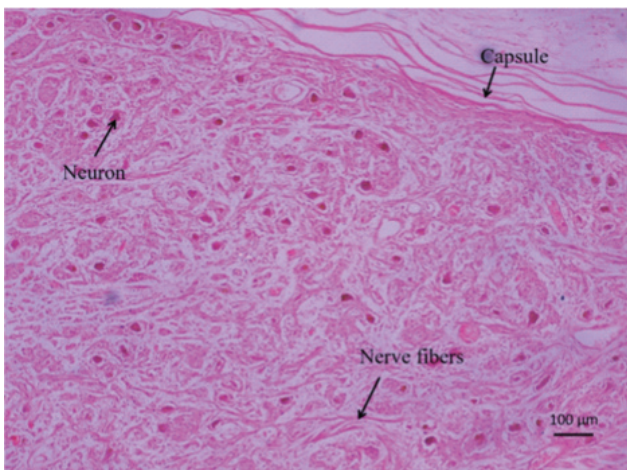
**[Table/Fig-3]:** Intermediate splanchnic ganglion (ISG) on the root of the greater splanchnic nerve (GSN) arising from the T8 ganglion.

GSN: Greater splanchnic nerve; LSN: Lesser splanchnic nerve

ISG observed macroscopically were studied by haematoxylin and eosin stain. Microanatomy of the ISG demonstrated multipolar neurons with eccentrically placed spherical nuclei and prominent nucleoli. The cytoplasm showed Nissl substance and golden brown lipofuscin pigment. A layer of flattened satellite cells were seen surrounding the neurons. Interstitial connective tissue revealed nerve fibres, nuclei of Schwann cells and few capillaries [Table/Fig-5-7]. Microanatomy of the thoracic splanchnic nerves was not done. However, microanatomy of the thickened part of the GSN was done in few specimens, out of interest, did not reveal any ganglionic cells and needs to be studied further.



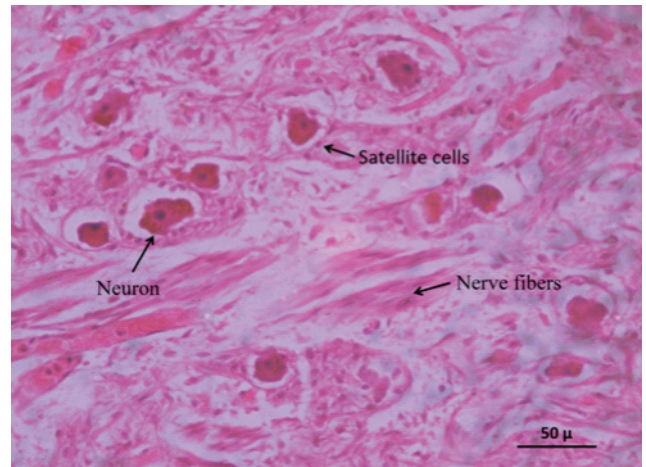
**[Table/Fig-4]:** Greater splanchnic nerve (GSN). White arrows indicate thickening of GSN. TSC: Thoracic sympathetic chain; LSN: Lesser splanchnic nerve; ISN: least splanchnic nerve; CG: Celiac ganglion



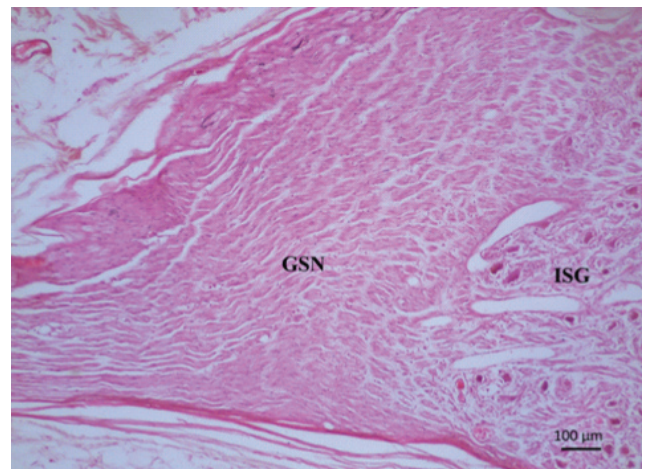
**[Table/Fig-5]:** Intermediate splanchnic ganglion. 100x Haematoxylin & Eosin stain.

## DISCUSSION

Intermediate ganglia represent the displaced cells of neural origin from the primordia of the sympathetic trunk ganglia during embryonic development. These cells have not reached the primordia of the prevertebral plexuses and are found in aggregations along the path of the thoracic splanchnic nerves and differentiate into ganglion cells [5]. Intermediate ganglia are located in the rami communicantes, splanchnic nerves, spinal nerves, or sympathetic branches and their number, size and localization varies with each individual [1,6]. Splanchnic ganglia have been observed on the trunk of the GSN, between the GSN and aorta or between the GSN and LSN as well [6,7]. ISG was observed in 41% of specimens on the GSN and in three specimens on the lesser splanchnic nerve in a cadaveric study [8]. Incidence of splanchnic ganglia in the present study



**[Table/Fig-6]:** Intermediate splanchnic ganglion shows multipolar neurons with eccentrically placed spherical nuclei. Cytoplasm shows Nissl substance and golden brown lipofuscin pigment. Satellite cells are seen around the neurons. 400x. Haematoxylin & Eosin stain.



**[Table/Fig-7]:** Greater splanchnic nerve (GSN) and intermediate splanchnic ganglion (ISG). 100x. Haematoxylin & Eosin stain.

Study	Incidence
Lobstein 1823 [2]	2 cases
Naidoo et al. 2000 [3]	44±7% (17/38)
Cunningham 1875 [4]	77% (22/26)
Mitchell 1953 [6]	22/60 (36±6%)
Jit and Mukherjee 1960 [8]	41%
Sakthivel et al. 2016 [9]	44.3% (31/70)
De Sousa 1955 [10]	41%
Dayal et al. 2014 [11]	22% (11/50)
Kommuru et al. 2014 [12]	21% (13/62)
Present study	52% (52/100)

**[Table/Fig-8]:** Comparative incidence of the splanchnic ganglion in previous studies.

differs widely from previous studies, comparison of which is given in [Table/Fig-8]. Highest incidence of 77% was reported by Cunningham followed by 44% (Naidoo et al., [3] Sakthivel et al., [9]) and 41% (De Sousa [10], Jit and Mukerjee [8]). Lower incidence of 22% and 21% were reported by Dayal et al. [11] and Kommuru et al. [12] respectively. In the present study the ISG was observed in 52% of the specimen in the GSN.

ISG of the GSN was first described by Lobstein in 1823 in two cases [2]. Cunningham studied the ISG in detail and observed them in 20 of 26 dissections (77%) being the highest incidence [4]. Furthermore, in three of the cases where the ganglion was absent, a swelling or thickening of the nerve trunk was observed. These ganglia were constantly found at the level of the body of T12 or intervertebral disc between T11 and T12. And in one specimen, the ganglion was present at the level of T10, in one of the roots of the GSN [4]. In the present study as well, the ISG on the trunk of the GSN were located at the level of T11 and T12 vertebrae. However, the ganglia present on the roots of the GSN were found at the level of T8, T9, T10 and T11 vertebrae.

Groen et al., observed the ISG, mostly in the small branches of sympathetic trunk, in the thoracic part of the GSN and occasionally in the lesser splanchnic nerves [1]. Few ganglia were noticed in the lower thoracic rami communicantes but none in the spinal nerves or the least splanchnic nerves [1]. Naidoo et al., demonstrated intermediate ganglia in 60% of the adult cadavers and 39% of the fetal specimens on the main trunk of the thoracic part of the GSN, which were situated between the T10 and T12 vertebrae [3]. Dayal et al., observed the ISG in 11 sides of 34 adult cadavers with bilateral presence in three cadavers but not in the fetal specimens. In their study the size of the splanchnic ganglion ranged from 3 x 3 mm to 15 x 5 mm [11]. The present study is limited to adult cadavers. If the study had included foetal specimens, it would have been possible to compare the foetal and adult specimens.

Kuntz observed macroscopic ganglion in all the specimens of GSN at the level of T11 or T12 [5]. A few specimens of lesser splanchnic nerve exhibited macroscopic ganglion, however microscopic ganglion was demonstrated in all the specimens [5]. Even though no visible ganglion was found on the least splanchnic nerve, ganglion cells were demonstrated microscopically [5]. Histological study of the trunk of GSN revealed ganglion cells along the lower one-third of the GSN [7]. In the present study, histological picture of the ISG was similar to that of a sympathetic ganglion. Microscopic examination of few specimens of the thickened trunk of the GSN did not reveal any ganglion cells. However, extensive histological examination of the GSN was not performed.

Numerous delicate branches from the ganglia were given off to the aortic coat, and sometimes to the celiac plexus,

superior mesenteric plexus or renal plexus [4]. Naidoo et al., demonstrated medial collateral branches given off from the ISG terminating in the aortic and oesophageal plexuses, which were observed in the present study as well [4]. Occasionally the fibers from intermediate ganglia might interconnect with the lumbar splanchnic nerves [6], which were not observed in the present study. The medial branches arising from these ganglia could be a reason for incomplete surgical denervation and these branches could act as an alternate pathway for pain conduction after sympathectomy.

Surgical denervation of thoracic splanchnic nerves by thoracoscopic splanchnicectomy, a minimally invasive procedure is an effective treatment in the control of pain caused by chronic pancreatitis and carcinoma of pancreas [3]. A retrospective study on fluoroscopy-guided splanchnic nerve neurolysis in 21 patients for upper abdominal pain, analyzed the pain reduction, opioid use and quality of life up to three months after the procedure and found significant pain reduction and decreased opioid use [13]. Even though significant pain relief was achieved following the procedure but long-term follow-up studies have revealed recurrence of pain severe enough to require narcotic analgesics. Buscher et al., observed that 28% of the patients who underwent splanchnicectomy for chronic pancreatitis were pain free at 48 months [14].

Malec-Milewska, in their study reported that 24 of 30 patients who underwent bilateral thoracic splanchnicectomy for chronic pancreatitis achieved immediate pain relief postoperatively and significant pain reduction at one-year follow-up [15]. In another study on quality of life in patients with chronic pancreatitis, 38 (69%) of 55 patients had recurrence of abdominal pain, after a median follow-up of 32 months [16]. Even though patients vastly improved at an early follow-up, only 20% appear to have obtained long-term reductions in their pain and disability scores at 5-year median follow-up [17].

Microanatomy of the thoracic splanchnic nerves revealed reduction in the myelinated fibres but increase in the unmyelinated fibers from proximal to distal part of the splanchnic nerves, proving that the postganglionic fibers arise not only from sympathetic ganglia but from the ISG as well. Thus, the splanchnic nerves with ISG function as synaptic relays, and not just conduction pathways [5]. The medial collateral branches from the ISG which provide an alternate pathway via aortic and esophageal plexuses to upper sympathetic chain could be an explanation for the recurrence of pain following splanchnicectomy [3].

## CONCLUSION

The present study describes the structure and connections of the intermediate splanchnic ganglion. Awareness and appreciation of these ganglia, particularly its connections

with aortic and esophageal plexuses is of clinical relevance and should be taken into account while performing thoracic splanchnicectomy especially denervation of the medial branches from the intermediate splanchnic ganglia may be considered to have complete pain relief.

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