12.6A: Overview of the Spinal Nerves

Spinal nerves, a part of the peripheral nervous system (PNS), are mixed nerves that send motor, sensory, and autonomic signals between the CNS and the body.

Learning Objectives

• Describe spinal nerves of the peripheral nervous system

Key Points

• Afferent sensory axons bring sensory information from the body to the spinal cord and brain; they travel through the dorsal roots of the spinal cord.
• Efferent motor axons bring motor information from the brain to the body; they travel through the ventral roots of the spinal cord.
• All spinal nerves—except the first pair—emerge from the spinal column through an opening between vertebrae, called an intervertebral foramen.
• The spinal nerves are typically labeled by their location in the body: thoracic, lumbar, or sacral.

Key Terms

• ventral root: Also called the anterior root, it is the efferent motor root of a spinal nerve.
• autonomic: Acting or occurring involuntarily, without conscious control.
• dorsal root: Also known as the posterior root, the afferent sensory root of a spinal nerve.
- **intervertebral foramen**: The foramen allows for the passage of the spinal nerve root, dorsal root ganglion, the spinal artery of the segmental artery, the communicating veins between the internal and external plexuses, recurrent meningeal (sinu-vertebral) nerves, and transforaminal ligaments.

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**Spinal Nerve Anatomy**

The term spinal nerve generally refers to a mixed spinal nerve that carries motor, sensory, and autonomic signals between the spinal cord and the body.

Humans have 31 left–right pairs of spinal nerves, each roughly corresponding to a segment of the vertebral column: eight cervical spinal nerve pairs (C1–C8), 12 thoracic pairs (T1–T12), five lumbar pairs (L1–L5), five sacral pairs (S1–S5), and one coccygeal pair. The spinal nerves are part of the peripheral nervous system (PNS).

A spinal nerve: Spinal nerves arise from a combination of nerve fibers from the dorsal and ventral roots of the spinal cord.
Location

**Intervertebral foramina:** Intervertebral foramina are indicated by arrows.

Each spinal nerve is formed by the combination of nerve fibers from the dorsal and ventral roots of the spinal cord. The dorsal roots carry afferent sensory axons, while the ventral roots carry efferent motor axons.

The spinal nerve emerges from the spinal column through an opening (intervertebral foramen) between adjacent vertebrae.

This is true for all spinal nerves except for the first spinal nerve pair, which emerges between the occipital bone and the atlas (the first vertebra). Thus the cervical nerves are numbered by the vertebra below, except C8, which exists below C7 and above T1.

The thoracic, lumbar, and sacral nerves are then numbered by the vertebra above. In the case of a lumbarized S1 vertebra (i.e., L6) or a sacralized L5 vertebra, the nerves are typically still counted to L5 and the next nerve is S1.
Spinal Nerve Innervation

Outside the vertebral column, the nerve divides into branches. The dorsal ramus contains nerves that serve the dorsal portions of the trunk; it carries visceral motor, somatic motor, and somatic sensory information to and from the skin and muscles of the back (epaxial muscles).

The ventral ramus contains nerves that serve the remaining ventral parts of the trunk and the upper and lower limbs (hypaxial muscles); they carry visceral motor, somatic motor, and sensory information to and from the ventrolateral body surface, structures in the body wall, and the limbs.

The meningeal branches (recurrent meningeal or sinuvertebral nerves) branch from the spinal nerve and re-enter the intervertebral foramen to serve the ligaments, dura, blood vessels, intervertebral discs, facet joints, and periosteum of the vertebrae.

The rami communicantes contain autonomic nerves that serve visceral functions, such as carrying visceral motor and sensory information to and from the visceral organs.

Cervical Nerves

The posterior distribution of the cervical nerves includes the suboccipital nerve (C1), the greater occipital nerve (C2), and the third occipital nerve (C3). The anterior distribution includes the cervical plexus (C1–C4) and brachial plexus (C5–T1).

The muscles innervated by the cervical nerves are the sternohyoid, sternothyroid, and omohyoid muscles.

A loop of nerves called ansa cervicalis is also part of the cervical plexus.

Thoracic Nerves

Thoracic nerve branches exit the spine and go directly to the paravertebral ganglia of the autonomic nervous system, where they are involved in the functions of organs and glands in the head, neck, thorax, and abdomen.

Anterior Divisions

The intercostal nerves come from thoracic nerves T1–T11, and run between the ribs. The subcostal nerve comes from nerve T12, and runs below the twelfth rib.

Posterior Divisions

The medial branches (ramus medialis) of the posterior branches of the upper six thoracic nerves run between the semispinalis dorsi and multifidus, which they supply.

They then pierce the rhomboid and trapezius muscles, and reach the skin by the sides of the spinous processes. This branch is called the medial cutaneous ramus.
The medial branches of the lower six thoracic nerves are distributed chiefly to the multifidus and longissimus dorsi, occasionally they give off filaments to the skin near the middle line. This sensitive branch is called the posterior cutaneous ramus.

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**Lumbar Nerves**

The lumbar nerves are divided into posterior and anterior divisions.

**Posterior Divisions**

The medial branches of the posterior divisions of the lumbar nerves run close to the articular processes of the vertebrae and end in the multifidus muscle. The lateral branches supply the erector spinae muscles.

**Anterior Divisions**

The anterior divisions of the lumbar nerves (rami anteriores) consist of long, slender branches that accompany the lumbar arteries around the sides of the vertebral bodies, beneath the psoas major.

The first and second, and sometimes the third and fourth, lumbar nerves are each connected with the lumbar part of the sympathetic trunk by a white ramus communicans.

The nerves pass obliquely outward behind the psoas major, or between its fasciculi, distributing filaments to it and the quadratus lumboorum.

The first three and the greater part of the fourth are connected by anastomotic loops and form the lumbar plexus.

The smaller part of the fourth joins with the fifth to form the lumbosacral trunk, which assists in the formation of the sacral plexus. The fourth nerve is named the furcal nerve, from the fact that it is subdivided between the two plexuses.

**Sacral Nerves**

There are five paired sacral nerves, half of them arising through the sacrum on the left side and the other half on the right side. Each nerve emerges in two divisions: one division through the anterior sacral foramina and the other division through the posterior sacral foramina.

The sacral nerves have both afferent and efferent fibers, thus they are responsible for part of the sensory perception and the movements of the lower extremities of the human body.

The pudendal nerve and parasympathetic fibers arise from S2, S3, and S4. They supply the descending colon and rectum, urinary bladder, and genital organs. These pathways have both afferent and efferent fibers.
Coccygeal Nerve

The coccygeal nerve is the 31st pair of spinal nerves and arises from the conus medullaris. Its anterior root helps form the coccygeal plexus.

Function

Spinal nerve motor functions are summarized in the table below.

**Actions of the spinal nerves**

<table>
<thead>
<tr>
<th>Level</th>
<th>Motor Function</th>
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<tbody>
<tr>
<td>C1–C6</td>
<td>Neck flexors</td>
</tr>
<tr>
<td>C1–T1</td>
<td>Neck extensors</td>
</tr>
<tr>
<td>C3, C4, C5</td>
<td>Supply diaphragm (mostly C4)</td>
</tr>
<tr>
<td>C5, C6</td>
<td>Move shoulder, raise arm (deltoid); flex elbow (biceps)</td>
</tr>
<tr>
<td>C6</td>
<td>Externally rotate (supinate) the arm</td>
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<tr>
<td>C6, C7</td>
<td>Extend the elbow and wrist (triceps and wrist extensors); pronate wrist</td>
</tr>
<tr>
<td>C7, C8</td>
<td>Flex wrist; supply small muscles of the hand</td>
</tr>
<tr>
<td>T1–T6</td>
<td>Intercostals and trunk above the waist</td>
</tr>
<tr>
<td>T7–L1</td>
<td>Abdominal muscles</td>
</tr>
<tr>
<td>L1–L4</td>
<td>Flex thigh</td>
</tr>
<tr>
<td>L2, L3, L4</td>
<td>Adduct thigh; extend leg at the knee (quadriceps femoris)</td>
</tr>
<tr>
<td>L4, L5, S1</td>
<td>Abduct thigh; flex leg at the knee (hamstrings); dorsiflex foot (tibialis anterior); extend toes</td>
</tr>
<tr>
<td>L5, S1, S2</td>
<td>Extend leg at the hip (gluteus maximus); plantar flex foot and flex toes</td>
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