

THE MORPHOLOGY AND HISTOLOGY OF THORACIC SYMPATHETIC GANGLIA:A FETAL STUDY.

¹Ramandeep Kaur, ²Jaswinder Kaur, ³Kanchan Kapoor

¹Phd Scholar, Department of Anatomy, MMIMSR, Mullana.

²Professor, Department of Anatomy, MMIMSR, Mullana.

³Professor and Head, Department of Anatomy, GMCH Chandigarh.

Corresponding author:

Ramandeep Kaur, Ph.D Research Scholar, Department of Anatomy, Maharishi Markandeshwar Institute of Medical Science and Research, Mullana-Ambala (Haryana) India.Email:ramandeepdhillon9393@gmail.com, Contact No.+91 9878419165

Abstract

Introduction: The thoracic sympathetic trunk possesses 12 ganglia, one corresponding to each thoracic nerve, it lies anterior to head of ribs or side of the body of thoracic vertebrae. Splanchnic nerves arise from the thoracic ganglia and supply thoracic and abdominal viscera.

Material and Method: The present study included 50 preserved fetus specimens sent for routine autopsy in Department of Anatomy, Government medical college and hospital, Chandigarh. The thoracic and abdominal wall of the fetus was incised, then all organs were removed to expose the sympathetic chain. Morphological observations were noted. Next the thoracic ganglion was removed and fixed in paraffin for the histological processing in different gestational ages.

Observation: The fetus were divided into 4 age group (Group A=11-15weeks, Group B=15+_20weeks, Group C=20+_25weeks and Group D=25 weeks onwards)

Morphological observation: The length of thoracic chain was noted which was directly proportional to gestational age. The number of ganglia showed variability 12 in 22 cases, 11 in 18 cases and 10 in 7 cases. The origin of splanchnic nerves from thoracic ganglia was quite variable.

Histological observation: In group A the neuroblast cells were observed with eccentric nucleus. Presence of satellite cells was noticed in group B surrounding neuroblasts. In group C, some neuroblasts were seen undergoing mitosis whereas others showed more differentiation. In group D mature adult like neuroblasts were seen with processes, satellite cell sheath and perinuclear halo.

Keywords: Thoracic, splanchnic, Fetus, Ganglion, Neuroblast.

Introduction

The sympathetic trunks consist of two ganglionated nerve trunks that extend along the length of the vertebral column. In the neck, there were 3 ganglia; in thorax: 11 or 12; in the lumbar region 4 or 5 and in pelvis, 4 or 5. In the neck, trunks lie anterior to the transverse processes of the cervical vertebrae; in the thorax they are anterior to the heads of the ribs or lie on the sides of the vertebral bodies; in the abdomen, it lies anterolateral to the sides of the bodies of the lumbar vertebrae; and in the pelvis, they are anterior to the sacrum.¹

The thoracic sympathetic trunk possesses 12 ganglia, corresponding to each thoracic nerve, but often 1st is fused with inferior cervical ganglion to form a large stellate ganglion above the neck of the 1st rib. The ganglion is attached to spinal nerve by white and grey rami and it gives communicantes to spinal nerves.² There were three splanchnic nerves of the thoracic sympathetic trunk; arising from the lower eight ganglia. The greater splanchnic nerve (GSN) is formed by branches of the 5th to 9th thoracic sympathetic ganglia, the lesser splanchnic nerve (LSN) from 10th to 11th thoracic sympathetic ganglia and the least splanchnic nerve from the 12th thoracic ganglion. Splanchnic nerves contain predominantly visceral efferent fibers and pain conducting visceral afferent fibers.³ Splanchnic ganglia of the greater splanchnic nerve was first described by Lobstein in 1823.⁴ These ganglia give off numerous medial branches to the aortic coat, and sometimes to the coeliac plexus, superior mesenteric plexus, renal plexus or oesophageal plexuses.⁵ Preganglionic ax-

ons are coming from the lateral grey column (horn) of the spinal cord. The myelinated axons of these cells leave the cord and join the paravertebral ganglia of the sympathetic trunk through the white rami communicantes while postganglionic axons leave the trunk through the grey rami communicantes. The axons of postganglionic neurons are nonmyelinated and distributed to target organs in various ways.⁶

The group of visceral nerves that arise from the thoracic sympathetic trunks which carry pre and postganglionic sympathetic and afferent nerve fibres supplying upper abdominal organs.^{7,8} The pattern of connections of pANS don't change significantly between the fetal period and the adult according to Kuntz⁷ and Pick.⁹ Anatomical variations of the thoracic sympathetic trunk in relation to intercostal nerves may be one of the reasons that cause surgical failures.

Aims and objectives

The present study was undertaken to

- To find out variations in the number of ganglia in the thoracic part of the sympathetic chain.
- To observe the variations in the formation of splanchnic nerves in the thoracic part of the sympathetic chain.
- To study histogenesis of thoracic ganglia.

Materials and method

50 formalin preserved fetus specimens from 11-28th week of gestation from spontaneous abortions received at Department of Anat-

omy, Government medical college and hospital 32 Chandigarh were the part of study. The research work was conducted after obtaining necessary permission from the parents and ethical clearance from the institute. The age estimation was obtained from the fetuses' medical records as well as through standard crown rump length measurements. General anatomical features were recorded. The congenitally malformed fetuses were excluded from study. Then fetuses were fixed in formalin. Then the fetuses were dissected by anterior midline and lateral incisions, organs were eviscerated and the sympathetic chains were dissected from cervical to sacral region. The thoracic part of sympathetic chain was exposed bilaterally. (as shown in fig 1&2)

The fetuses were divided into four gestational age groups: Group A (11-15 weeks) Group B (15+-20 weeks) Group C (20+-25 weeks) and Group D (25+ onwards).

The length of thoracic sympathetic chain and number of thoracic ganglia were measured. It was not possible to measure the size of thoracic sympathetic ganglia as these were very small. The dissections were done under a dissecting microscope or with the help of a convex lens. Next, Light microscopic study of fetal thoracic ganglia was done with H & E staining in different gestational age groups to note the histological changes.



Figure 1 : Anterior midline incision



Figure 2: Evisceration of thoracic and abdominal viscera

Observation

The thoracic part of sympathetic chain was present bilaterally in all fetus specimens with variation in number of ganglia.

Morphological

The number of thoracic ganglia and length of thoracic part of sympathetic chain was noted and discussed as under.

Table 1: Showing age distribution in groups

Group	Gestational age	Number of fetus	Total number of chains
A	11-15	11	22
B	15+_20	13	26
C	20+_25	14	28
D	25 onwards	12	24

In group A 22 chains were dissected ,followed by 26 in Group B,28 in group C and 24 in group D.

Group	Mean length(in cm)
A	2.88
B	3.16
C	4.24
D	6.75

Table 2: Showing mean length of thoracic part of sympathetic chain

The mean length of thoracic chain ranged from 2.88cm to 6.75cm. There was slight increase in length from A-B group but there was significant increase from group C to D. The length of chain was increasing with the gestational age.

Number	Number of cases	%age
10	7	14%
11	18	36%
12	22	42%

Table 3: Showing total number of ganglia

In most of the chains (48%) 12 ganglion were present. While in 36% cases there were 11 ganglion in thoracic sympathetic chain. In 3% cases the 2-3 ganglia were seen fused.

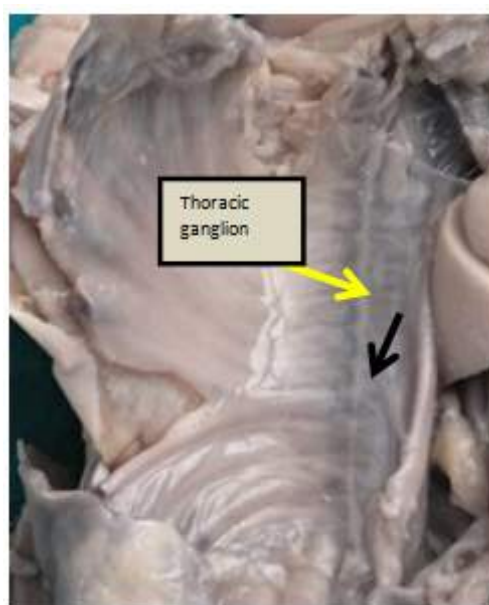
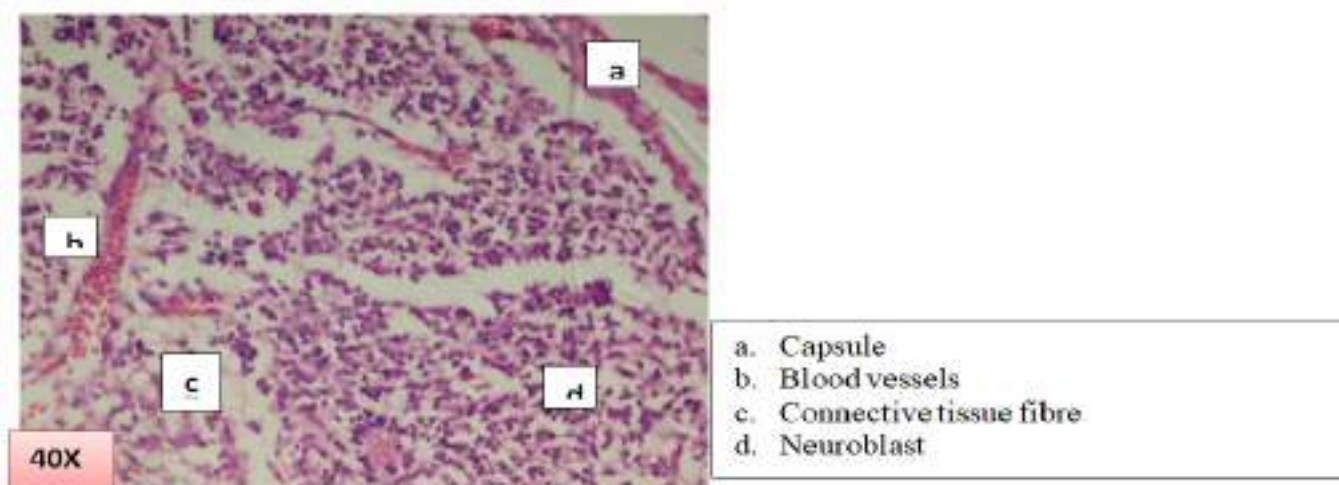


Figure 3: Showing origin of splanchnic nerves (arrow marked)

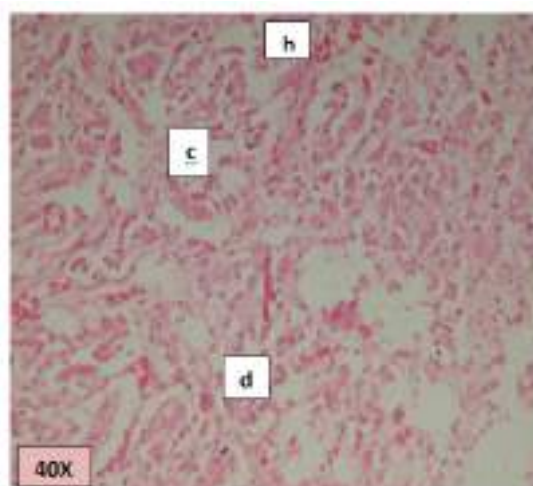
The origin of splanchnic nerve was quite variable in present study. In fetus from 20 weeks onward we were able to locate the splanchnic nerves. However in small age groups the splanchnic nerves were not distinguished. The origin of GSN was seen arising from 6,7,8 and 9th in 37% cases, LSN arising from 10 and 11th in 63 %cases, Least SN from 12th in 8% cases.

Histological observations

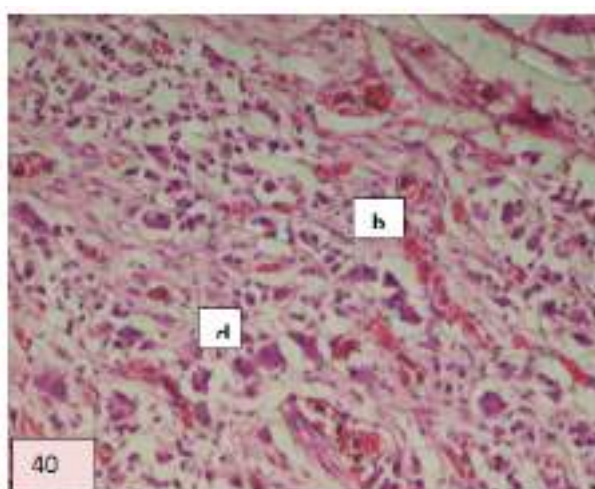
The thoracic ganglia were removed and fixed in Paraffin wax. The paraffin blocks were section and stained with H& E staining to examine the changes in appearance of cells, their differentiation in different age groups according to their gestation.



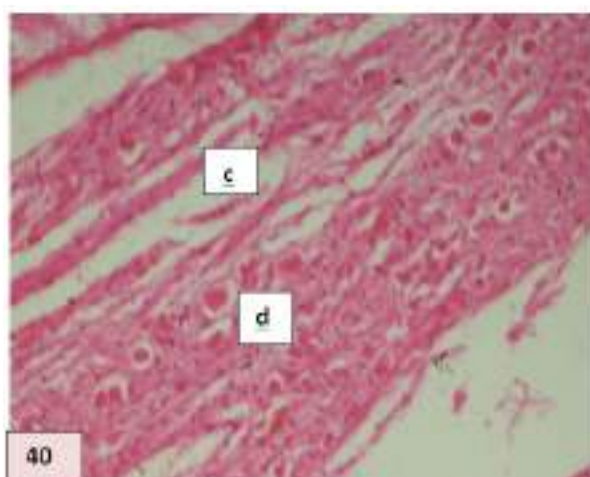
Group A: The Capsule was very well defined at 11 week onwards. The neuroblast cells were small and numerous with connective tissue fibres and blood vessels.



Group B: The neuroblasts were increased in size and few neuroblast were seen surrounded by satellite cell sheath. Blood vessels were numerous with connective tissue fibres.



Group C: In group C the neuroblast were quite big in size with perinuclear halo space and satellite cell sheath. Blood vessels were numerous seen with connective tissue fibre intervening. Few neuroblast were seen undergoing mitosis.



Group D: Fully mature adult like neurons seen with perinuclear space surrounded by satellite cell sheath. Few cells were also seen undergoing mitosis. The connective tissue fibre and nuclei of the cells seen among the mature neurons.

Discussion

The formation of sympathetic chain was noted in 9cm stage of human embryo.¹⁰ Neurons to the human sympathetic chain are contributed by ventromedial aspect of the dorsal root Ganglia and are also derived from the ventral aspect of neural tube which pass along

the ventral nerve roots.¹¹ The aggregation of cells, representing the primordia of the future ganglia of the sympathetic trunk, are first evident in the lower thoracic and upper lumbar regions, and they are located on the posterolateral aspects of the aorta. Such aggregations of primordial cells are arranged initially in an ill-defined column,

and in embryos at the 15 mm stage, they are present in all except the cervical region.⁸

In present study the presence of sympathetic chain was noted in all fetuses from 11 weeks onwards and it could be a guide for the forensics in determination of age.

The thoracic sympathetic branches in man show a complex, segmentally organized pattern and may have a considerable component of somatosensory nerve fibers. The segmental organization of the thoracic sympathetic trunk and all its ramifications was studied in 6 human fetuses (16-22 weeks) by means of the acetylcholinesterase in to staining method. Each trunk was divided into 12 sympathetic segments. A segment is defined as that part of the sympathetic trunk which is connected via its rami communicantes with one spinal nerve. Three categories of nerves are discerned: (1) large splanchnic rootlets confined to the greater, lesser and least thoracic splanchnic nerves, (2) medium-sized splanchnic nerves directed towards thoracic viscera, some of which give off branches towards costovertebral joint plexuses and, described for the first time in man, (3) small nerves which ramify extensively and form nerve plexuses in the capsule of the costovertebral joints.¹² Hemanth Kommuru et al conducted study on 31 embalmed cadavers and found the stellate ganglion was unilaterally present in 15 cadavers, bilaterally in 4 cadavers. There were 11 thoracic ganglion in 11 cadavers. The highest origin of splanchnic nerve was from 4th thoracic ganglion and lowest from 11th ganglion. Lesser splanchnic nerve was seen originating from 10 & 11th ganglia in 63% specimens. Least was seen originating from 11th in 27% and from 12th in 11% cases.¹³ In the study done on 6 adult and ¹⁴ fetal cadavers, the origin of splanchnic nerve was bilaterally asymmetrical in all cases. The greater splanchnic nerve was seen in all cases whereas lesser and least were inconsistent. The splanchnic nerve were observed most frequently over range: GSN T6-T9 in 73%, LSN from T10-T11 in 29% and Least From T11-T12 in 14% cases. The higher origin of greater splanchnic nerve above T5 has clinical complications in technique of taking thoracic splanchnicectomy.¹⁴ Excision of the sympathetic chain during video assisted thoracic sympathectomy is a safe and effective method in treating hyperhidrosis, facial flushing and intractable angina with good long term results and satisfaction.¹⁵ A variable number of thoracic splanchnic branches leave the chain, especially in the upper part of the thorax to join the cardiac and pulmonary plexus; others join the aortic plexus and are distributed through them. The thoracic cardiac branches contain about twice as many fibres as that reach the cardiac plexus by the larger cervical sympathetic cardiac branches.¹⁶ Information on the variability of the anatomy of the thoracic sympathetic chain and splanchnic nerves may be important for the success of subdiaphragmatic neuroablative surgical approaches to pain control and splanchnic neurectomy for the management of chronic abdominal pain.¹⁷

In present study done on 50 preserved fetus specimens the number of ganglia was usually 11-12 at all the stages of gestational age. There were 10 thoracic ganglion in 7 cases, 11 in 18 cases and 12 in 22 cases. The origin of splanchnic nerve was seen in fetus of higher gestational age and it was quite variable. The greater splanchnic nerve was seen originating from 7, 8, and 9th thoracic ganglia in 37%, lesser from 10-11th in 63% cases and least from 12th in 8% cases.

Kiran studied 90 samples of human fetal sympathetic chains ranging from 8th week to full term were analyzed. Serially cut paraffin sections were stained with H&E, Cresyl fast violet, Marshland silver impregnation method and neuron specific enolase immunohistochemical stain. Results demonstrated the sympathetic chain attained its adult position extending from cervical level to the sacral

level by 12th week of gestation. Histologically, the sympathetic chain had a primitive appearance up to 10th week of gestation. The early sympathoblast stage extended from 12 to 16 weeks. The sympathoblasts were committed to form neurons by 18th week of gestation. This process of differentiation took 10 weeks from 18th to 28th week of gestation. Maturation involved a further 6 weeks, from 30th to 36th weeks of gestation, at which time there was an increase in cell size, RER, neuronal filaments and number of dendrites.¹⁸

In present study the neuroblast were seen with perinuclear halo space surrounded by satellite cell sheath in group C (20 week onwards). In 11 weeks the capsule surrounding ganglia was clearly seen. Fully adult like mature neuron was seen from 25 week onwards. Hence, the study done on fetuses, the variation in the thoracic ganglion, splanchnic nerves and the cytoplasmic and nuclear changes at different gestational ages will add knowledge to the existing literature. In forensic science the histology of ganglion could help to note the age of fetus.

Clinical importance: T2 is the key ganglion for the palmar hyperhidrosis and in addition to stellectomy for Raynaud's disease. So it is essential to know the details, pattern, and variations of the sympathetic chain for thoracic dorsal sympathectomy.

Medico-legal aspect: The remains of fetus with sympathetic chain and histology of ganglion could be helpful in determining age.

Conclusion

The present work on examining the number of thoracic ganglion, its histogenesis and presence of splanchnic nerves their origin, it would be baseline for further research as work done on fetuses is very less. The variations in the thoracic sympathetic chain and the formation of splanchnic neural pattern were identified and inconsistent results of splanchnectomies may be due to anatomical variations in the formation of splanchnic nerves.

Ethical Clearance: Taken from Institutional Ethical Committee Of GMCH Chandigarh and Maharishi Markandeswar Deemed university, Mullana (Ambala).

Source of funding- Self

Conflict of interest – Nil

References

1. Cunningham DJ. Notes on the great splanchnic ganglion. *Journal of Anatomy*. 1875; 9: 303-05.
2. Lumley JSP, Craven JL, Aitken JT. *Essential anatomy and some clinical applications*, Churchill Livingstone, Edinburgh Hong-kong. 1995.
3. Last R.J and Mc Minn R.M.H. *Last's anatomy, regional and applied*. 6th Ed. Edinburgh: Churchill Livingstone. 1994.
4. Lobstein JF. *De nervi sympathetici humani fabrica*. F. G. Levrault, Paris. 1923.
5. Naidoo N, Partab P, Pather N, Moodly J, Singh B, and Satyapal KS. Thoracic splanchnic nerves; implication for splanchnic denervation. *J Anat*. 2001; 199: 585-90.
6. Elias M. Cervical sympathetic and stellate ganglion blocks. *Pain Physician*. 2000; 3(3): 294-304.
7. Kuntz A. Components of splanchnic and intermesenteric nerves. *J Comp Neurol*. 1956; 105: 251-268.
8. Mitchell GAG. *Anatomy of the Autonomic Nervous System*. Edinburgh: E & S Livingstone; 1953.
9. Pick J, Sheehan D. Sympathetic rami in man. *J. Anat*. 1946; 80: 12-20.
10. Keibel, F Mall FP: *Manual of human embryology*. 2nd Ed JP Lippincott Co., Philadelphia: 1912; 28-33.

11. Brizze KR, Kuntz A. The histogenesis of sympathetic ganglionic cells. An experimental study. 1950; *Jn of N. Pathgy and expert Neurology* 9: 164-9.
12. Groen GJ, Baljet B, Boekelaar AB, Drukker J. Branches of the thoracic sympathetic trunk in the human fetus. *Anat Embryol (Berl)*. 1987;176(4):401-11.
13. Kommuru H, Jothi S, Bapuji P, Sree D L, Antony J. Thoracic part of sympathetic chain and its branching pattern variations in South Indian cadavers. *J Clin Diagn Res*. 2014;8(12).
14. Naidoo N, Partab P, Pather N, Moodley J, Singh B, Satyapal KS. Thoracic splanchnic nerves: Implications for splanchnic denervation. *J Anat*. 2001;199:585-90.
15. Rathinam S, Nanjaiah P, Sivalingam S, Rajesh P B. Excision of sympathetic ganglia and the rami communicantes with histological confirmation offers better early and late outcomes in Video assisted thoracoscopic sympathectomy. *J Cardiothorac. Surg*. 2008; 3:50.
16. Saccomanno G. The components of the upper thoracic sympathetic nerves. *J. Comp. Neurol*. 1943; 79(3):355-378.
17. Bradley EL III, Bem. Nerve blocks and neuroablative surgery for chronic pancreatitis. *World J Surg*. 2003; 27:1241-48.
18. Kiran S. The Histogenesis Of Neurons In Human Sympathetic Ganglia – A Light Microscopic Study. *J Anat. Soc. India*. 2002; 51(2): 148-155.