Peripheral and Autonomic Nervous Systems

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SPINAL NERVES

• Overview
  • Thirty-one pairs of spinal nerves are connected to the spinal cord
  • No special names; numbered by level of vertebral column at which they emerge from the spinal cavity
  • Eight cervical nerve pairs (C1 through C8)
  • 12 thoracic nerve pairs (T1 through T12)
  • Five lumbar nerve pairs (L1 through L5)
  • Five sacral nerve pairs (S1 through S5)
  • One coccygeal nerve pair
SPINAL NERVES

- Lumbar, sacral, and coccygeal nerve roots descend from point of origin to the lower end of the spinal cord (level of first lumbar vertebra) before reaching the intervertebral foramina of the respective vertebrae, through which the nerves emerge.
- Cauda equina describes the appearance of the lower end of the spinal cord and its spinal nerves as a horse’s tail.
**Spinal nerves.** Each of 31 pairs of spinal nerves exits the spinal cavity from the intervertebral foramina. The names of the vertebrae are given on the left and the names of the corresponding spinal nerves on the right. Note that after leaving the spinal cavity, many of the spinal nerves interconnect to form networks called plexuses. The inset shows a dissection of the cervical region, showing a posterior view of cervical spinal nerves exiting intervertebral foramina on the right side.
SPINAL NERVES: PLEXUSES

- Nerve plexuses
  - Plexus: complex network formed by the ventral rami of most spinal nerves (not T2 through T12), subdividing and then joining together to form individual nerves
  - Each individual nerve that emerges contains all the fibers that innervate a particular region of the body
  - In plexuses, spinal nerve fibers are rearranged according to their ultimate destination, reducing the number of nerves needed to supply each body part
SPINAL NERVES: PLEXUSES

- Four major pairs of plexuses
  - Cervical plexus
  - Brachial Plexus
  - Lumbar Plexus
  - Sacral Plexus
  - Brachial plexus
Cervical Plexus  C1-C5

- Located deep within the neck to the muscles and skin of the neck, upper shoulders, and part of the head
- Phrenic nerve exits the cervical plexus and innervates the diaphragm
The Cervical Plexus

- C1
- C2
- C3
- C4
- C5

Lesser occipital nerve
Great auricular nerve
Transverse cervical nerve
Ansa cervicalis:
  - Anterior root
  - Posterior root
Supraclavicular nerves
Phrenic nerve

Hypoglossal nerve (XII)

Roots
Fig. 11: Interscalene nerve block: Modification according to G. Meier

1. Cricoid
2. Superior thyroid notch
3. Sternoceleidomastoid muscle
4. Puncture site for anterior access
5. Vertical, infraclavicular puncture site
Brachial Plexus

- Located deep within the shoulder
- Individual nerves emerging from brachial plexus innervate the lower part of the shoulder and the entire arm
The Brachial Plexus

- Roots
- Trunks
- Anterior divisions
- Posterior divisions
- Cords
- C5
- C6
- C7
- C8
- T1
- Long thoracic nerve

- Posterior scapular nerve
- Suprascapular nerve
- Lateral cord
- Posterior cord
- Medial cord
- Musculocutaneous nerve
- Axillary nerve
- Radial nerve
- Median nerve
- Ulnar nerve
- Ulna
- Median nerve
- Radial nerve
- Radius
- Superficial branch of ulnar nerve
- Digital branch of ulnar nerve
- Digital branch of median nerve
1. Biceps
2. Ulnar Nerve
3. Median Nerve
4. Coracobrachialis
5. Deltoid
6. Musculocutaneous Nerve
7. Brachial Plexus
8. Trapezius
9. Anterior Scalene Muscle
10. Phrenic Nerve
11. Subclavian Artery
Lumbar Plexus      L1-L5

- Located in the lumbar region of the back in the psoas muscle
- Formed by intermingling fibers of L1 through L5
- Femoral nerve exits the lumbar plexus, divides into many branches, and supplies the thigh and leg
The Lumbar Plexus

- Hip bone
- Sacrum
- Femoral nerve
- Pudendal nerve
- Sciatic nerve
- Femur
- Tibial nerve
- Common fibular nerve
- Superficial fibular nerve
- Deep fibular nerve
- Fibula
- Tibia
- Tibial nerve
- Medial plantar nerve
- Lateral plantar nerve

Roots
Anterior divisions
Posterior divisions

L1
L2
L3
L4
L5

Iliohypogastric nerve
Ilioinguinal nerve
Genitofemoral nerve
Obturator nerve
Lateral femoral cutaneous nerve
Femoral nerve
Obturator nerve
Lumbosacral trunk

From lumbar plexus
From sacral plexus
3 Lumbar plexus block. a Tuffier's line, b posterior superior iliac spine. The distance from the midline is 4–6 cm.
SPINAL NERVES: PLEXUSES

- Sacral plexus and coccygeal plexus
  - Located in the pelvic cavity in the anterior surface of the piriformis muscle
  - Formed by intermingling of fibers from L4 through S4
  - Tibial, common peroneal, and sciatic nerves exit the sacral plexus and supply nearly all the skin of the leg, posterior thigh muscles, and leg and foot muscles
SPINAL NERVES

- Dermatomes and myotomes
  - Dermatome: region of skin surface area supplied by afferent (sensory) fibers of a given spinal nerve
  - Myotome: skeletal muscle or muscles supplied by efferent (motor) fibers of a given spinal nerve
Fig. 14-6. **Segmental distribution of spinal nerves.** A dermatome is a region of skin supplied by afferent (sensory) fibers of a given spinal nerve. A myotome is a region of skeletal muscle innervated by efferent (motor) fibers of a given spinal nerve. Spinal nerves at different segments of the spinal cord innervate different sets of dermatomes and myotomes.
Fig. 14-7. Dermatome distribution of spinal nerves. A, The front of the body’s surface. B, The back of the body’s surface. C, The side of the body’s surface. The inset shows the segments of the spinal cord connected with each of the spinal nerves associated with the sensory dermatomes shown. C, Cervical segments and spinal nerves; T, thoracic segments and spinal nerves; L, lumbar segments and spinal nerves; S, sacral segments and spinal nerves.
Fig. 14-8. Myotomes and body movement. Myotomes are skeletal muscles innervated by one or more given spinal nerves. These examples show which spinal nerves innervate the skeletal muscles that produce the movements indicated by the arrows. A, Rotation and abduction/adduction of arm and hip. B, Flexion/extension of hand and wrist; pronation/supination of hand. C, Flexion/extension/hyperextension of arm, hip, knee; dorsiflexion and plantar flexion of foot. C, Cervical spinal nerves; L, lumbar spinal nerves; S, sacral spinal nerves.
CRANIAL NERVES

- Overview
  - 12 pairs of cranial nerves connect to the brain, mostly the brainstem
  - Identified by name (determined by either distribution or function) or number (order in which they emerge, anterior to posterior) or both
  - Composed of bundles of axons
    - Mixed cranial nerve: axons of sensory and motor neurons
    - Sensory cranial nerve: axons of sensory neurons only
    - Motor cranial nerve: mainly axons of motor neurons and a small number of sensory fibers (proprioceptors)
Fig. 14-9. Cranial nerves. Ventral surface of the brain showing attachment of the cranial nerves.

Cranial nerves:
- Optic nerve (II)
- Trochlear nerve (IV)
- Trigeminal nerve (V)
- Abducens nerve (VI)
- Facial nerve (VII)
- Vestibulocochlear nerve (VIII)
- Glossopharyngeal nerve (IX)
- Vagus nerve (X)
- Hypoglossal nerve (XII)
- Accessory nerve (XI)
I Olfactory Nerve

- sense of smell
- damage causes impaired sense of smell
II Optic Nerve

- provides vision
- damage causes blindness in part or all of the visual field
III Oculomotor Nerve

- controls muscles that turn the eyeball up, down, and medially, as well as controlling the iris, lens, and upper eyelid
- damage causes drooping eyelid, dilated pupil, double vision, difficulty focusing and inability to move eye in certain directions
IV Trochlear Nerve

- eye movement (superior oblique muscle)
- damage causes double vision and inability to rotate eye inferolaterally
V Trigeminal Nerve

- largest of the cranial nerves
- most important sensory nerve of the face
- forks into three divisions:
  - ophthalmic division (V₁) – sensory
  - maxillary division (V₂) – sensory
  - mandibular division (V₃) - mixed
VI Abducens Nerve

- provides eye movement (lateral rectus m.)
- damage results in inability to rotate eye laterally and at rest; eye rotates medially
VII  Facial Nerve

- **motor** – major motor nerve of facial muscles: facial expressions; salivary glands and tear, nasal and palatine glands
- **sensory** - taste on anterior 2/3’s of tongue
- **damage** produces sagging facial muscles and disturbed sense of taste (no sweet and salty)
clinical test: test anterior 2/3’s of tongue with substances such as sugar, salt, vinegar, and quinine; test response of tear glands to ammonia fumes; test motor functions by asking subject to close eyes, smile, whistle, frown, raise eyebrows, etc.
VIII Vestibulocochlear Nerve

- nerve of hearing and equilibrium
- damage produces deafness, dizziness, nausea, loss of balance and nystagmus (involuntary rhythms oscillation of the eyes from side to side)
IX Glossopharyngeal Nerve

- swallowing, salivation, gagging, control of BP and respiration

- sensations from posterior 1/3 of tongue

- damage results in loss of bitter and sour taste and impaired swallowing
X Vagus Nerve

- most extensive distribution of any cranial nerve
- major role in the control of cardiac, pulmonary, digestive, and urinary function
- swallowing, speech, regulation of viscera
- damage causes hoarseness or loss of voice, impaired swallowing and fatal if both are cut
Accessory Nerve

- swallowing, head, neck and shoulder movement
- damage causes impaired head, neck, shoulder movement; head turns towards injured side
tongue movements for speech, food manipulation and swallowing
- if both are damaged – can’t protrude tongue
- if one side is damaged – tongue deviates towards injured side; see ipsilateral atrophy
AUTONOMIC NERVOUS SYSTEM

• Overview
  • Contains afferent (sensory) and efferent (motor) components (the efferent components are emphasized here)
  • Major function: to regulate heartbeat, smooth muscle contraction, and glandular secretions to maintain homeostasis
  • Two efferent divisions: sympathetic division and parasympathetic division
  • Many autonomic effectors are dually innervated, which allows remarkably precise control of effector
Fig. 14-17. Autonomic conduction paths. A, The left side of the diagram shows that one somatic motor neuron conducts impulses all the way from the spinal cord to a somatic effector. Conduction from the spinal cord to any visceral effector, however, requires a relay of at least two autonomic motor neurons—a preganglionic and a postganglionic neuron, shown on the right side of the diagram. B, Sketch showing a portion of the left and right sympathetic chain or trunk.
Fig. 14-18. Major autonomic pathways.
Functions of the autonomic nervous system

- Overview of autonomic function
  - The autonomic nervous system functions to regulate visceral effectors in ways that tend to maintain or quickly restore homeostasis
  - Sympathetic and parasympathetic divisions are often exerting antagonistic influences on visceral effectors
  - Doubly innervated effectors continually receive both sympathetic and parasympathetic impulses; summation of the two determines the controlling effect
AUTONOMIC NERVOUS SYSTEM: FUNCTIONS

• Functions of the sympathetic division
  • Under resting conditions, the sympathetic division can act to maintain the normal functioning of doubly innervated autonomic effectors
  • Sympathetic impulses function to maintain normal tone of the smooth muscle in blood vessel walls
  • Major function of sympathetic division is as an “emergency” system—the “fight or flight” reaction

• Functions of the parasympathetic division
  • Dominant controller of most autonomic effectors most of the time
  • Acetylcholine: slows heartbeat and promotes digestion and elimination
Lifespan Changes

- Brain cells begin to die before birth
- Over average lifetime, brain shrinks 10%
- By age 90, frontal cortex has lost half its neurons
- Decreased levels of neurotransmitters with age
- Fading memory
- Slowed responses and reflexes
- Increased risk of falling
- Changes in sleep patterns that result in fewer sleeping hours