- Irritation of the recurrent laryngeal nerve by enlarged lymph nodes in children may also produce a persistent cough.
- Some fibres arising in the geniculate ganglion of facial nerve pass into the vagus through communications between the two nerves. They reach the skin of auricle through the auricular branch of vagus. Sometimes a sensory ganglion may have a viral infection (called herpes zoster) and vesicles appear on the area of skin supplied by the ganglion. In herpes zoster of the geniculate ganglion, vesicles appear on the skin of auricle.
- Injury to pharyngeal branch causes dysphagia. Paralysis of muscles of soft palate results in nasal regurgitation of fluids and nasal tone of voice. Lesions of superior laryngeal nerve produces anaesthesia in the upper part of larynx and paralysis of cricothyroid muscle. The voice is weak and gets tired easily.
- Injury to right recurrent laryngeal nerve results in hoarseness and dysphonia due to paralysis of the right vocal cord (Fig. 24.57).
- Paralysis of both vocal cords results in aphony and inspiratory stridor (high pitched and harsh respiratory sound). It may occur during thyroid surgery.

**Fig. 24.56:** Paralysis of muscles of soft palate on left side

**Fig. 24.57:** Paralysis of right recurrent laryngeal nerve

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**ELEVENTH CRANIAL NERVE**

**ACCESSORY NERVE**

Accessory nerve is the eleventh cranial nerve. It has two roots, cranial and spinal. The cranial root is assisting to the vagus, and is distributed through the branches of the latter. The spinal root has a more independent course (Fig. 24.58).

**Functional Components**

1. The cranial root is special visceral (branchial) efferent. It arises from the lower part of nucleus ambiguus. It is distributed through the branches of vagus to the muscles of the palate, the pharynx, the larynx, and possibly the heart (Fig. 24.58).

2. The spinal root is also special visceral efferent. It arises from a long spinal nucleus situated in the lateral part of the anterior grey column of the spinal cord extending between segments C1 to C5. Its fibres supply the sternocleidomastoid and the trapezius muscles.

**Nuclei**

- The cranial root arises from the lower part of the nucleus ambiguus.
- The spinal root arises from a long spinal nucleus situated on the lateral part of anterior grey column of spinal cord, extending from C1 to C5 segments. It is in line with nucleus ambiguus.

**Course and Terminations of the Spinal Root**

1. The spinal root emerges from a long spinal nucleus situated on the lateral part of anterior grey column of spinal cord, extending from C1 to C5 segments. It joins together to form a common stem together to form a common stem.

**Fig. 24.58:** Course of the accessory nerve
2. It runs laterally with the glosopharyngeal vagus and spinal accessory nerves, crosses the jugular tubercle, and reaches jugular foramen.

3. In the jugular foramen, the cranial root unites for a short distance with the spinal root, and again separates from it as it passes out of the foramen (Fig. 24.58).

4. The cranial root finally fuses with the vagus at its inferior ganglion, and is distributed through the branches of the vagus to the muscles of the palate, the pharynx, the larynx and possibly the heart.

**Course and Distribution of the Spinal Root**

1. It arises from the upper five segments of the spinal cord (Fig. 24.58).

2. It emerges in the form of a row of filaments attached to the cord midway between the ventral and dorsal nerve roots.

3. In the vertebral canal, the filaments unite to form a single trunk which ascends in front of the dorsal nerve roots and behind the ligamentum denticulatum.

4. The nerve enters the cranium through the foramen magnum lying behind the vertebral artery (see Fig. 1.16).

5. Within the cranium, the nerve runs upwards and laterally, crosses the jugular tubercle (with the ninth and tenth cranial nerves) and reaches the jugular foramen.

6. The nerve leaves the skull through the middle part of the jugular foramen where it fuses with a short length of the cranial root. It soon separates from the latter and passes out of the foramen.

7. In its extracranial course, the nerve descends vertically between the internal jugular vein and the internal carotid artery deep to the parotid and to the styloid process (Fig. 24.52). It reaches a point midway between the angle of mandible and the mastoid process. Then it runs downwards and backwards superficial to the internal jugular vein and is surrounded by lymph nodes.

The nerve pierces the anterior border of the sternocleidomastoid at the junction of its upper one-fourth with the lower three-fourths, and communicates with second and third cervical nerves within the muscle.

The nerve enters the posterior triangle of the neck by emerging through the posterior border of the sternocleidomastoid a little above its middle. In the triangle (Fig. 24.59), it runs downwards and backwards embedded in the fascial roof of the triangle. Here it lies over the levator scapulae. It is related to the superficial lymph nodes. The nerve leaves the posterior triangle by passing deep to the anterior border of the trapezius 5 cm above the clavicle.

On the deep surface of the trapezius, the nerve communicates with spinal nerves C3 and C4, and ends by supplying the trapezius.

**Distribution:**

The spinal accessory nerve supplies:

- The sternocleidomastoid, the chin turning
- The trapezius, the shrugging muscle

Cervical nerves provide proprioceptive sensations to these muscles.

**CLINICAL ANATOMY**

- The accessory nerve is tested easily by
  a. By asking the patient to shrug the shoulders (trapezius) against resistance and comparing the power on the two sides.
  b. By asking the patient to turn the chin to the opposite side (sternocleidomastoid) against resistance and again comparing the power on the two sides (Fig. 24.60).

- Lesions of spinal root of accessory nerve cause:
  - Drooping of the shoulder (Fig. 24.61) and inability to turn chin to opposite side.
  - Irritation of the nerve during biopsy of enlarged caseous lymph nodes, may produce torticollis or wry neck.

- Supranuclear connections act on the ipsilateral sternocleidomastoid and on the contralateral trapezius. This results in turning of the head away from relevant hemisphere during seizure.
NERVES OF HEAD AND NECK [325]

- Superior root supplies superior belly of omohyoid whereas ansa cervicalis supplies sternohyoid^{41MS97,98}, sternothyroid^{41MS97}, and inferior belly of omohyoid^{41MS97}.

Ansa cervicalis, and branches of the first cervical nerve distributed through the hypoglossal nerve.

Note: - Thyrohyoid^{41MS97} and geniohyoid are supplied by separate branches of C1 nerve through hypoglossal nerve (not by ansa cervicalis or any of its root).

PARASYMPATHETIC GANGLIA OF HEAD AND NECK

- Parasympathetic ganglia of head and neck transmit three types of fibers: (i) parasympathetic fibers, (ii) sympathetic fibers, and (iii) sensory fibers. These are called parasympathetic ganglia because only parasympathetic fibers synapse (relay) in the ganglia, other two types of fibers simply pass through without relay in the ganglia. Important parasympathetic ganglia in head and neck are: (i) otic ganglion, (ii) submandibular ganglion, (iii) pterygopalatine ganglion, and (iv) ciliary ganglion.

OTIC GANGLION

- Topographically, it is connected to mandibular nerve^{41LE Pg1(99)}, while functionally it is related to glosopharyngeal (IX) nerve^{41LE}. Its roots are:
  i) Sensory root: By Auriculotemporal nerve.
  ii) Sympathetic root: By sympathetic plexus around middle meningeal artery^{41LE Pg1(99)}.
  iii) Parasympathetic (secretomotor) root: This root is by lesser petrosal nerve. Preganglionic fibres begin in inferior salivatory nucleus, pass through glosopharyngeal nerve, then its tympanic branch, tympanic plexus, and the lesser petrosal nerve and relay in otic ganglion. Postganglionic fibers pass through auriculotemporal nerve and supplies parotid gland^{41Pg1(99), TN 86}.
  iv) Motor root: It is derived from nerve to medial pterygoid^{41Pg1(99)} which passes unrelayed through ganglion and supplied tensor veli palatini and tensor tympani (Note: Otic ganglion has a motor root, beside three standard roots of parasympathetic ganglion of head and neck: sensory, sympathetic and parasympathetic).

SUBMANDIBULAR GANGLION
PTERYGOPALATINE GANGLION (SPHENOPALATINE GANGLION)

- It is the largest parasympathetic ganglion, suspended by two roots to maxillary nerve. Functionally, it is re
facial nerve. It is called ganglion of "hay fever". Its roots are:
  
  i) Sensory root: It is from maxillary nerve.
  ii) Sympathetic root: It is from sympathetic plexus around internal carotid artery through deep petrosal nerve.
  iii) Secretomotor (parasympathetic) root: Postganglionic fibers arise from lacrimary nucleus, pass through
      facial nerve, then to its greater petrosal branch. Greater petrosal nerve unites with deep petrosal
      (sympathetic fibers) to form nerve to pterygoid canal (vidian nerve) and palatine nerves, and pharynx
      glands.

- Branches of the pterygopalatine ganglion are:
  
  i) For lacrimal gland: Postganglionic fibers pass through zygomatic nerve (branch of maxillary nerve)
     zygomaticotemporal division which gives communicating branch to lacrimal nerve for supplying lacrimal
     gland.
  ii) Nasopalatine nerve: For nasal and palatine glands.
  iii) Nasal branches: For mucus membrane and glands of lateral wall of nasal cavity.
  iv) Palatine branches: One greater palatine and 2-3 lesser palatine branches for glands of soft palate and
      nasal cavity.
  v) Orbital branches: For orbital periosteum.
  vi) Pharyngeal branches: For glands of pharynx.

CILIARY GANGLION

- Topographically, ciliary ganglion is related to nasociliary nerve (a branch of ophthalmic division of trigeminal nerve),
  but functionally it is related to oculomotor nerve. Its roots are:
  
  i) Sensory root: It is from nasociliary nerve.
  ii) Sympathetic root: It is from plexus around ophthalmic artery.
  iii) Parasympathetic root: It is from a branch to inferior oblique muscle. These fibers arise from Edinger Westphal
      nucleus, join oculomotor nerve and then to its branch to inferior oblique to relay in ciliary ganglion.

- Postganglionic fibers pass through short ciliary nerves to supply sphincter pupillae and ciliary muscles.

CERVICAL SYMPATHETIC GANGLIA

- There are three cervical sympathetic ganglia: superior, middle, and inferior.

Superior cervical ganglion

- It lies just below skull, opposite the 2nd and 3rd cervical vertebrae. It is largest of three ganglia.
  It is formed by fusion of upper 4 cervical nerve ganglia (C1-C4). It also has communications
  with cranial nerves IX, X, XI and XII, and with external and recurrent laryngeal nerve.

- Branches of superior cervical ganglion are:
  
  i) Gray rami communicantes: To ventral rami C2-C4 cranial nerves.
  ii) Internal carotid nerve: Forms plexus around ICA.
  iii) External carotid nerve: Forms plexus around ECA.
  iv) Pharyngeal branches: Take part in formation of pharyngeal plexus.
  v) Left superior cervical cardiac branch: For superficial cardiac plexus.
  vi) Right superior cervical cardiac branch: For deep cardiac plexus.

Middle cervical ganglion

- It is the smallest of three ganglia. It lies in front of vertebral C7. It is formed by fusion of 5th and 6th cervical nerve
  connections (C5-C6). It is connected to inferior cervical ganglion directly, and also through a loop that winds round
  the subclavian artery. This loop is called ansa subclavia.

- Branch of middle cervical ganglia are:
  
  i) Gray rami communicantes: To ventral rami of C7 and C8 spinal nerves.
  ii) Thyroid branches: Along inferior thyroid artery.
  iii) Tracheal and esophageal branches.
  iv) Middle cervical cardiac branch: Largest of sympathetic cardiac branch and goes to deep cardiac plexus.
Inferior cervical ganglion (stellate ganglion or cervicothoracic ganglion)

- It is formed by fusion of 7th and 8th cervical ganglia, and often fused with 1st thoracic ganglion (T1). Therefore, also called cervicothoracic ganglion. As it is star shaped, it is also called stellate ganglion. It is situated between transverse process of C7 vertebra and neck of 1st rib.
- **Branches** inferior cervical ganglion are:
  i) **Gray rami communicans**: To ventral rami of C7 and C8 spinal nerves.
  ii) **Ventral branches**: Form plexus around vertebral artery.
  iii) **Subclavian branches**: Form plexus around subclavian artery.
  iv) **Inferior cervical cardiac branch**: For deep cardiac plexus.
- Destruction of stellate ganglion causes Horner's syndrome, which is characterized by ptosis, miosis, anhidrosis, enophthalmus and loss of ciliospinal reflex.
CRANIAL NERVES

Cranial nerve nuclei

1. All of the following cranial nerves contain somatic efferents, except - (AI 08)
   a) VII nerve (facial nerve)
   b) III nerve (oculomotor nerve)
   c) IV nerve (trochlear nerve)
   d) VI nerve (abducent nerve)

2. Which of the following nuclei belongs to the general visceral efferent column - (AIIMS 04)
   a) Facial nerve nucleus
   b) Trigeminal nerve nucleus
   c) Dorsal nucleus of vagus
   d) Nucleus ambiguous

3. General visceral efferents include all except - (Jipmer 2K)
   a) Dorsal nucleus of vagus
   b) Edinger-Westphal nucleus
   c) Superior salivatory nucleus
   d) Motor nucleus of trigeminal

4. General visceral fibres do not supply - (NEET/DNB Pattern)
   a) Smooth muscles
   b) Skeletal muscles
   c) Cardiac muscles
   d) Glands

Cranial nerves: General

5. Most common nerve involved in an intraocular aneurysm is - (AI 96)
   a) Trochlear
   b) VII
   c) VIII
   d) Oculomotor

6. Cranial nerve not carrying parasympathetic fibres - (AIIMS May 10)
   a) Fourth
   b) Seventh
   c) Third
   d) Ninth

7. The smallest cranial nerve is the - (Nimhans 92; AMU 02)
   a) Olfactory
   b) Oculomotor
   c) Trochlear
   d) Accessory

8. The cranial nerve with the longest intracranial course - (UPSC 93; PGI 96; AI 96; Kerala 97)
   a) Optic
   b) Abducent
   c) Trigeminal
   d) Oculomotor
   c) Trochlear

9. Which is the only nerve which exits the brainstem on dorsal side - (NEET/DNB Pattern)
   a) Facial
   b) Trochlear
   c) Abducent

10. Which of the cranial nerve decussate with in the brain - (Nimhans 01; J&K 02; WB 03)
    a) Trochlear
    b) Optic
    c) Oculomotor

11. Nucleus ambiguous doesn’t include - (NEET/DNB)
    a) 7th nerve nucleus
    b) 9th nerve nucleus
    c) 10th nerve nucleus
    d) 11th nerve nucleus

12. Nucleus in brain common to IX, X and Y nerve - (Delhi 92; JIPMER 93)
    a) Nucleus solitarius
    b) Nucleus ambiguus
    c) Dentate nucleus
    d) Red nucleus

13. Seventh, Ninth and Tenth cranial nerve - (AIIMS 92, W)
    a) Nucleus tractus solitarius
    b) Nucleus ambiguous
    c) Dorsal nucleus of vagus
    d) Long and of V nerve

14. Which nerves does not arise form the - (AIIMS 92, W)
    a) Facial
    b) Glossopharyngeal
    c) Vagus
    d) Dorsal horn of gray matter

15. Which of the following cranial nerve posterior fossa? (AIIMS 92, W)
    a) 3rd to 12th
    b) 4th to 12th
    c) 5th to 12th
    d) 6th to 12th

16. Superior rectus is supplied by which nerve - (AIIMS 92, W)
    a) Superior division of 3rd nerve
    b) Inferior division of 3rd nerve
    c) Abducent nerve
    d) Trochlear nerve

17. All are characteristics of 3rd nerve - (AIIMS 92, W)
    a) Carries parasympathetic nerve fibres
    b) Supplies inferior oblique
    c) Enters orbit through the inferior orbital fissure
    d) Causes miosis

18. III nerve palsy causes all of the following - (AIIMS 92, W)
    a) Ptosis
    b) Mydriasis
    c) Medial deviation of eyeball
    d) Pupillary reflex lost

19. Which action of extra-ocular involvement of Oculomotor nerve - (AIIMS 92, W)
    a) Abduction
    b) Depression
    c) Elevation
    d) Adduction

20. In complete 3rd nerve palsy - (AIIMS 92, W)
    a) Eye deviated medially
    b) Superior and inferior rectus
    c) Dilated pupil
    d) Ptosis
    e) Conversion accommodation

21. Which is not a feature of 3rd nerve palsy - (AIIMS 92, W)
    a) Miosis
    b) Difficulty in accommodation
    c) Superior gaze palsy
    d) Diplopia
19. Pyramidal tracts originate in:
   (a) Somatosensory cortex  
   (b) Premotor cortex  
   (c) Motor cortex  
   (d) All of the above

20. Percentage of sensory fibers in a pure motor nerve is:
   (a) 5  
   (b) 10  
   (c) 20  
   (d) 40

21. During the descent of pyramidal tracts, point to point discrimination of body parts occurs in the substance of:
   (a) Internal capsule  
   (b) Midbrain  
   (c) Pons  
   (d) Medulla

22. The percentage of pyramidal fibers making direct synaptic connections with motor neurons:
   (a) 5-10  
   (b) 15-20  
   (c) 25-30  
   (d) 35-45

23. Of all the pyramidal fibers:
   (a) 55% end in cervical region  
   (b) 40% end in thoracic region  
   (c) 5% end in lumbosacral region  
   (d) All of the above are true

24. Most common site of lesion to the pyramidal tracts:
   (a) Internal capsule  
   (b) Midbrain  
   (c) Pons  
   (d) Medulla

25. Pre-central gyrus and corticospinal tracts are required for:
   (a) Voluntary movement  
   (b) Position sense appreciation  
   (c) Orientation in time and place  
   (d) Stereognosis and spatial skills

26. Apoplexy means:
   (a) Injury to motor area 4  
   (b) Paralysis on one side of the body  
   (c) Paralysis of both the lower limbs  
   (d) Sudden attack of paralysis

27. Pseudobulbar palsy:
   (a) Leads to paralysis or weakness of muscles that control swallowing and tongue movements  
   (b) Results following injury to extra-pyramidal tracts  
   (c) Seen as a consequence of cortico-spinal tract injury  
   (d) All of the above

28. Body posture and complex coarse movements are controlled mostly by:
   (a) Cerebrum  
   (b) Cerebellum  
   (c) Spinal cord  
   (d) Extrapyramidal system

29. Extrapyramidal tract includes all except:
   (a) Rubrospinal tract  
   (b) Tectospinal tract  
   (c) Corticospinal tract  
   (d) Medial longitudinal fasciculus

30. Which part of brain helps supporting the body against gravity?
   (a) Superior colliculus  
   (b) Medial longitudinal bundle  
   (c) Vestibular nuclei  
   (d) Red nucleus

31. Lower motor neurons (LMNs) are:
   - (a) Neuron located at the level of medullary pyramid  
   - (b) Neurons in the cerebellum that are concerned with muscular movements  
   - (c) Neurons that give rise to pyramidal system  
   - (d) Spinal and cranial motor neurons that directly innervate the muscles

32. Transection at the level of medullary pyramids leads to:
   (a) Flaccidity  
   (b) Positive grasping reflex  
   (c) Abnormal Babinski's sign  
   (d) Hypotonia

33. Following hemiplegia, reflex activity returns after:
   (a) 1-2 days  
   (b) 7-10 days  
   (c) 2-3 weeks  
   (d) 2-3 months

Answers
1. (b)  2. (b)  3. (d)  4. (a)  5. (c)  6. (b)  7. (a)  8. (d)  9. (c)  10. (c)
11. (d)  12. (a)  13. (c)  14. (d)  15. (a)  16. (d)  17. (b)  18. (d)  19. (d)  20. (d)
21. (a)  22. (b)  23. (a)  24. (a)  25. (a)  26. (d)  27. (a)  28. (d)  29. (c)  30. (c)
21. (d)  32. (c)  33. (c)
The Autonomic Nervous System

I. Difference between Somatic and Autonomic Nervous System (ANS)
II. Organization of the ANS
   A. Sympathetic division
   B. Parasympathetic division
III. Chemical transmission at autonomic junctions
IV. Responses of effector organs to autonomic nerve impulse

**Important Note**

Multiple System Atrophy (MSA) is a neurodegenerative disorder associated with autonomic failure due to loss of pre-ganglionic autonomic neurons in the spinal cord and brain stem. This results in difficulty to regulate body temperature, fluid and electrolyte balance and blood pressure. In addition there may be associated cerebellar and basal ganglia dysfunction.

**DIFFERENCE BETWEEN SOMATIC AND ANS**

The major differences between the somatic and ANS are given in Table 11.93.1 and shown in Fig. 11.93.1.

**ORGANIZATION OF THE ANS**

Based on anatomical and physiological differences, the ANS is divided into two divisions: sympathetic and parasympathetic.

**A. SYMPATHETIC DIVISION OF ANS**

Sympathetic preganglionic fibers leave the spinal cord with the ventral roots of the spinal nerves...
Table 11.93.1: Somatic and Autonomic nervous system (ANS) compared

<table>
<thead>
<tr>
<th>Somatic nervous system</th>
<th>Autonomic nervous system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In somatic polysynaptic pathway at least 'three' neurons are involved. (i) Afferent (sensory) neuron with its cell body in the dorsal root ganglion. (ii) An interneuron (connector neuron) in the dorsal horn of the grey matter which by means of its axon transmits the impulses to the efferent neuron. (iii) Efferent (motor) neuron i.e. ventral horn cell with its axon which transmits the motor impulses to the skeletal muscle (effector organ).</td>
<td>1. In autonomic nerve supply to viscera, 'three' neurons can also be recognized. (i) Afferent (sensory) neuron proceeding from an internal organ. Its cell body lies in the dorsal root ganglion (or its cranial equivalent) and a central process is sent into the grey matter. (ii) Interneuron called preganglionic neuron whose cell body is situated in the intermediolateral column of spinal cord (also called 'lateral horn'). Its axon synapses on the cell body of postganglionic neuron. (iii) Postganglionic neuron, whose cell body is always located outside the CNS and its axon ends on the visceral effector. (Each preganglionic axon diverges to an average of 8-9 postganglionic neuron, therefore, autonomic output is diffuse.)</td>
</tr>
<tr>
<td>2. It consists of 'single' efferent neuron between CNS and effector organ.</td>
<td>2. It has two efferent neuron chains between CNS and the effector organ; the 1st efferent neuron has its cell body in the CNS. The synapse between the two efferent neurons lies outside the CNS in a cell cluster called autonomic ganglion. The nerve fibers passing between the CNS and the ganglia are called preganglionic autonomic fibers (myelinated), B group of fibers; those passing between the ganglia and the effector cells are the postganglionic fibers (non-myelinated, C group of fibers).</td>
</tr>
<tr>
<td>3. The nerve fiber of efferent neuron leaves the CNS and passes without any synapse to the skeletal muscle.</td>
<td>3. It innervates smooth and cardiac muscles, glands and GIT neurons.</td>
</tr>
<tr>
<td>4. It innervates skeletal muscle.</td>
<td>4. The neurotransmitter released at efferent (motor) neuron endings is A-ch.</td>
</tr>
<tr>
<td>5. The neurotransmitter released at efferent (motor) neuron endings is A-ch.</td>
<td>5. The neurotransmitter released between pre and postganglionic fibers is A-ch while the neurotransmitter between postganglionic fibers and the effector cell depends on the component of ANS (see below).</td>
</tr>
<tr>
<td>6. It always leads to muscle excitation; inhibition takes place 'centrally' through the participation of inhibitory interneurons.</td>
<td>6. It can lead to either excitation or inhibition of effector organ; inhibition occurs peripherally through a direct influence on effector.</td>
</tr>
</tbody>
</table>

2. The preganglionic fibers pass via the white rami communicantes to the paravertebral sympathetic ganglia which lies close to the spinal cord. These ganglia form the two chains of ganglia, one on each side of the cord called sympathetic trunk. Most of the preganglionic fibers end on the cell bodies of the postganglionic neurons in the sympathetic chain. The sympathetic trunk extends the entire length of the spinal cord from the cervical levels high in the neck down to the sacral levels. The 'extra' ganglia in the sympathetic trunk receives preganglionic fibers from the thoracolumbar regions because some of the preganglionic fibers, once in the paravertebral chains, turn to travel upward or downward for several segments before forming synapses with postganglionic neurons. (Fig. 11.93.3; parts 1 to 4). Other possible paths taken by the sympathetic preganglionic fibers are shown in (Fig. 11.93.3, parts 2, 3 and 5). |

4. The postganglionic fibers:
   (i) pass to the viscera in the various sympathetic nerves;  
   (ii) others re-enter the spinal nerves via the grey
Fig. 11.03.2 Distribution of the parasympathetic (left) and sympathetic (right) divisions of the autonomic nervous system.

Note

1. Inferior cervical ganglion fused with T₁ ganglion to form 'Stellate' ganglion
2. Preganglionic sympathetic fibres directly supply the adrenal medulla gland.