Spinal nerves

Aygul Shafigullina

Department of Morphology and General Pathology
**Spinal nerve** – a mixed nerve, formed in the vicinity of an intervertebral foramen, where fuse a dorsal root and a ventral root, which supplies the innervation of a segment of the body.
**Composition:** each spinal nerve contains both motor and sensory axons.

**Spinal roots:**
- Nerve fibers emerge from the spinal cord in a paired, uninterrupted series of **dorsal** (input, sensory, and afferent) and **ventral** (output, motor, and efferent) **rootlets**, which join to form **31 pairs** of dorsal and ventral roots.
Dorsal (sensory, afferent) root:
- convey input from the sensory receptors in the body to the spinal cord.
- The cell bodies of the pseudounipolar neurons lie in the dorsal ganglion
- Some fibers supply the sensory innervation to a skin segment (dermatome), whereas other fibers provide nerve endings to deep structures
- There is usually no C1 and Co1 dermatome (no dorsal root)
- Adjacent dermatomes overlap
- The loss of one dorsal root - diminished sensation (not a complete loss) in that area
- Anesthesia or paresthesia involving an entire dermatome is indicative of spinal cord injury or root damage. Partial dermatome involvement - peripheral nerve damage.
Spinal nerve

Dermatomes – skin segments
FIGURE 1.23 Dermatomes and distribution of cutaneous nerves on the anterior aspect of the body.
Ventral (motor, efferent) root:
- convey output from the spinal cord
- The cell bodies lie in the ventral horn of the spinal cord gray matter and project axons which may:
  - 1) innervate voluntary striated muscles (*general somatic efferent*)
  - 2) synapse with neurons in peripheral ganglia, which in turn, innervate involuntary smooth muscles and glands (*general visceral efferent, sympathetic or parasympathetic*)
Muscles that abduct the arm are innervated by C5 and C6 spinal levels (spinal nerves) and develop from somites initially associated with C5 and C6 regions of developing spinal cord.
The fibers of the ventral root of each spinal nerve supply the motor innervation to specific groups of voluntary muscles known as myotomes.

- A central lesion will involve to some extent all of the muscles of a myotome.
- A peripheral nerve injury will involve only a portion of a myotome.
Nature of spinal nerve:
- Afferent
- Efferent
- Autonomous (C8-L2 – sympathetic, S2-S4 – parasympathetic)
Spinal nerve (31 pair)

C1: Cervical spinal nerve roots C1 - C7 correspond with upper aspects of vertebral bodies.

C8: Sensation of C7 nerve is for the middle finger.

T1: C8 and lower spinal nerve roots leave below the corresponding vertebral body.

T4: Sensation of T4 spinal nerve is approximately level with the nipple line.

T6: Sensation of T6 spinal nerve root is approximately level with the bottom of the sternum.

T10: Sensation of T10 spinal nerve root is approximately level with the abdomen.

T12: Sensation of T12 spinal nerve root is approximately level with the pubic bone.

L1: The sensations of lumbar nerves are over the legs.

L5: Sensation of S3, S4 & S5 nerves is the perineal (genital) area.

S1: Coc1 Sensation to coccygeal area.

Bone notch at the base of the neck is C7.

The spinal cord ends approximately between L1 & L2.

Sacral cord segments (S1-S5 "cauda equina") are level with T12-L1 vertebrae.

The sacral vertebrae are fused to make up the sacrum.

The coccygeal vertebrae are fused to make the coccyx or "tail bone".

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Figure 7-2. The first seven cervical nerves ("heavenly seven") exit above their corresponding vertebral bodies. (Courtesy Randall J. Wright, MD.)
Subdivisions of the spinal nerve:

1) **Dorsal (posterior) ramus** supply the dermatomes and myotomes of the median portion of the back.

2) **Ventral (anterior) ramus** supply the dermatomes and myotomes of the lateral and anterior portions of the body and the extremities in their entirety.

3) **Meningeal ramus**

4) **White rami communicantes (thoraco-lumbar segments of spinal cord)**
Branches of spinal nerve

- **Rami communicantes (C8-L2):**
  - White (myelinated)
  - Gray (unmyelinated)
White ramus communicant (15 pairs = 15 segments C8-L2):
- Connects the spinal nerve and the sympathetic chain between C8 and L2, inclusive
- Conveys sympathetic preganglionic myelinated fibers to the paraveterbral and prevetebral ganglia
- Conveys visceral afferent fibers to the spinal nerve
Gray ramus communicant (31 pairs = 31 pairs spinal nerves):
- Connects the sympathetic chain and the spinal nerves at every level
- Conveys sympathetic postsynaptic unmyelinated fibers from the paravertebral ganglia to the spinal nerve to reach the skin
- Every spinal nerve receives a gray ramus from the sympathetic chain!
Spinal cord and sympathetic trunk

(a) Location of the sympathetic trunk
Branches of spinal nerve

- **Meningeal branch:**
  - **sensory** (meninges and vessels)
  - **Sympathetic** (smooth muscle cells of vessels)
Branches of spinal nerve

- **Posterior (dorsal) branches:**
  - **Sensory** (somatic)
  - **Motor** (skeletal muscles)
  - **sympathetic** (smooth muscle cells of vessels, skin glands, pilomotor muscles)
Dorsal rami maintain metameric structure!
Branches of spinal nerve

- **Anterior (ventral) ramus:**
  - Sensory (somatic)
  - Motor (skeletal muscles)
  - Sympathetic (smooth muscle cells, vessels, skin glands, pilomotor muscles)
Subdivisions of the spinal nerve:
1) the dorsal (posterior) ramus
   - skin (the posterior portion of the dermatome) and muscles of the back
2) the ventral (anterior) primary ramus
   - the muscles and skin of the lateral and ventral aspects of the body.
3) the meningeal ramus is actually the first branch of the spinal nerve.
4) rami communicantes (white and gray)

Ventral rami form plexuses (except thoracic region)
Anterior branch:
- Metameres only in thoracic regions
- Form cervical, brachial, lumbar-sacral-coccygeal plexuses
- Development of the extremities – development of the plexuses
- Innervate the lateral and anterior portions of the body and the extremities

Posterior branch:
- Metameres in all regions
- Innervate dermatomes and myotomes of the median portion of the back
Cervical plexus

Cervical plexus and links with the twelfth cranial nerve

- Lesser occipital nerve
- Great auricular nerve
- Nerve to sternocleidomastoid muscle
- Nerve to levator scapulae
- Branches to trapezius
- Nerve to levator scapulae
- Nerve to scalenus medius
- Supraclavicular branches of cervical plexus

Hypoglossal nerve
C1 fibres passing to hypoglossal nerve to supply superficial cervical muscles
Descendens cervicis
Nerve to geniohyoid and thyrohyoid muscles
Transverse cervical nerve of neck
Branches to strap muscles of the neck
Descendens hypoglossi
Phrenic nerve

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Brachial plexus

- **Cords**: Lateral, Medial, Posterior
- **Divisions**: Dorsal scapular, Suprascapular, Nerve to subclavius
- **Trunks**: C5, C6, C7, C8, T1
- **Roots**: C5, C6, C7, C8, T1

- Lateral pectoral nerve
- Musculocutaneous nerve
- Axillary nerve
- Median nerve
- Ulnar nerve
- Radial nerve
- Thoraco dorsal nerve
- Upper subscapular nerve
- Medial pectoral nerve
- Lower subscapular nerve
- Medial cutaneous nerve of the arm
- Medial cutaneous nerve of the forearm
- Long thoracic nerve
- Nerve to subclavius
Canalis nervi radialis (canalis humeromuscularis)

- **Inlet:**
  - between the upper and middle thirds of the arm on medial side
  - humerus and the medial and lateral heads of the triceps muscle

- **Outlet:**
  - between the middle and lower thirds of the arm on lateral side
  - It is bounded by the brachialis and brachioradialis muscles

- **anteriorly** – humerus
- **posteriorly** – m.triceps brachii
Palpation of anatomic structures

The median nerve accompanies the artery until just before the cubital fossa. It passes between the ulnar and humeral heads of the pronator teres before it travels down the forearm. Compression neuropathies of the median nerve can arise when this muscle is very tense.
Fig. 3.28 Topography of the muscles in the forearm—anterio-r view.
Carpal tunnel syndrome

tunnel n. medianus tendons
Thoracic region – intercostal nerves – metameric distribution
Lumbar plexus

1 (twice) Get Laid On Fridays

2 from 1
2 from 2
2 from 3
Sacral plexus
Lumbar plexus vs Sacral plexus

**Lumbar plexus:**
- Femoral n.
- Saphenous n.
- Obturator n.
- Lateral femoral cutaneous n.

**Sacral plexus:**
- Sciatic n.
- N. to hamstring m.
- Posterior cutaneous n.
- Common peroneal n.
- Tibial n.
- Sural n.
Lasègue's Test

Increased pain on dorsiflexion of the patient's foot increases sensitivity of the test.

Figure 2. Straight-Leg-Raising Test.
Panel A shows the straight-leg-raising test, with assessment for the presence or absence of Lasègue's sign, and Panel B shows the spinal nerve roots under traction during the test.
Sciatic Nerve Pain Location

The growing uterus putting pressure on the sciatic nerve

Sciotic nerve origin
Spine
Sciotic nerve

Origin of the burning sensation and pain that travels down the leg through the sciatic nerve (the green line)
Tendon reflexes tests

FIGURE 1.25 Some important tendon reflexes used in medical practice.
Tendon reflexes tests

- **Biceps brachii tendon reflex:** C5 and 6 (flexion of the elbow joint by tapping the biceps tendon)
- **Triceps tendon reflex:** C6, 7, and 8 (extension of the elbow joint by tapping the triceps tendon)
- **Brachioradialis tendon reflex:** C5, 6, and 7 (supination of the radioulnar joints by tapping the insertion of the brachioradialis tendon)
- **Abdominal superficial reflexes (contraction of underlying abdominal muscles by stroking the skin):** Upper abdominal skin T6 to 7, middle abdominal skin T8 to 9, and lower abdominal skin T10 to 12
- **Patellar tendon reflex (knee jerk):** L2, 3, and 4 (extension of the knee joint on tapping the patellar tendon)
- **Achilles tendon reflex (ankle jerk):** S1 and 2 (plantar flexion of the ankle joint on tapping the Achilles tendon)
Innervation of skeletal muscles

- α- and γ- motoneurons of anterior horn of spinal cord
- Motoneurons of cranial nerves (CN III, IV, V, VI, VII, IX, X, XI, XII)
- Pseudounipolar neurons of spinal ganglia
- Pseudounipolar neurons of cranial nerves ganglia and sensory nuclei
- NO! vegetative innervation
The Motor Unit

- Motor neuron
- Branches of motor neurons
- Myofibrils
- Muscle fiber
Motor Unit = 1 Motoneuron + muscle fibers, it stimulates
Number of muscle fibers in MU – from 4 to several 100s per 1 Motoneuron
Average number – 150

Less number of muscle fibers in Motor unit (A) – gross movement

Large number of muscle fibers in Motor unit (B) – fine and precise movement
Henneman’s size principle - Rule of motor units recruitment

- under load, motor units are recruited from smallest to largest.
- from slow-twitch, low-force, fatigue-resistant muscle fibers to fast-twitch, high-force, less fatigue-resistant muscle fibers.
- Advantages:
  1) Task-appropriate recruitment
  2) It **minimizes the amount of fatigue** an organism experiences (by using fatigue-resistant muscle fibers first and only using fatigable fibers when high forces are needed).
  3) It also permits **fine control of force** at all levels of output

Muscle tone is due to random, asynchronous motor unit contractions
Afferent innervation of muscles

1) Muscle spindle (in stretch reflex)
   - Intrafusal muscle fibers + stretch receptors + capsule
   - Stretched intrafusal fibers (muscle belly) - sense muscle length – contraction of muscle belly - return to original size

2) Golgi tendon organ
   - Located in tendon
   - Sense tension of tendon
   - Stretched tendon – relaxation of muscle belly – return to original size
Stretch Reflex

Group Ia afferent

α-motoneuron

Antagonistic muscle

Muscle spindle (intrafusal muscle)

Extrafusal muscle

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Golgi Tendon Reflex

- Group Ia afferent
- α-motoneuron
- Antagonistic muscle
- Golgi tendon organ
- Extrafusal muscle

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Golgi tendon organ

Spinal Cord Reflex Arc

- Golgi tendon organ
- tension
- muscle-tendon junction
- relaxation response
- muscle belly
Spinal meninges and spaces

- Epidural space (contains fat)
- Subdural space
- Subarachnoid space
- Pia mater
- Arachnoid
- Dura mater (spinal dural sheath)
- Spinal meninges
- Bone of vertebra
- Dorsal root ganglion
- Body of vertebra

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Blood Supply to the Spinal Cord

Anterior spinal artery
Vertebral artery
Subclavian artery
Radicular artery
Great vertebral radicular artery (artery of Adamkiewicz)
Lumbar radicular artery

Anterior spinal artery territory
Anterior sulcal artery
Corona
Lateral column
Dorsal column
Posterolateral artery

Posterior spinal artery territory

1) Internal vertebral plexus (within the vertebral canal)
2) External vertebral plexus (surrounds the vertebral column)
3) Basi-vertebral Plexus (within the vertebral body)
4) Intervertebral veins
Phantom limb and phantom pain
Phantom limb and phantom pain

A phantom limb is the sensation that an amputated or missing limb is still attached.