

Cervical Vertebrae, Prevertebral Region, and Exterior of Base of the Skull

Clinical Case 46.1

Patient Andy G. This 17-year-old high school senior injured his neck diving into a stream during a pregraduation party. He was rushed to the emergency room where he was placed in a stabilizing brace to prevent any neck movement. The spinal cord injury management team finds he has no sensation from his paralyzed lower extremities, abdomen, and chest to the level of the sternal angle (T2 dermatome). He has some sensation over his shoulders and some bicep function when tested reflexively. There is no muscle or sensory function in his forearms or hands. Two days after the accident, he develops respiratory problems and must be intubated and placed on a respirator. X-rays show a fracture of the C5 vertebra.

Cervical Vertebrae

There are 7 cervical vertebrae. The 1st and 2nd are distinctively unique. The 3rd, 4th, 5th, and 6th are typical cervical vertebrae, and the 7th is transitory between the cervical and thoracic form of vertebrae. All cervical vertebrae have one distinguishing feature—they possess a foramen in their transverse processes (the **foramen transversarium**). The foramina transversarii of the upper six cervical vertebrae transmit the vertebral artery as it ascends to the posterior cranial fossa. One other major clinical and anatomical relationship regarding the cervical vertebrae is that the cervical spinal nerves pass superior to their related vertebrae as they exit the spinal column.

Since there are 7 cervical vertebrae and 8 cervical spinal nerves, the 7th cervical vertebrae will have the 7th cervical nerve above and the 8th cervical nerve below. All other spinal nerves in the thoracic, lumbar, and sacral region therefore exit the spinal column below their associated vertebra.

TYPICAL CERVICAL VERTEBRA (fig. 46.1)

The body is rectangular and concaved on the superior aspect. It will articulate with the convex inferior surface of the vertebral body superior to it. The size of the vertebral bodies increases in the lower vertebrae to support the additional weight of the head, neck, and upper extremity on the spinal column.

The **pedicles** arise from the body and project in a posterolateral fashion to join the neural arch. The **vertebral foramen** is therefore triangular in shape in the cervical region. The **articular processes** are at the junction of the pedicles and the laminae. They form a column of bone laterally that articulates in concert with the bodies of the cervical vertebrae. The articulating facets are horizontally oriented superiorly but gradually assume an anterior oblique orientation as one descends in the cervical region. These joints allow flexion and extension of the cervical column.

The **laminae** form the posterolateral legs of the triangular vertebral foramen. They serve as bony attachments for the deep muscles of the neck and protect the underlying cervical spinal cord. A cervical **laminectomy** is a neurosurgical/orthopedic procedure that is done to gain access to the cervical spinal cord or to relieve pressure on the cervical cord following a severe neck injury.

The **spinous processes** of the cervical vertebrae are most posterior and unite the laminae. In the typical cervical vertebrae, the spinous process is bifid. The **ligamentum nuchae**, a thick midline septum of connective tissue, attaches to this bifid spinous process. The spinous process and the ligamentum nuchae are attachment sites for muscles of the back of the neck.

The **transverse processes** project anterolaterally from the vertebral body, pedicle and articular process. **Understanding the anatomy of the transverse processes of the typical vertebra is the key to understanding many of the important clinical points in the neck.** The transverse

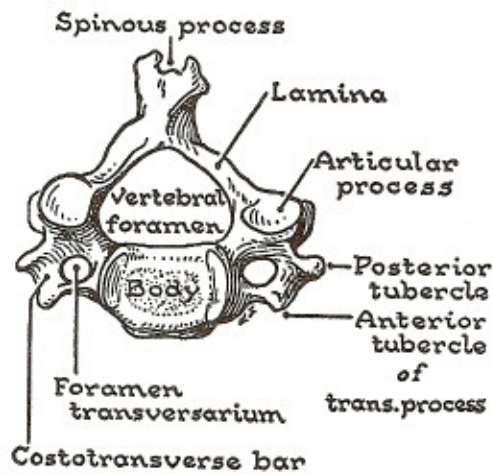


Figure 46.1. Typical cervical vertebra (from above).

process is "cup-shaped" on its superior surface and holds the emerging spinal nerve that passes from the intervertebral foramen. The **foramen transversarium** is situated in the anterior aspect of the base of each transverse process, and the vertebral artery contained within the foramen is therefore anterior to the emerging cervical nerve. **Posterior and anterior tubercles** exist at the tips of the transverse processes of C3–6 (the remaining cervical vertebrae have only posterior tubercles). The **posterior tubercles** give attachments to the muscles in the floor of the posterior triangle (scalene mass, levator scapulae, splenius, and semispinalis cervicis). The anterior tubercle gives attachment to two important reference muscles in the root of the neck—the **scalenus anterior** and the **longus colli** muscles. The emerging roots of the cervical and brachial plexuses are therefore found between the scalenus anterior and scalenus mass in the neck. The anterior tubercle is also equivalent to the bone mass that would form the ribs in the thoracic region. Cervical ribs are formed when the anterior tubercle is excessively extended into the neck. The **costotransverse bar** is a segment of bone in the transverse processes that connect the anterior and posterior tubercles distal to the foramen transversarium.

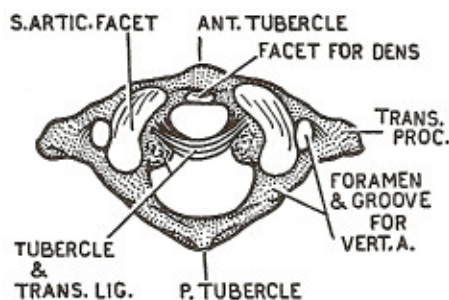


Figure 46.2. The atlas and the transverse ligament (posterosuperior view).

The **1st cervical vertebra** supports the skull and is therefore called the **atlas** (after the mythical Greek god who supported the globe). The atlas is unique in that it lacks a body and is composed of an **anterior** and **posterior arch** with laterally projecting **transverse processes** (fig. 46.2). The body of the atlas is the **dens** (odontoid process) of the 2nd cervical vertebra (fig. 46.3). The dens articulates with a posterior facet on the anterior arch of the atlas and a transverse ligament. This allows the atlas to rotate around the dens in a horizontal plane. This movement is demonstrated by asking patients to motion a "no" sign with their head.

The **superior articulating facets** of the atlas articulate with the **condyles** of the **occipital bone**. The movement in these **atlanto-occipital** joints is a rocking movement in the sagittal plane. This movement occurs when a patient nods the head to indicate a "yes" sign. The superior articulating facets are reniform (kidney-shaped) and match the form of the opposing occipital condyles. Within the concavity of the medial aspect of the superior articulating facets are the **tubercles** of the atlas. They serve to attach the **transverse ligament** (horizontal part of cruciate ligament) that articulates with the dens and prevents the dens from sliding posteriorly into the C1 vertebral foramen, which contains the spinal cord.

The transverse processes of the atlas are prominent and extend more laterally than the transverse processes of the underlying upper cervical vertebrae. The transverse processes of C1 can be felt behind the mandibular ramus (fig. 43.2). The foramina transversarii in the transverse processes of C1 are more lateral than the underlying foramina transversarii of the C2 vertebra. The vertebral artery therefore courses laterally as it ascends between the C2 and C1 vertebrae.

The **posterior arch** of the atlas overlies the cervical spinal cord just below the foramen magnum. It has **two** important physical markings that should be noted. First, a **groove for the vertebral artery** exists on the superior aspect of the posterior arch just behind the superior articulating facet. This indicates the course that the vertebral artery takes as it passes from the foramen transversarium of the atlas, to pierce the dura mater and to enter the posterior cranial fossa through the foramen magnum. Secondly, a sharp crest on the superior border of

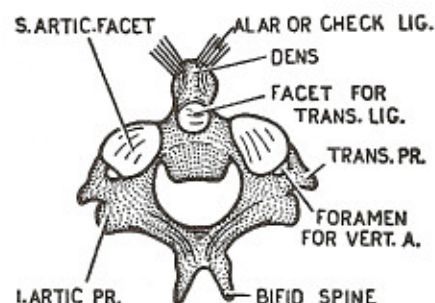


Figure 46.3. Axis (posterosuperior view).

the posterior arch of the atlas marks the inferior attachment site for the **posterior atlanto-occipital membrane**. This is a tough, elastic membrane (equivalent to **ligamentum flavum**) that attaches superiorly to the posterior margin of the foramen magnum. It may be pierced by a needle for a tap of the **cerebrospinal fluid (CSF)** in the cisterna magna of the posterior cranial fossa. The posterior atlanto-occipital membrane also bridges over the vertebral artery to fuse with the capsule of the atlanto-occipital joint.

The **2nd cervical vertebra or axis** (fig. 46.3) has a superior projecting process, the **dens**, which serves as the body of the overlying atlas. The **superior articulating facet of the axis** articulates with the **inferior articulating facet of the atlas**. This sliding joint permits a rotation of the atlas around the dens and over the atlanto-axial joint. The **transverse processes** of the axis are shorter in their lateral projection than the transverse processes of the atlas. Each transverse process has a **foramen transversarium** and a **posterior tubercle**. The laminae extend from the **articular processes** to the bifid spine in the same fashion as seen in a typical cervical vertebrae.

The **7th cervical vertebra** has a transitional form between a typical cervical and thoracic vertebra. The long **nonbifid spine** projects horizontally to be subcutaneous at the base of the neck. It is called the **vertebra prominens**. The **transverse processes** have a **foramen transversarium**, but it usually does not contain the vertebral artery. Veins are present in the foramen transversarium of the 7th cervical vertebra. An **anterior tubercle is not present** on the 7th cervical vertebra. Cervical ribs when they occur are most frequently found on the anterior aspect of the transverse process of the 7th cervical vertebra. The presence of a cervical rib in this location may produce compression of the lower trunk of the brachial plexus (C8, T1) and/or the subclavian artery as they cross the superior surface of the 1st rib.

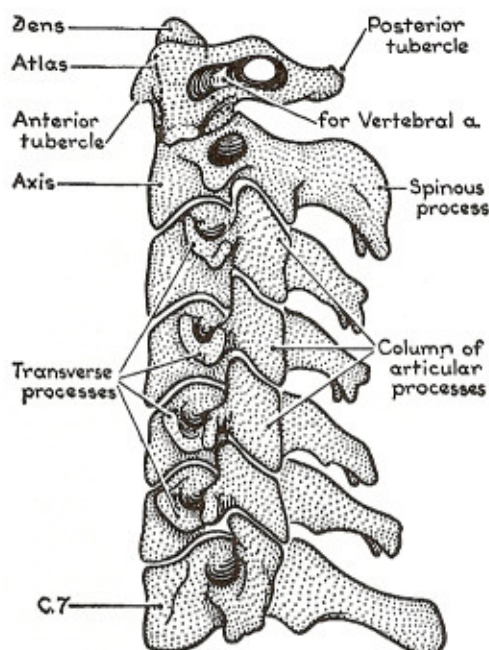


Figure 46.4. Cervical vertebrae on side view.

Deep Cervical Structures

Articulated cervical vertebrae (fig. 46.4), when clothed with the muscles attached to the anterior tubercles of the transverse processes, present a relatively flat prevertebral surface.

Deep anterior cervical muscles are grouped according to their relations to the roots of the cervical and brachial plexuses (fig. 46.5).

Muscles medial to the plexuses:

1. Rectus Capitis Anterior
2. Longus Colli (cervicis)
3. Longus Capitis
4. Scalenus Anterior

Muscles lateral to the plexuses:

1. Rectus Capitis Lateralis
2. Scalenus Medius and Posterior (Scalene Mass)
3. Levator Scapulae

The **longus colli** extends from the body of the 3rd thoracic vertebra to the anterior tubercle of the atlas and is attached to the bodies of the vertebrae in between. It is attached to the anterior tubercles of C3–6 and is a **landmark structure** on which the **cervical sympathetic trunk** ascends in the neck.

The **longus capitis** arises from the anterior tubercles of C3–6 and inserts superiorly on the **basiocciput** posterior to the pharyngeal tubercle. It is also related to the sympathetic chain in the upper neck.

The **scalenus anterior** is the **key muscle for relationships in the root of the neck** (Chapter 44). It attaches to the anterior tubercles of C3–6 and the scalene tubercle on the upper surface of the 1st rib. The brachial plexus and subclavian artery (2nd part) are posterior; the subclavian vein, phrenic nerve, suprascapular artery, and transverse cervical artery are anterior; and the carotid sheath, sympathetic chain, thyrocervical trunk, and vertebral artery are medial to the scalenus anterior.

The **rectus capitis anterior** and **rectus capitis lateralis** lie between the atlas and the base of the skull. The **hypoglossal nerve XII** and the **anterior ramus of C1** emerge from the prevertebral area at this point and join to course anteriorly to the strap muscles of the neck and floor of the mouth.

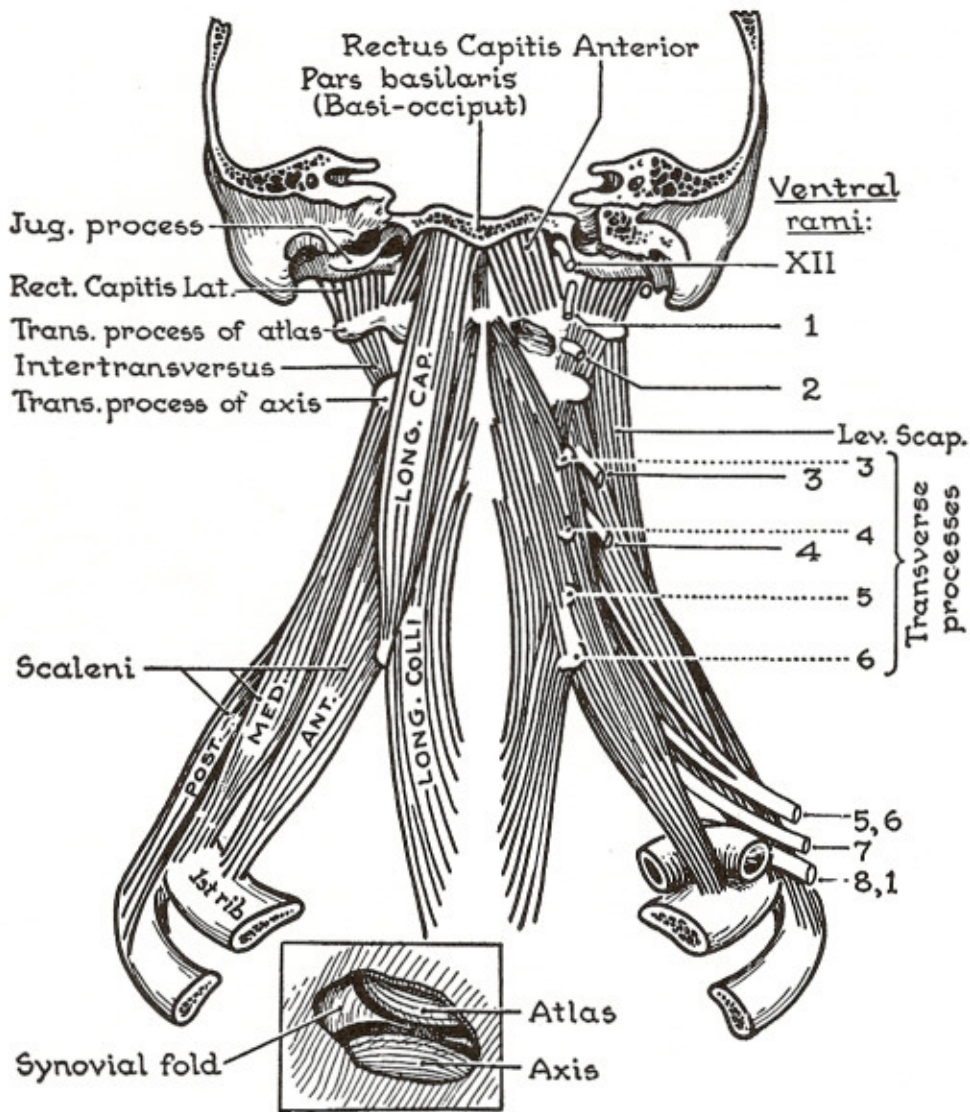


Figure 46.5. The prevertebral muscles: deep anterior cervical muscles.

The scalenus medius, scalenus posterior, and the levator scapulae (fig. 46.5) arise from the posterior tubercles of the cervical vertebrae and insert onto the 1st rib, 2nd rib and superior angle of the scapula, respectively. These prevertebral muscles can be torn in "whiplash" injuries and may be a source for the post-traumatic pain that is associated with this type of injury.

The prevertebral fascia covers the prevertebral muscles and forms the fascia on the floor of the posterior triangle of the neck. The brachial plexus and the subclavian artery carry this fascia into the axilla as the axillary fascia. The prevertebral fascia forms the posterior limit of the retropharyngeal space (fig. 45.5) and is a plane on which head and neck infections can spread inferiorly into the posterior mediastinum of the thorax.

VERTEBRAL ARTERY (figs. 46.6 and 44.1)

It arises from the first part of the subclavian artery and ascends between the scalenus anterior and longus colli to enter the foramen transversarium of C6. The subsequent course through the foramen transversarii of C5-C2 is deep to the prevertebral fascia. The artery courses laterally from C2 to enter the foramen transversarium of C1 and then turns medial to cross the posterior arch of the atlas (fig. 46.6). The vertebral artery then passes under the posterior atlanto-occipital membrane, pierces the dura, and enters the subarachnoid space. The two vertebral arteries then pass through the foramen magnum and unite to form a single basilar artery on the basiocciput of the posterior cranial fossa (fig. 39.13). The vertebral arteries

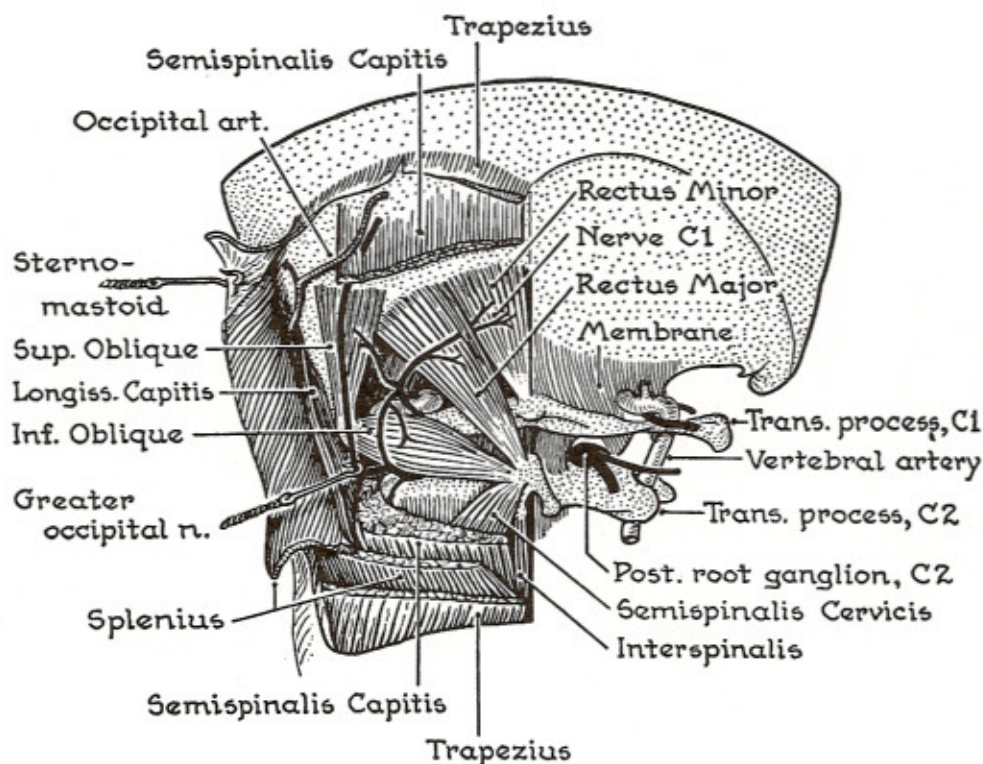


Figure 46.6. The suboccipital region, containing the suboccipital triangle.

provide a major blood supply to the cerebral cortex (medial and posterior surfaces), the brainstem and cerebellum, and the atlanto-occipital joints.

VENTRAL RAMI OF CERVICAL NERVES

The ventral ramus of C1 joins nerve XII and is distributed to the ansa cervicalis (superior root), the thyrohyoid muscle and the geniohyoid muscle by separate branches from XII as it courses to the tongue. C1 is a motor nerve. It has no dorsal root ganglion, and there is no C1 dermatome on the skin. The 2nd cervical nerve has a posterior ramus that gives rise to the **greater occipital nerve** in the suboccipital triangle (fig. 46.6). This nerve is the basis for the C2 dermatome that overlies the occipital bone and abuts the V¹ dermatome at the vertex of the skull. The anterior rami of C2 carry sensory fibers to the cervical plexus in the neck and motor fibers to the inferior root of the ansa cervicalis.

The cervical plexus is composed of sensory fibers in the ventral rami of C2–4, while the ansa cervicalis is composed of motor fibers from the ventral rami of C1–3. The ventral rami of C3–5 form the phrenic nerve that crosses the anterior aspect of the scalenus anterior and descends through the thorax to innervate the diaphragm and its adjacent parietal pleura and peritoneum. Preserving the motor supply to the diaphragm is of utmost importance in treating neck injuries.

Craniovertebral Joints

JOINTS BETWEEN SKULL, ATLAS, AND AXIS

Five synovial joints are involved between the skull, C1 vertebra, and C2 vertebra. The bilateral superior articulating facets on the axis (C2) articulate with the bilateral inferior articulating facets on the atlas (C1). These atlanto-axial joints and the joint between the dens (odontoid process) on the axis and the anterior arch and transverse ligament on the atlas (fig. 46.7) allow rotation of the head in the transverse plane. This allows the patients to turn their heads from side to side. The bilateral superior articulating facets on the atlas articulate with their corresponding occipital condyles on the base of the skull. This joint allows for a nodding movement of the skull in the sagittal plane.

The capsules of the bilateral atlanto-axial and atlanto-occipital joints enclose the synovial joints completely. Unlike other spinal column joints associated with the articulating processes of the vertebrae, the upper two cervical intervertebral joints are anterior to the emerging

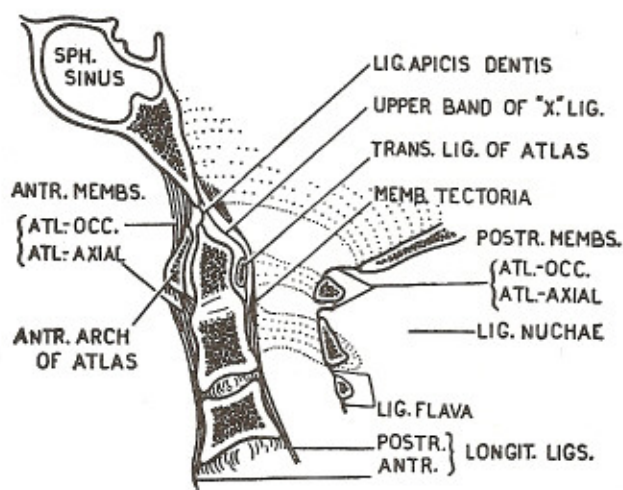


Figure 46.7. Ligaments connecting the skull to the vertebral column (paramedian section).

spinal nerves. The atlanto-occipital joint is also anterior to the horizontal component of the vertebral artery, which is crossing the posterior arch of C1 to enter the foramen magnum.

The midline atlanto-axial joint between the dens and the atlas has a very different form of capsular investment (fig. 46.7). The anterior arch of the atlas is attached in two connective tissue support ligaments: the **atlanto-axial ligament**, inferiorly, and the **anterior atlanto-occipital membrane**, superiorly. These two ligaments are comparable to the anterior longitudinal ligaments of the vertebrae in the lower elements of the spinal column. Posterior to this midline joint, the posterior longitudinal

ligament of the spinal column is modified to span the interval from C2 to the foramen magnum. This connective tissue covering of the posterior aspect of the midline atlanto-occipital joint is called the **membrana tectoria**. It forms the posterior limit of the joint and is in contact with the dura that surrounds the spinal cord in the vertebral foramen of C1 and C2.

The posterior arches of C1 and C2 are also connected by dense elastic ligaments: the **posterior atlanto-occipital membrane** and the **posterior atlanto-axial membrane**. These are comparable to the ligamentum flava that connect the adjacent lamina of lower vertebrae in the spinal column (fig. 46.7). The posterior atlanto-occipital membrane is an important clinical landmark as well. Here the vertebral artery passes from its cervical relation to its subarachnoid position in the foramen magnum (fig. 46.6). One can also use this site between C1 and the foramen magnum for taking a cerebrospinal fluid "tap." The posterior atlanto-occipital membrane and its underlying dura and arachnoid would be penetrated by a needle to gain access to the subarachnoid cistern at the base of the posterior cranial fossa, the **cisterna magna**.

Exterior Base of the Skull

The undersurface of the skull can be divided into 3 anatomical regions—**anterior**, **intermediate**, and **posterior**—by two imaginary lines (fig. 46.8). Each line traverses an important set of foramina on the base of the skull

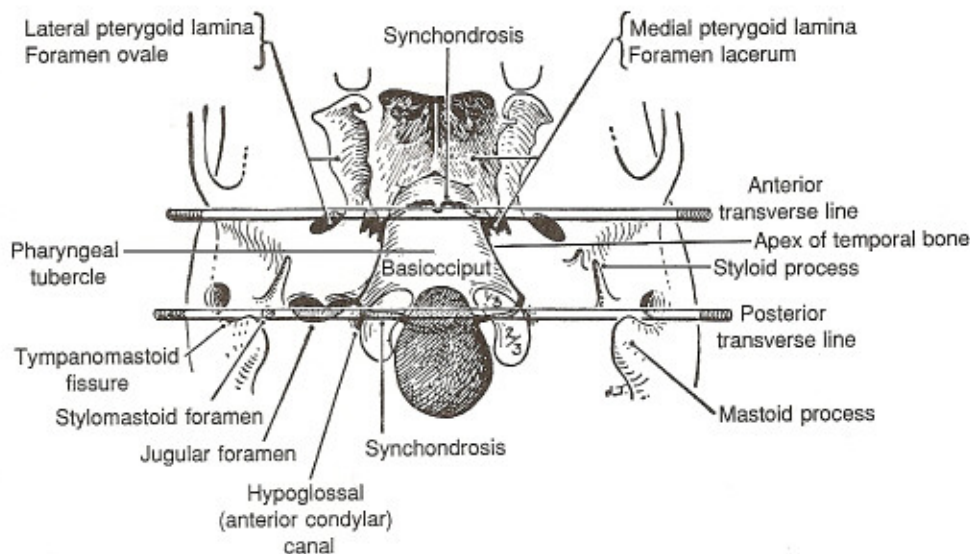


Figure 46.8. "Anterior transverse line" and "posterior transverse line" on exterior of the base of the skull.

and can serve as keys for understanding the relative relationships of major nerves and vessels at the base of the skull.

The **anterior transverse line** spans the base of the skull between the mandibular notches of each ramus of the mandible. This line traverses the **foramen ovale** at the base of the **lateral pterygoid plate** and the **foramen lacerum** at the base of the **medial pterygoid plate** of the sphenoid bone. It also demarks the site of fusion of the occipital and sphenoid bones on the basiocciput.

The **posterior transverse line** unites the anterior margins of the right and left mastoid processes of the temporal bones. This imaginary line crosses the **stylomastoid foramen**, the **jugular foramen**, the **hypoglossal canal**, the **occipital condyles**, and the **foramen magnum**.

Structures associated with the Anterior Transverse Line are:

1. **Masseter muscle** and its neurovascular supply in the mandibular notch.
2. **V³** exiting the foramen ovale with **middle meningeal artery** posteriorly entering the foramen spinosum (fig. 46.9).

3. **Lateral and medial pterygoid muscles** arising from the lateral and medial sides of the lateral pterygoid plates, respectively.
4. **Cartilaginous portion of the auditory (eustachian) tube** and the **tensor palati muscle** origin at the base of the medial pterygoid plate.
5. The **foramen lacerum** is filled with cartilage in life but has an inferior relationship to the **levator palati muscle** and **deep petrosal nerve** (sympathetic post-ganglionic fibers). The levator palati muscle arises from the tip of the petrous temporal bone at the margin of the foramen lacerum. The deep petrosal nerve courses anteriorly to enter the **pterygoid canal** of the sphenoid bone at the anterior margin of the foramen lacerum. In the canal, the deep petrosal nerve joins the **greater (superficial) petrosal nerve (VII)**, which passes over the intracranial surface of the foramen lacerum. The **internal carotid artery** is also superior to the foramen lacerum as it courses through the middle cranial fossa.
6. The **pharyngeal tubercle** on the basiocciput is just posterior to the anterior transverse line. It marks the superior attachment of the **midline raphe** of the

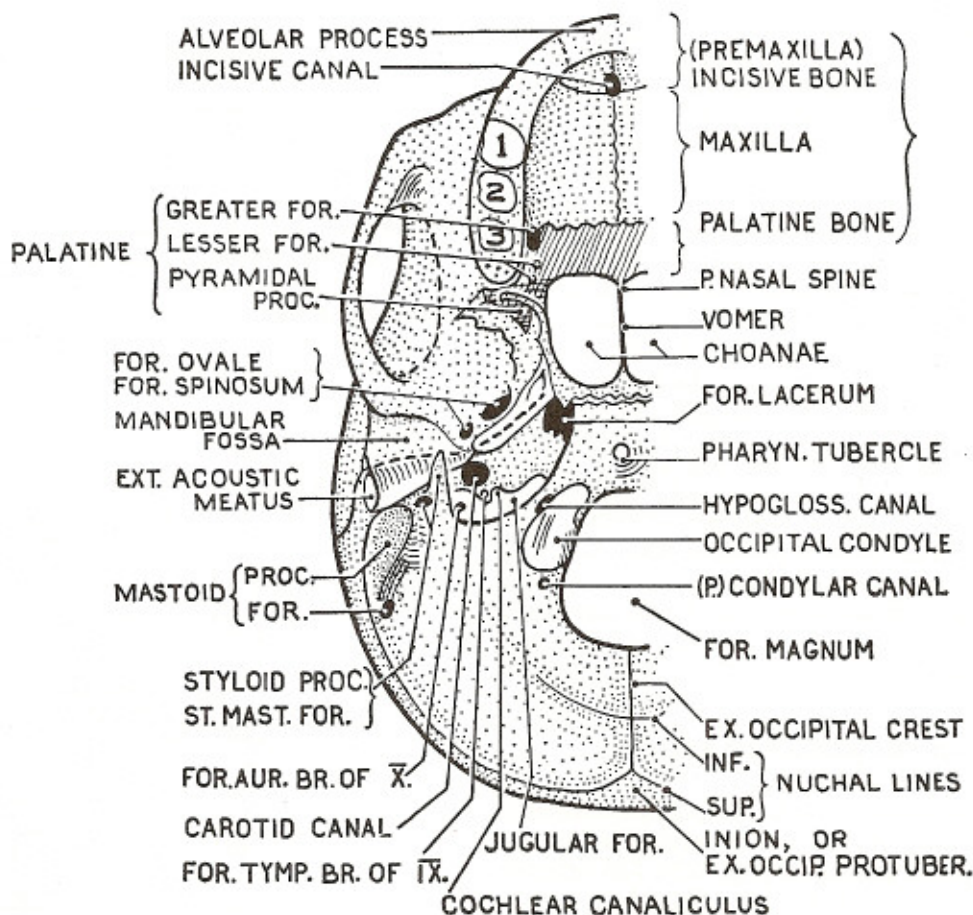


Figure 46.9. The exterior of the base of the skull.

pharynx. It also marks the separation between the visceral and prevertebral fascial planes at the base of the skull.

Structures on the Posterior Transverse Line include:

1. The origins of the **sternomastoid** and **posterior belly of the digastric muscle** are associated with the mastoid process.
2. **Nerve VII**, which is motor to the posterior belly of the digastric, the stylohyoid, and **all the muscles of facial expression**, exits the temporal bone from the stylomastoid foramen.
3. The **internal jugular vein** and cranial nerves **IX, X, and XI** exit the jugular foramen. They are enclosed in the carotid sheath with the internal carotid artery at the base of the skull. The **internal carotid artery** and the **nerve of the internal carotid artery** (sympathetic postganglionic fibers) enter the carotid canal anterior to the jugular foramen.
4. The **jugular fossa**, which is a bony space between the jugular foramen and the base of the skull, has small canaliculi in its lateral aspect. These small canals allow the auricular branches of IX and X to enter the middle ear and join VII to form the tympanic plexus. Nerve X will be sensory to the external auditory meatus, and nerve IX will give sensory branches to the mucosa of the middle ear and auditory tube, and preganglionic secretomotor branches to the **lesser petrosal nerve** for parotid innervation. Nerve VII will form the **greater petrosal nerve**, which exits the middle ear, courses over the middle cranial fossa and the superior aspect of the foramen lacerum, and enters the pterygoid canal. It will innervate the glands of the orbit, nasal cavity, and palatal region of the oral cavity.
5. The **hypoglossal canal** is the exit site for cranial nerve XII. It is on the lateral aspect of the occipital condyle on the base of the skull. The anterior ramus of C1 also courses on the lateral side of the atlanto-occipital joint and joins nerve XII at this point. The hypoglossal nerve and its accompanying C1 fibers then descend with the carotid sheath to the level of the posterior belly of the digastric.
6. The **vertebral arteries** are related to the medial side of the occipital condyles as they course through the foramen magnum to join and form the **basilar artery** on the superior aspect of the basiocciput in the posterior cranial fossa.

“ANTERIOR AREA” FEATURES

The basal skull area anterior to the anterior transverse line contains the bony elements associated with the nasal cavity and roof of the oral cavity (fig. 46.9). The **superior alveolar processes** form a U-shaped ridge of bone, which supports the upper teeth. Within the superior alveolar process, the **hard palate** arches superiorly to fuse with

its opposite component in a midline suture. The hard palate is formed by two bony processes—the **palatine processes** of the **maxillae** anteriorly and the **horizontal processes** of the **palatine bones** posteriorly. An **incisive foramen** is present anteriorly in the midline between the palatine processes of the maxillae. This transmits the terminal components of the **nasopalatine nerve (V²)** and the **greater palatine artery**. The horizontal process of the palatine bone contains the **greater and lesser palatine foramina** near the alveolar process. These foramina transmit the **greater and lesser palatine nerves (V²) and vessels** to the hard and soft palate, respectively. The horizontal processes of the palatine bones fuse in the midline of the hard palate and form the **posterior nasal spine**.

The posterior openings of the nasal cavities, the **choanae**, are in the anterior area of the base of the skull. The choanae are superior to the soft, moveable palate in life. Each choana is separated by the **vomer**, a midline bone in the nasal cavity that extends along the midline suture of the palate from the posterior nasal spine to the region of the incisive foramen. The medial pterygoid plates form the lateral margins of choanae.

Lateral to the alveolar processes are the zygomatic bones and prominences of the “cheek bones” (zygomatic arch).

“INTERMEDIATE AREA”

Between the anterior and posterior transverse lines on the base of the skull are an important set of structures that lie on an oblique plane between the mastoid process and the foramen lacerum (fig. 46.10). Laterally, the **external auditory meatus** marks the lateral extent of the bony **external auditory canal**. The external auditory canal continues to the pinna by a cartilaginous extension. The **mandibular fossa** lies anterior to the external auditory meatus and forms the posterior articulating surface on

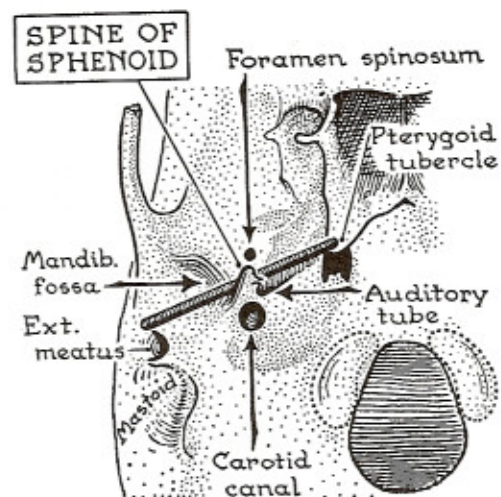


Figure 46.10. Oblique line on exterior of base of skull.

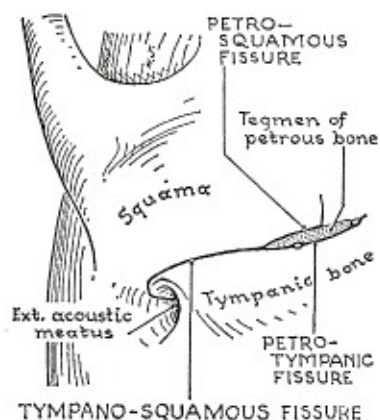


Figure 46.11. Explanation of terms. The tympanosquamous fissure is bifurcated by the tegmen tympani reaching the surface here from the roof (tegmen) of the middle ear. This is a detail of interest to ear surgeons.

the inferior surface of the squamous portion of the temporal bone for the **temporomandibular joint**. The articular tubercle of the temporal bone is anterior to the mandibular fossa and also serves as an articulating surface for the temporomandibular joint. Between the tympanic plate of the external acoustic meatus and the mandibular fossa is the **tympanosquamous fissure** (fig. 46.11). The medial extension of this fissure is the **petrotympanic fissure** where the **chorda tympani (VII)** exits from the middle ear to reach the infratemporal fossa. The chorda tympani courses on the medial aspect of the **spine of the sphenoid bone** (fig. 46.10). This bone projection is also related to the **foramen spinosum**, **middle meningeal artery**, and **auriculotemporal nerve (V³)**, which runs in a posterior oblique plane lateral to the spine of the sphenoid to enter the parotid gland between the external acoustic meatus and the temporomandibular joint.

The cartilaginous auditory tube lies medial to the spine of the sphenoid. It lies in the suture between the petrous temporal bone and the greater wing of the sphenoid. The auditory tube opens into the nasal cavity just posterior to the medial pterygoid plate. It connects the middle ear and the nasal cavity by a lateral osseous and medial cartilaginous tube and serves to equalize the pressure in the

middle ear with the pressure in the nasal cavity (atmospheric pressure).

“POSTERIOR AREA”

This is the bony surface of the occipital bone that forms the roof of the suboccipital triangle. It is a site for muscle attachments and is described on page 343.

Clinical Mini-Problems

- Why would a “cervical rib” on C7 create vascular and nerve disorders in the upper extremity?
 - If you have studied the hand, would the neurological symptoms be on the thumb or little finger side of the hand?
- The lateral cervical radiograph of a patient with rheumatoid arthritis showed marked posterior displacement of the odontoid process (dens) of C2 into the vertebral canal in the superior aspect of the vertebral canal. Which specific ligament has been affected in this disease to produce this radiographic finding?
- Three weeks following a rear-end car accident, a patient complained of constant neck pain but showed no radiologic evidence of bone injury in the cervical region. The physician diagnosed the disorders as “whiplash syndrome” and explained to the patient that some of the muscles on the anterior aspect of the cervical vertebral column may be injured.
 - Which muscles lie on the anterior aspect of the cervical vertebral bodies?
 - Which major nerves are associated with these muscles in the neck?
- What nerves and vessels would be in jeopardy of being damaged if the spine of the sphenoid bone became necrotic (dissolved by infection)?

(Answers to these questions can be found on p. 588.)

Great Vessels and Nerves of the Neck: Review and Summary

Clinical Case 47.1

Patient Doris F. This 55-year-old woman temporarily lost vision in her left eye. Greatly alarmed, she went immediately to see her physician. She described her "blindness" as being like someone had drawn a shade down over her left eye. The blindness lasted 30 minutes and then her sight was restored quite rapidly. The physician examined her retina with an ophthalmoscope and found no abnormality. He immediately got an appointment for her with your tutor, the chairman of ophthalmology. After hearing the history, he asks you not to look at the retina but to listen with a stethoscope to the left carotid artery over the carotid triangle. You hear a loud "bruit" over the artery and learn that this is due to an atheromatous plaque at the bifurcation of the common carotid. The blindness was due to platelet clots breaking off from the ulcerated area of the vessel and occluding the central artery of the retina in the left optic nerve. A consultation is arranged for a vascular surgeon to correct the arterial defect in the carotid system. You arrange to watch the operation.

General Disposition

The structures deep to the parotid region and the posterior belly of the digastric muscle are:

1. Internal jugular vein
2. Internal carotid artery
3. Cranial nerves IX, X, XI, and XII
4. Sympathetic trunk

These structures enter or leave the skull through 1 of 3 openings:

1. Jugular foramen—internal jugular vein and cranial nerves IX, X, XI.
2. Hypoglossal canal—nerve XII.
3. Carotid canal—internal carotid artery and nerve of the internal carotid artery.

The **jugular foramen** opens into the **jugular fossa**, which lies between the occipital and the temporal bones. The fossa contains the superior bulb of the internal jugular vein. This bulb receives the continuation of sigmoid sinus from the lateral aspect of the jugular foramen and the inferior petrosal sinus from the medial side of the jugular foramen. The three cranial nerves IX, X, and XI enter the jugular foramen alongside of the inferior petrosal sinus from the medial side adjacent to the brainstem.

The **hypoglossal canal** transmits the hypoglossal nerve (XII). It converges on the medial side of the inferior opening of the jugular fossa and joins the internal jugular vein IX, X, XI, and the internal carotid artery in the carotid sheath from the base of the skull to the level of the posterior belly of the digastric muscle (figs. 47.1 and 47.2).

The **carotid canal** is anterior to the jugular foramen and opens into the middle cranial fossa. The jugular foramen is within the posterior cranial fossa.

All four cranial nerves descend for a short distance between the internal jugular vein and the internal carotid artery (figs. 47.1 and 47.2). Cranial nerve X (**vagus nerve**) continues vertically through the neck within the carotid sheath between the internal jugular vein and the internal carotid and common carotid arteries. Cranial nerve IX (**glossopharyngeal nerve**) leaves the carotid sheath at the level of the posterior belly of the digastric to enter the pharynx with the **stylopharyngeus muscle** between the internal and external carotid arteries. Nerve IX innervates the stylopharyngeus as it spirals around this muscle to enter the pharynx between the superior and middle constrictor muscles. Nerve IX is then sensory to the posterior one-third of the tongue, tonsillar area, and pharynx. Cranial nerve XI (**accessory nerve**) leaves the carotid sheath below the posterior belly of the digastric and crosses the internal jugular vein to reach the sternomastoid muscle. The **hypoglossal nerve** (XII) passes anteriorly on the lateral surface of both the internal and external carotid arteries to reach the tongue.

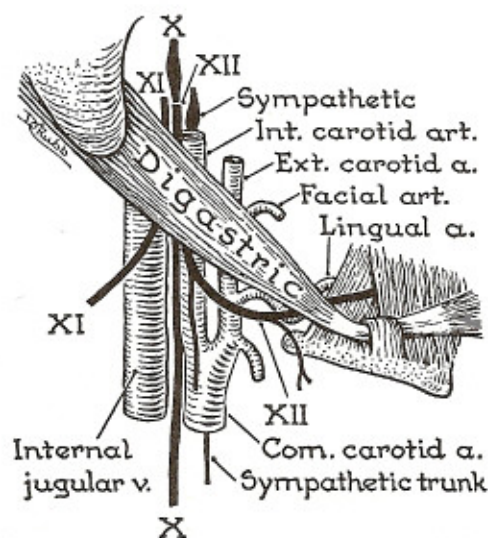


Figure 47.1. Key: posterior belly of digastric.

Common and Internal Carotid Arteries

The carotid system (fig. 47.3) ascends in the neck in the carotid sheath with the vagus nerve posterior and the internal jugular vein lateral to the arteries. The common

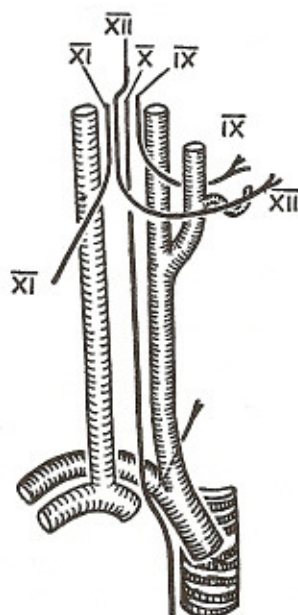


Figure 47.2. Relations of nerves IX–XII to great vessels.

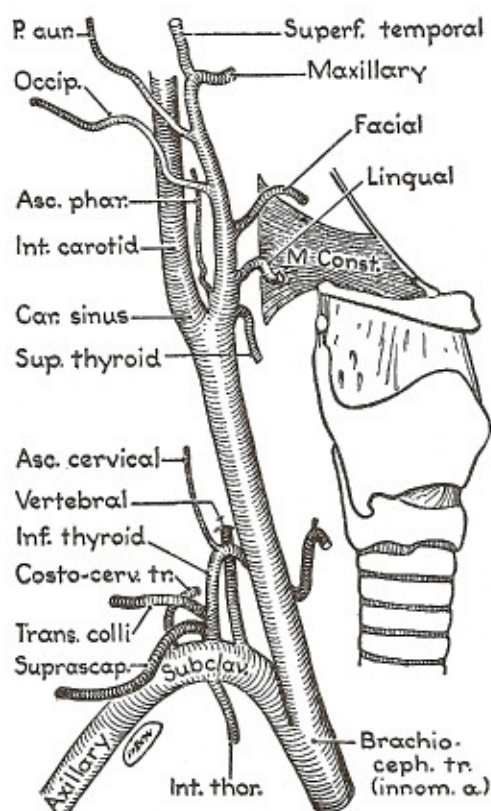


Figure 47.3. The carotid and subclavian arteries.

carotid bifurcates at the level of the hyoid bone (C3 vertebral level), and the internal carotid artery remains associated with the carotid sheath to the base of the skull. The sympathetic trunk lies posterior to the carotid sheath throughout its course through the deep neck. The cervical sympathetic trunk is contained within a separate fascial investment between the carotid sheath and the prevertebral fascia that invests the longus colli and the longus capitis muscles.

MEDIAL RELATIONSHIPS

The carotid system lies adjacent to the side of the digestive and respiratory passages in the neck. The narrowing of the pharynx inferiorly as it joins the esophagus brings the right and left common carotid arteries within 2 cm of each other at the root of the neck.

The thyroid gland, the trachea, and the thyroid cartilage lie medial to the common carotid arteries in the lower part of the neck. The **superior laryngeal nerve** lies on the medial aspect of **both** the internal and external carotid arteries. Its terminal branches, the **internal laryngeal nerve** and the **external laryngeal nerves** are medial to the common carotid artery as they descend to innervate structures (fig. 43.14).

BRANCHES

The common carotid gives no branches in the neck and bifurcates into the internal and external carotid arteries at about the level of the hyoid bone. The external carotid arteries give off the branches that supply the face, scalp, and deep structures of the upper neck, floor of the mouth, and nasal cavities. The internal carotid ascends to enter the carotid canal on the base of the skull and has **no branches outside** of the cranial cavity.

A prominent dilatation of the internal carotid artery is evident at its origin. This is the **carotid sinus**, which contains baroreceptors. These nerve receptors transmit neural information regarding systemic blood pressure via the glossopharyngeal nerve (IX) to the brainstem. The **carotid body** is a group of chemoreceptor organs at the bifurcation of the internal and external carotid arteries. The carotid body is not evident but can be detected by light microscopy. It is innervated by sensory branches of cranial nerve X.

Internal Jugular Vein

This continuation of the sigmoid sinus exits the posterior cranial fossa through the jugular foramen and ends in the root of the neck by uniting with the subclavian vein to form the brachiocephalic vein (fig. 47.4).

Bulbs. The internal jugular vein has a bulb at both ends. The **superior bulb** is a dilatation of the vein in the jugular fossa. The **inferior bulb** is a dilatation of the vein below a bicuspid valve. This valve serves to resist the "back-flow" of blood into the neck when pressure increases in the right atrium and superior vena cava. The inferior bulb is located approximately 1 cm above the superior border of the sternoclavicular joint.

The **internal jugular vein** lies posterior to the internal carotid artery at the base of the skull. As it descends in the carotid sheath, the internal jugular vein moves laterally to lie on the external aspect of the carotid sheath in the neck. **Nerve XI and the ansa cervicalis** are usually lateral to the internal jugular vein below the posterior belly of the digastric muscle (fig. 47.1).

At the root of the neck, the internal jugular vein crosses anterior to the first part of the subclavian artery and its branches. It also receives a lymphatic trunk (thoracic duct and right lymphatic duct) at its point of union with the subclavian vein. The vein lies on the anterior aspect of the cupola of the lung as it enters the brachiocephalic vein.

The sigmoid sinuses and the inferior petrosal sinuses drain the posterior cranial fossa and the cavernous sinuses. They drain into the internal jugular vein through

the jugular foramen. These intracranial sinuses and the internal jugular vein drain the blood that reaches the intracranial cavity from the internal carotid artery, the vertebral arteries, and the middle meningeal arteries, which arise from the external carotid artery. The thyroid venous drainage is very prominent. Since both the thyroid gland and parathyroid glands are endocrine glands, the hormones that they release require ready access to the systemic circulation. It is a common anatomical feature that **endocrine glands have an extensive and well-developed venous drainage**. The **superior and middle thyroid veins** join the internal jugular veins while the **inferior thyroid veins** drain into the brachiocephalic veins.

The **external jugular vein** lies on the external surface of the sternomastoid muscle and may drain into the internal jugular vein or the subclavian vein as they pass deep to the sternomastoid muscle.

The **lymphatic drainage of the head and neck** is closely associated with the internal jugular vein. Head and neck infections and diseases can stimulate lymph node enlargements around the internal jugular veins. These cervical lymph nodes then become palpable and painful at the margins of the sternomastoid muscles as they enlarge. Normally, these lymph nodes are not palpable as they surround the internal jugular vein deep to the sternomastoid muscle.

The Last Four Cranial Nerves (Extracranial Courses)

Nerves IX and X are mixed motor and sensory nerves. They both have superior and inferior sensory ganglia located on them at the base of the skull. The inferior ganglia are concerned with visceral sensory functions and are larger than the superior sensory ganglia, which receive sensations from body wall structures (somatic sensation). Cranial nerves IX and X both contain motor fibers that innervate voluntary skeletal muscle. They also contain parasympathetic fibers.

Nerves XI and XII are motor nerves that innervate skeletal muscles.

Glossopharyngeal Nerve (N.IX). This nerve (summarized in fig. 47.5) leaves the skull through the jugular foramen with nerves X and XI. Within the jugular fossa, an auricular branch, the **tympanic nerve**, passes through a bony canaliculus and enters the middle ear cavity to form part of the **tympanic plexus** on the **promontory**. **Sensory fibers** in the **tympanic nerve** innervate the mucous membrane of the middle ear, mastoid air sinuses, and bony part of the auditory tube. **Parasympathetic preganglionic fibers** within the tympanic nerve leave the tympanic plexus and penetrate the anterior aspect of the petrous bone. These fibers enter the middle cranial fossa

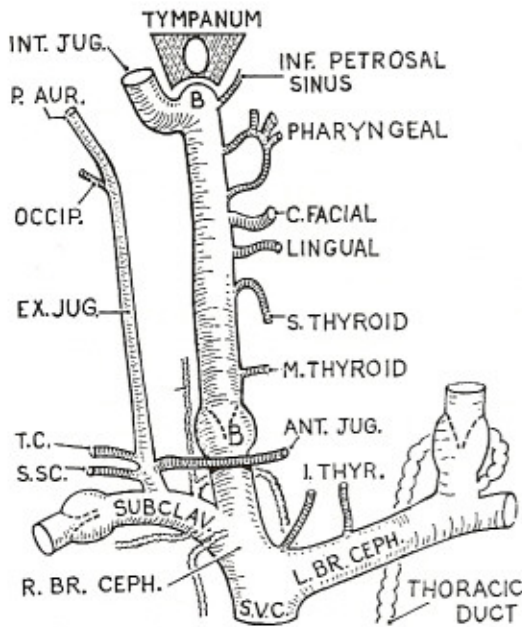


Figure 47.4. The internal jugular vein. B, jugular bulb; SSC, suprascapular; SVC, superior vena cava; TC, transversa colli.

through the **hiatus** of the **lesser petrosal nerve**. The **lesser petrosal nerve** courses through the dura of the middle cranial fossa to exit the cranium through the foramen ovale with V³. The preganglionic parasympathetic fibers then enter the **otic ganglion**, which is associated with the medial aspect of V³, and synapse on the postganglionic

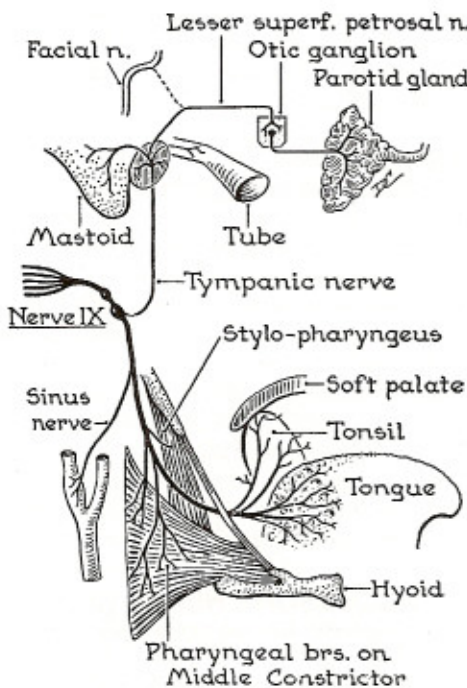


Figure 47.5. Distribution of the glossopharyngeal (IX) nerve.

parasympathetic neurons within the otic ganglion. Postganglionic fibers leave the ganglion, join the auriculo-temporal nerve, and innervate the parotid gland.

The main trunk of the glossopharyngeal nerve descends in the carotid sheath to the posterior border of the stylopharyngeus muscle, which it joins to penetrate the wall of the pharynx. While winding around the stylopharyngeus in its descent, nerve IX innervates this muscle, which assists in elevation of the thyroid cartilage during swallowing. The **sensory distribution** of the glossopharyngeal nerve within the pharynx is into the mucosa on the middle constrictor (pharyngeal plexus), the mucosa of the posterior one-third of the tongue, the mucosa of the tonsillar region, and some of the mucous membrane of the soft palate. Nerve IX carries special taste sensation from the posterior one-third of the tongue and general sensation (pain and temperature) from the posterior one-third of the tongue and the other mucosal areas. The cell bodies for these visceral sensory receptors in the pharyngeal region are in the inferior ganglion of nerve IX in the jugular fossa.

The **sinus nerve** branch from nerve IX innervates the carotid sinus and carries afferent information regarding systemic blood pressure to the brainstem.

VAGUS NERVE (N.X)

This vagrant or wandering nerve supplies structures in the head, neck, thorax, and abdomen (fig. 47.6). The vagus nerve enters the jugular foramen and gives its first branches from the superior sensory ganglion. A **meningeal branch** re-enters the jugular foramen and innervates the dura of the posterior cranial fossa. An **auricular branch** enters the middle ear through a bony canaliculus in the lateral wall of the jugular fossa. It will leave the tympanic plexus and penetrate the tympanic membrane to innervate the **skin lining the external auditory meatus**. Nerve X can be tested clinically by stimulating this area of skin (X dermatome) with a "pinprick." Stimulation of this tissue in ear infections may induce nausea and vomiting, which is associated with the vagal innervation of the gastrointestinal tract. The dura and skin are associated with somatic (body wall) development and these sensory nerves have their cell bodies in the superior ganglion of nerve X.

The inferior ganglion of nerve X is the largest and it has direct branches to the carotid bifurcation (**sinus nerve**), the pharyngeal plexus (**pharyngeal branch**), and the larynx (**superior laryngeal nerve**). The sinus nerve innervates the carotid sinus and carotid body along with nerve IX. Its sensory fibers transmit information regarding blood pressure and oxygen tension in the blood to the cardiovascular regulating "centers" in the brainstem.

The pharyngeal nerve contains motor and sensory fibers to the palate and pharynx. The voluntary control of skeletal muscles in the palate and pharynx can be tested clinically by asking the patient to say "ah." If the vagi

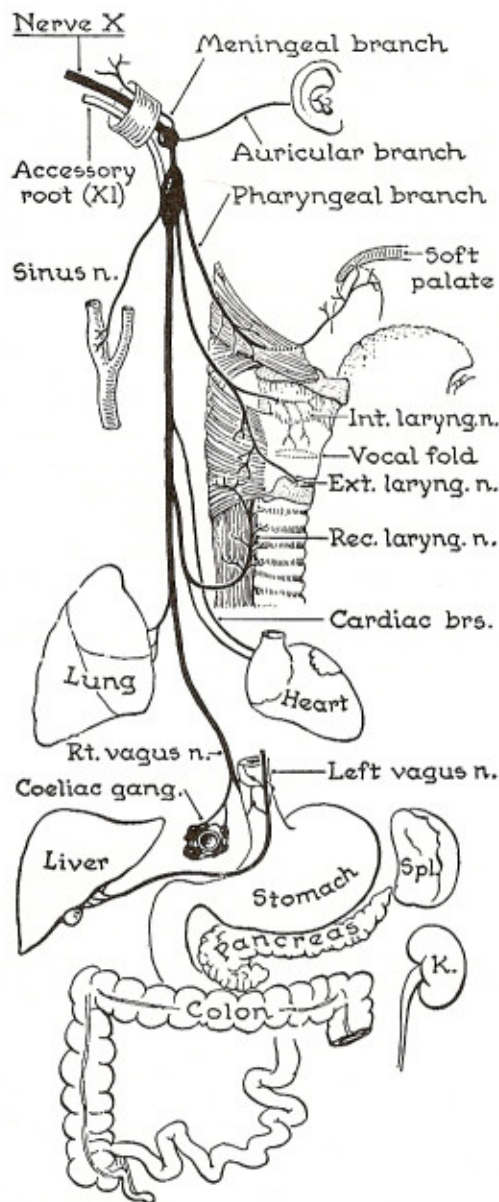


Figure 47.6. Distribution of the vagus (X) nerve.

and their pharyngeal branches to the palate are intact, the palate will rise in the midline. If one of the vagi or its pharyngeal branch is damaged, the palate will deviate away from the side of the affected nerve. **This is a very common clinical test for assessing the "intactness" of the vagus nerve at the base of the skull.** The major muscle that produces this clinical sign is the contraction of levator palati. The pharyngeal branch of nerve X also innervates the superior constrictor, middle constrictor, palatopharyngeus, and palatoglossal muscles. Secretomotor fibers in the vagus nerve are parasympathetic to the mucous and serous glands in the pharynx and larynx. These preganglionic parasympathetics run in the vagus nerve

and synapse in ganglia located in the myenteric regions of the pharynx and larynx.

Sensory fibers in the pharyngeal nerve innervate receptors in the pharyngeal mucosa. Both general sensation to the pharynx and special taste receptors on the epiglottis and pharyngeal mucosa are carried in nerve X. The cell bodies for all these sensory fibers are in the inferior ganglion of nerve X.

The **superior laryngeal nerve** descends medial to the internal and external carotid arteries and branches into the **internal** and **external laryngeal nerves**. The internal laryngeal nerve pierces the thyrohyoid membrane and is sensory to the mucosa of the larynx above the vocal cords. It is also sensory to the mucosa of the piriform recess of the pharynx. Stimulation of both of these mucosal areas will induce a "cough reflex," and the internal laryngeal nerve serves as the afferent limb of this reflex. Interruption of this reflex is sometimes necessary when an endotracheal tube is passed through the rima glottidis between the vocal cords. The internal laryngeal nerve may be "blocked" with a local anesthetic solution injected subcutaneously at the tip of the greater horns of the hyoid bone.

The external laryngeal branch is motor to the cricothyroid muscle. This muscle assists in "tensing" the vocal cords. Damage to the external laryngeal can cause alterations in the production of voice quality.

The recurrent laryngeal nerve, which branch from the vagus lower in its course, are extremely important in the production of a normal voice. Damage to either the recurrent laryngeal nerve or the vagus above their origin usually produces a hoarse, raspy voice similar to a whisper. The recurrent laryngeal nerves are motor to the inferior constrictor and all the muscles of the larynx except the cricothyroid muscles. They also carry secretomotor parasympathetic fibers to the serous and mucous glands of the trachea and larynx. Sensory reception within the bronchial tree below the vocal cords is also carried in the recurrent laryngeal branches.

The **right recurrent laryngeal nerve** branches in the neck and hooks around the subclavian artery before it ascends to the larynx and pharynx. The **left recurrent laryngeal** branches off the left vagus in the thorax at the level of the aortic arch. It ascends between the esophagus and trachea and enters the root of the neck on the medial aspect of the thyroid gland.

Branches of the vagi in the thorax and abdomen are related to parasympathetic innervation of the cardiac muscle, smooth muscle, and glands in the respiratory and gastrointestinal systems. Some cardiac branches of the vagus may arise in the neck and descend through the superior thoracic aperture to reach the heart.

ACCESSORY NERVE (N.XI) (Spinal Accessory Nerve)

The accessory nerve (fig. 47.7) has a double origin—**spinal and cranial.**

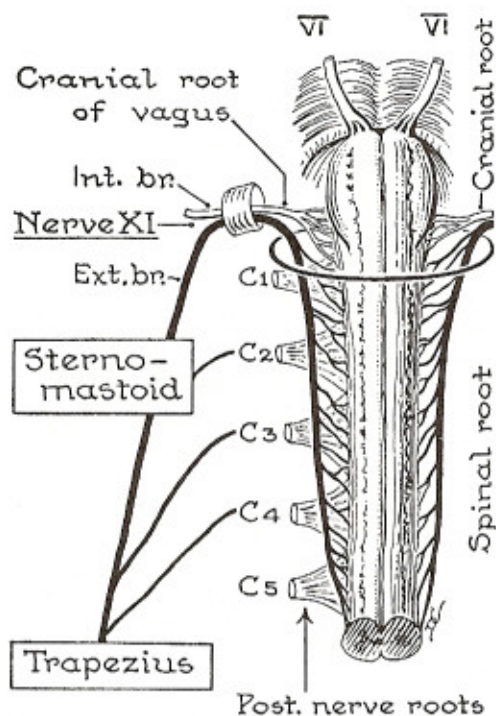


Figure 47.7. Origin and distribution of the accessory (XI) nerve. (Ventral nerve roots have been cut away.)

The spinal root arises from the anterior gray column (motor column) of the upper 4 or 5 segments of the spinal cord. The spinal root ascends in the subarachnoid space surrounding the spinal cord to enter the posterior cranial fossa through the foramen magnum. The **cranial root** arises from the medulla oblongata above the olive and is aggregated with the rootlets of the vagus nerve. The spinal and cranial roots of the accessory nerve fuse with the vagus nerve as they enter the jugular foramen and the spinal component of nerve XI separates from nerve X in the carotid sheath at the exit of the jugular fossa on the base of the skull.

The **cranial component of nerve XI remains in the vagus nerve and in a clinical sense may be considered a part of the vagus nerve.** Since nerve XI arises from the same motor nucleus of the brainstem (nucleus ambiguus) and goes to the same skeletal muscles in the head and neck—palate, pharynx, and larynx—as the vagus, the cranial root of nerve XI is tested with the vagus. The cranial root of XI is also affected by the same lesions in the brainstem and peripheral nerves that are considered to be vagal branches. It therefore follows, that the cranial root of XI cannot be distinguished clinically from the vagus and is thus included in the testing and function of X.

The spinal root of XI is a separate and distinguishable peripheral nerve. It separates from nerve X and descends in the carotid sheath to the level of the posterior belly of the digastric muscle. The accessory nerve then courses

posteriorly across the superficial aspect of the jugular vein to enter the deep surface of the sternomastoid muscle. **After innervating the sternomastoid muscle** with motor fibers (C2, 3 also contribute proprioceptive innervation to the sternomastoid muscle), the accessory nerve enters the investing fascia that forms the thick dense roof of the posterior triangle of the neck. It courses from the midpoint of the sternomastoid to the undersurface of the trapezius at the posterior aspect of the posterior triangle. Nerve XI is then distributed with proprioceptive fibers of C3 and 4 to the undersurface of the trapezius throughout its neck and superficial back location.

Damage to the spinal root of nerve XI may occur at the base of the skull, within the carotid sheath or more likely in the posterior triangle of the neck. Functional "intactness" of XI is tested by asking patients to "shrug their shoulders." Since the muscle can also be palpated during this maneuver, the clinician can distinguish if the trapezius on either side is functional. **Testing the sternomastoid for the intactness of the more proximal portions of XI is done by asking patients to flex their head (chin to chest position) against resistance.** Individual sternomastoids can be tested by having patients rotate their head to one side while the clinician palpates the sternomastoid muscle on the opposite side of the head and neck.

It should be noted that it is the peripheral component of the spinal branch of nerve XI that is being examined in the physical examination. The motor cells of XI in the cervical cord region of C1–6 overlap the motor cell bodies from the phrenic nerve to the diaphragm. Spinal cord injuries that would paralyze the sternomastoid and trapezius muscles would likely paralyze the diaphragm as well. If the patient were not supported by a mechanical respirator, it would be very likely that a spinal cord injury that affected the spinal root of XI would be fatal.

HYPOGLOSSAL NERVE (N.XII) (fig. 47.8)

The hypoglossal nerve innervates the muscle of the first somite, which migrates into the tongue during its development in man. Even though the hypoglossal nerve has a prominent and well-defined nucleus in the lower brainstem and exits the posterior cranial fossa through the hypoglossal canal in the occipital condyles, it is intimately associated with the first cervical somite in development. In fact, **nerve XII and the anterior ramus of C1 unite** as the two nerves course between the medial and lateral anterior rectus capitis muscles at the base of the skull. Nerve XII and its accompanying C1 motor fibers then descend in the carotid sheath to the lower border of the posterior belly of the digastric muscle. At this point, C1 fibers forming the **superior root (descendens hypoglossi) of the ansa cervicalis** are given off to descend on the external aspect of the carotid sheath and innervate the long infrahyoid ("strap") muscles of the neck. Nerve XII loops around the occipital artery as it leaves the ca-

rotid sheath to course anteriorly to the lateral surface of the hyoglossus muscle (fig. 47.8). Here a small branch of **C1 fibers are given off to innervate the thyrohyoid muscle**, and the main trunk of cranial nerve XII passes deep to the intervening tendon of the digastric muscles.

As nerve XII ascends into the musculature of the tongue on the lateral aspect of the **hyoglossus and genioglossus muscles**, it gives off its final C1 branch to the **geniohyoid muscle** in the floor of the mouth. Nerve XII is actually motor to the **three intrinsic muscles of the tongue (longitudinal, transverse, and vertical muscles)** and the three extrinsic muscles of the tongue (**hyoglossus, genioglossus, and styloglossus muscles**) (fig. 47.8). Nerve XII innervates all the muscles in the head and neck that end in **glossus** except the palatoglossus which is innervated by X.

Testing nerve XII can be done by asking the patients to protrude their tongue (stick it out). A bilaterally innervated tongue would protrude in the midline. Damage to nerve XII would cause the tongue to deviate toward the side of the damaged nerve and weakened or paralyzed muscles.

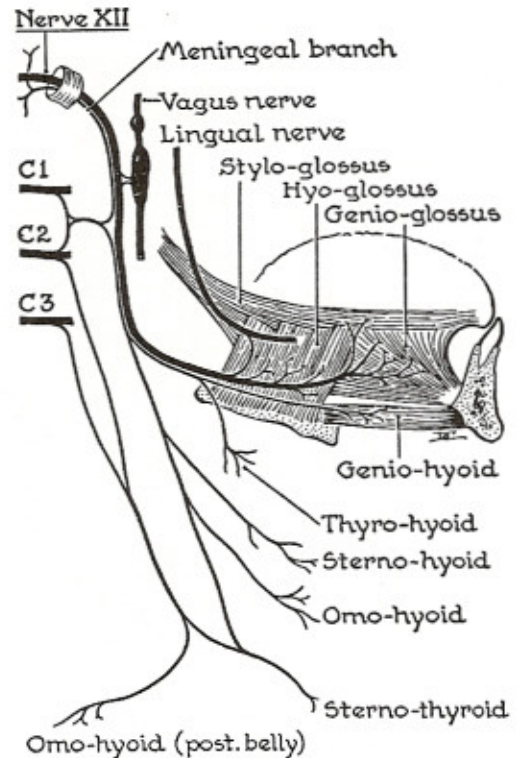


Figure 47.8. Distribution of hypoglossal (XII) nerve.

Sympathetic Trunk (Cervical Part) (fig. 47.9)

This part of the sympathetic trunk is an upper extension of the thoracic sympathetic trunk, which is located paravertebrally on the anterior aspect of the neck of the ribs. As the cervical sympathetic trunk ascends in the neck, it lies on the longus colli and longus capitis muscles, which arise from the anterior tubercles (costal equivalent) of the cervical vertebrae C3–6. The cervical sympathetic trunk is contained in a separate fascia (alar fascia), between the prevertebral fascia covering the longus colli and longus capitis muscles and the carotid sheath.

The sympathetic chain in the neck differs from the thoracic sympathetic chain in three major ways: (a) its location and relation to the vertebral column and prevertebral musculature; (b) the cervical sympathetic trunk has only 3 ganglia associated with 8 cervical nerves; and (c) there are no white rami communicantes associated with the cervical nerves.

The preganglionic parasympathetic fibers that ascend in the sympathetic trunk of the neck are from cell bodies in the intermediate lateral gray column of the T1–4 spinal cord segments. The preganglionic fibers will synapse in one of the 3 cervical ganglia—inferior, middle, and superior—on cell bodies of the postganglionic sympathetic neurons, which innervate the heart, upper extremity, head, and neck.

The **inferior cervical ganglion** lies anterior to the transverse process of the 7th cervical vertebra on the longus

colli muscle. It lies posterior to the vertebral artery as the artery arises from the first part of the subclavian artery. The inferior cervical ganglion may be fused with the first thoracic ganglion to form an enlarged stellate ganglion. The sympathetic trunk can be blocked at this point with an injection of local anesthetic ("stellate block").

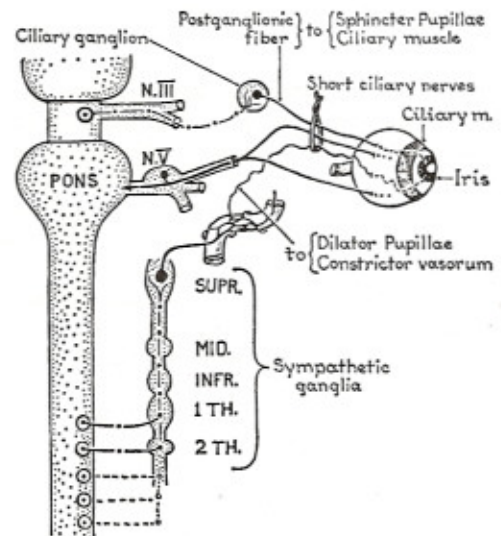


Figure 47.9. The nerve supply to the eyeball.

The inferior cervical ganglion has branches to the following structures: (a) **gray rami communicantes** to cervical nerves C7 and C8 of the brachial plexus; (b) **vascular branches** to the heart (which developed from mesoderm in the head region); (c) **vascular branches** to blood vessels arising from the first part of the subclavian artery; and (d) continuations of the sympathetic chain to the ganglia that lie subjacent (T1) and suprajacent (middle cervical ganglion). Many of the ascending fibers in the cervical chain that ascend from the inferior cervical ganglion "loop" anteriorly around the first part of the subclavian artery to form the **ansa subclavia**. Damage to the cervical sympathetic can occur if caution is not taken to avoid the subclavian artery in neck surgery.

The **middle cervical ganglion** is located at the height of the "loop" in the inferior thyroid artery (C6) on the anterior surface of the longus colli muscle. Postganglionic sympathetic neurons form the branches from the middle cervical ganglion: (a) the **gray rami communicantes** to cervical nerves 5 and 6, which contribute to the brachial plexus; (b) the cardiac branches to the heart; (c) arterial branches to vessels arising from the thyrocervical trunk; and (d) connections to the other two cervical ganglia. The superior cervical ganglion is the largest of the three cervical ganglia, and it lies on the longus capitis muscle at the vertebral levels of C2–3. It is the most superior of the sympathetic ganglia and the last point where ascending preganglionic sympathetic fibers can synapse on their respective postganglionic nerve cell bodies. The postganglionic sympathetic fibers leave the superior cervical ganglia as the following branches: (a) **gray rami communicantes** to the cervical nerves 2, 3, and 4 (C1 does not have a dorsal root and therefore would not transmit the postganglionic fibers to any associated skin dermatome); (b) cardiac branches to the heart; (c) vascular branches to the arteries arising from the external carotid in the neck; and (d) **the internal carotid nerve or plexus** (fig. 47.9).

The internal carotid nerve is the final termination of the sympathetic trunk superiorly. The fibers are postganglionic and course on the adventitia of the internal carotid artery. Just before the internal carotid artery enters the carotid canal in the base of the petrous temporal bone, the **deep petrosal nerve** leaves the arterial plexus to course anteriorly and enter the pterygoid canal of the sphenoid bone to fuse with the greater superficial petrosal nerve (VII). This mixed nerve of postganglionic sympathetic and preganglionic parasympathetic fibers is termed the **nerve of the pterygoid canal**, and it will enter into the pterygopalatine fossa. The postganglionic sympathetic fibers will associate with the terminal branches of the maxillary artery in the pterygoid fossa and travel to the arterioles of the vascular beds in the facial, nasal, and palatal regions served by these arteries.

The sympathetic fibers that continue into the middle cranial fossa on the internal carotid nerve go to vascular

branches in the orbit on the ophthalmic artery. These postganglionic sympathetic fibers also contain the **motor fibers to the dilator pupillae muscles of the iris** and the **superior tarsal muscle (of Mueller) in the levator palpebrae superioris muscle**. Both of these muscles are smooth muscle and require an innervation from the autonomic nervous system. Damage to these sympathetic fibers will result in a **Horner's syndrome**, which is characterized by 3 prominent signs: (a) miosis (pupillary constriction due to unopposed parasympathetic action on the constrictor pupillae); (b) ptosis (partial drooping of the eyelid due to paralysis of the smooth muscle component in the levator palpebrae superioris muscle); and (c) anhidrosis (lack of sweating on the V¹ and V² dermatomes that surround the eye). A fourth sign of enophthalmos is obscure in its anatomical basis and may be illusory. Horner's syndrome is a very important and frequent clinical sign. It can occur from brainstem trauma to the sympathetic neurons from the brain that descend to the thoracic level. It may also occur in T1 nerve lesions, cervical sympathetic trunk and ganglion lesions, and damage to the nerve of the internal carotid artery.

The **testing of the sympathetic innervation in the head and neck** is best done by an examination of the pupillary reflexes. Dim light causes the sympathetic system to dilate the pupil by activating the pupillary dilator and inhibiting the parasympathetically innervated pupillary constrictor. The converse reaction of pupillary constriction is a test for the integrity of the parasympathetic fibers in III. **Tachycardia** (increased rate of heart beat) is another sympathetic clinical sign that is associated with the cardiac innervation from the cervical ganglia.

Clinical Mini-Problems

1. Which cranial nerve is sensory to both the carotid sinus and the tonsillar region of the oral cavity? This nerve may be damaged in some forms of hypertension (high blood pressure), and the patient would also not have a gag reflex on the side of the damaged nerve.
2. Where does the thoracic duct drain into the venous system? It can be cannulated at this point in patients with lymphocytic leukemia.
3. Where would a clinician examine the lymph nodes that filter the lymph draining from the head?
4. How would one differentiate between a lesion in the vagus nerve in the posterior cranial fossa and a lesion in the vagus nerve at the level of the posterior belly of the digastric?

(Answers to these questions can be found on p. 588.)

Pharynx and Palate

Clinical Case 48.1

Patient Jennifer L. This 6-year-old girl has a past history of multiple upper respiratory infections during her first year in school. She has become a "mouth breather," apparently due to increased lymphoid tissue in the upper pharyngeal region causing partial obstruction of her respiratory pathway. Her physician arranges with a specialist for a tonsillectomy at the Medical Center. You get permission to watch close-up. The child is given a general anesthetic through a nasotracheal tube. The enlarged tonsils are excised from the lateral pharyngeal wall. Some superior constrictor muscle is also inadvertently excised at the base of the tonsil, but the bleeding is controlled by cauterizing the severed blood vessels. The child is placed on antibiotics to prevent infection "and spread into the lateral pharyngeal space," an area whose importance you had not realized. *Followup:* There is considerable pain in her throat for 3 days following the surgery, and she also has some "gagging" when she swallows. Released from hospital after 3 days, she recovers without other postsurgical complications. Her general health improves during the next year and her breathing normalizes.

Exterior of Pharynx

The posterior wall of the pharynx is related to the prevertebral fascia posteriorly and the great vessels and nerves within the carotid sheath posterolaterally. This fascio-

muscular wall is attached superiorly to the pharyngeal tubercle on the basiocciput (see fig. 48.4), the medial tip of the petrous bone, and the medial pterygoid plate of the sphenoid bone. It extends inferiorly to the level of the C6 vertebra, where it is continuous with the esophagus. The inferior union with the esophagus produces the narrowest and least dilatable part of the upper alimentary canal and is a site for foreign bodies to obstruct the canal.

PHARYNGEAL WALL

It has 4 distinct components (coats) from its exterior wall to its interior cavity: (a) investment of visceral fascia; (b) skeletal muscular wall; (c) fibrous internal muscular fascia; and (d) mucosal lining.

The outer facial lining is formed from the visceral fascia of the neck that also covers the external surface of the buccinator muscle. This **buccopharyngeal fascia** continues onto the external surface of the superior constrictor muscle, which shares a common origin with the buccinator—the **pterygomandibular raphe** (fig. 48.1). The pharyngeal plexus of veins and nerves lie deep to this fascia. The venous plexus drains the pharynx, including the soft palate and pharyngeal tonsil. This plexus communicates with the pterygoid plexus of veins and drains into the internal jugular vein above the posterior belly of the digastric (fig. 48.2). These veins lack valves, and infections of the tonsil, palate, and pharynx that gain access to this venous plexus (septicemia) can spread to the systemic circulation or in a retrograde fashion into the meningeal venous sinuses. The **nervous plexus** is formed by skeletal and parasympathetic motor branches of nerve X, sensory branches of nerve IX and vasomotor branches of the sympathetic system.

The **muscular layer** of the pharyngeal wall is composed of five paired skeletal (voluntary) muscles. Three form the "circular" outer layer of muscle: the **superior constrictor**, the **middle constrictor** and the **inferior constrictor**. Two are longitudinal muscles that run from the base of the skull and palate in a vertical manner to attach to the thyroid cartilage. These longitudinal muscles of the pharynx are the **stylopharyngeus** and **palatopharyngeus**.

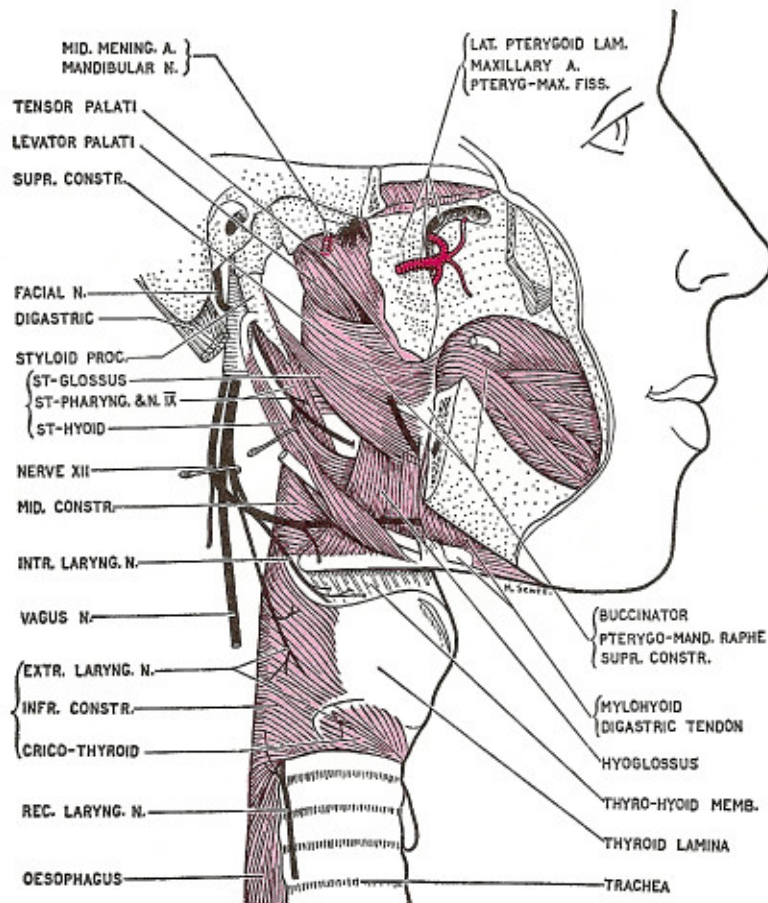


Figure 48.1. The lateral aspect of the pharynx.

THE THREE CONSTRICTORS (fig. 48.3)

The **superior constrictor** muscle arises from the medial pterygoid plate of the sphenoid bone, the pterygomandibular raphe and the upper 1/5th of the mylohyoid line on the mandible behind the 3rd molar tooth. The superior border of the muscle attaches to the petrous temporal bone apex and the pharyngeal tubercle through its associated investment of deep fascia. An interval exists between the base of the skull and the superior constrictor at the suture between the sphenoid and the petrous part of the temporal bone. This interval provides an entrance for the auditory tube to extend from the base of the skull to the nasopharynx. It also transmits the ascending pharyngeal artery from the external aspect of the superior constrictor to the internal surface of the pharynx (fig. 48.4). The inferior border of the superior constrictor is unattached and projects onto the inner surface of the middle constrictor to reach the midline pharyngeal raphe (fig. 48.4).

The **middle constrictor** muscle arises from the angle between the lesser and greater horns (cornua) of the hyoid bone (figs. 48.3 and 48.5). Figure 48.5 shows how this

origin is also associated with the lower aspect of the **stylohyoid ligament**. The insertion of this muscle into the midline raphe is such that the fibers of the middle constrictor overlap the superior constrictor superiorly but are internal to the fibers of the inferior constrictor, inferiorly (figs. 48.3 and 48.4). The interval between the superior and middle constrictors transmits the stylopharyngeus muscle and cranial nerve IX (figs. 48.3 and 48.4). The interval below the origin of the middle constrictor muscle is covered by the thyrohyoid membrane and transmits the internal laryngeal nerve and artery into the laryngeal cavity.

The **inferior constrictor** muscle has a broad area of origin from the oblique line of the thyroid cartilage and the fascia covering the cricothyroid muscle (fig. 48.3). It inserts into the midline raphe on the posterior aspect of the pharynx (fig. 48.4). The superior fibers of this muscle overlap the inferior fibers of the middle constrictor. The inferior border of the inferior constrictor blends with the superior end of the esophagus. A pronounced thickening of the inferior fibers of the inferior constrictor forms the **cricopharyngeus muscle**. This acts as a sphincter for the esophagus and prevents air from being sucked into

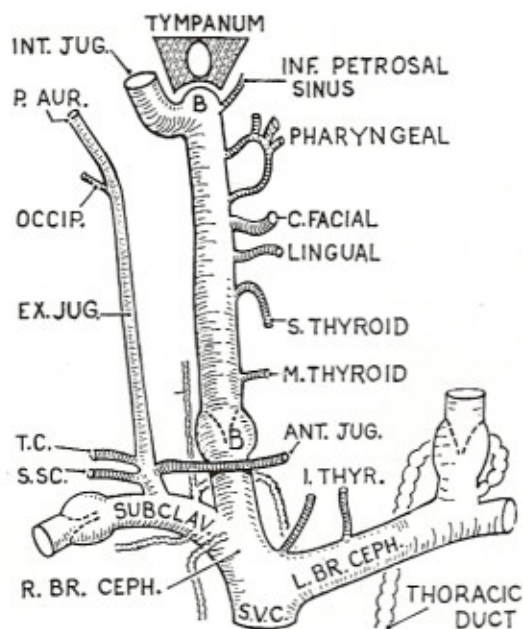


Figure 48.2. The internal jugular vein. *B.* jugular bulb; The vessels above the inferior jugular bulb are valveless. Head and neck venous drainage can therefore "back up" into the meningeal sinuses.

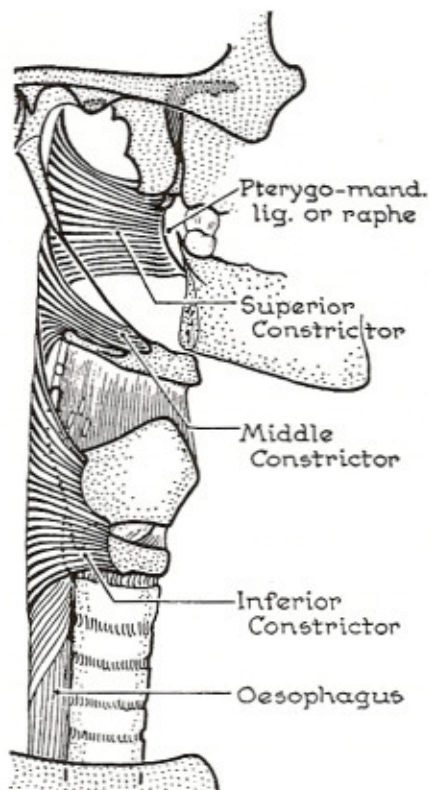


Figure 48.3. The 3 constrictors of the pharynx.

the alimentary system during inspiration (Negus). The inferior constrictor and the cricopharyngeus are innervated by the **recurrent laryngeal nerve (X)**, as it ascends on the medial side of the thyroid gland and pierces the pharyngeal wall below the inferior margin of the inferior constrictor (fig. 48.4). The **inferior laryngeal artery**, a branch of the inferior thyroid artery, also accompanies the recurrent laryngeal nerve into the laryngeal cavity.

The Two Longitudinal Muscles. While both the stylopharyngeus and the palatopharyngeus insert into the thyroid cartilage on the internal aspect of the middle and inferior constrictors, they are separated superiorly by the superior constrictor muscle.

The stylopharyngeus arises from the styloid process external to the superior constrictor at the base of the skull. It descends and enters the pharyngeal cavity with nerve IX in the interval between the superior and middle constrictor muscles (fig. 48.4) and inserts on the thyroid cartilage. It is innervated by nerve IX and helps to elevate the larynx during swallowing.

The **palatopharyngeus** muscle arises from the palate and lateral wall of the nasopharynx on the internal aspect of the superior constrictor muscle. It descends under the mucous membrane of the pharynx to insert into the thyroid cartilage. The palatopharyngeal fold of pharyngeal mucosa forms the **palatopharyngeal arch**, which is visible just posterior to the palatine tonsil. A superior extension of the palatopharyngeus onto the lateral nasal wall and the cartilage of the auditory tube is called the **salpingopharyngeus muscle**. The overlying mucosal fold posterior to the opening of the auditory tube (fig. 48.6) is called the **salpingopharyngeal fold**.

Interior of the Pharynx and the Palate

Opening into the pharynx anteriorly are the orifices leading from the nasal cavity, oral cavity, and laryngeal cavity (fig. 48.6). Thus, the pharynx is divided into three parts: the **nasopharynx**, **oropharynx**, and **laryngopharynx**. The **soft palate** separates the nasopharynx from the oropharynx and acts as a flap-valve to allow continuity between these regions during respiration.

The **nasopharynx** lies superior to the soft palate and opens into each nasal cavity through the right and left **choanae** (posterior nasal apertures). The lateral and posterior walls of the nasopharynx are formed by mucous membrane lining the inner surface of the superior aspect of the **superior constrictor muscle** and the two palatal muscles that surround the opening of the auditory tube, **levator palati** and **tensor palati** (figs. 48.1 and 48.7). These muscular walls of the nasopharynx are attached to the bones on the base skull; medial pterygoid lamina

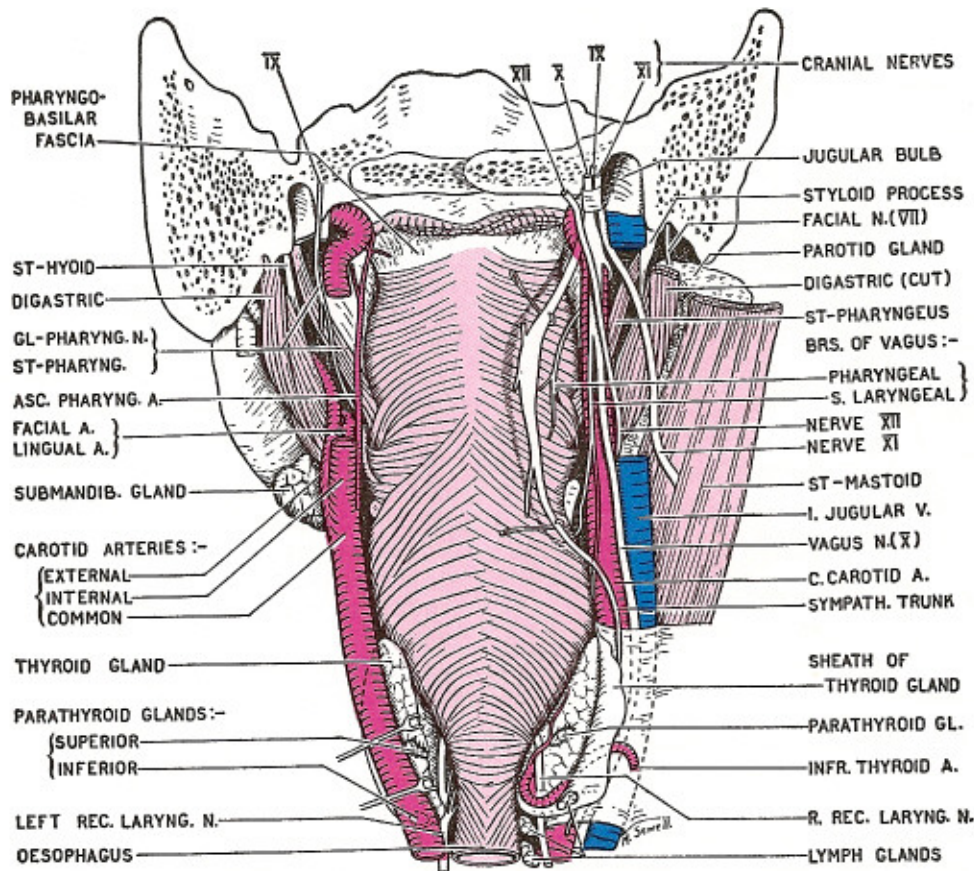


Figure 48.4. The pharynx, last 4 cranial nerves, sympathetic trunk, and great vessels—from behind. (The skull has been sectioned in the plane of 'the posterior transverse line.')

(plate), apex of the petrous part of the temporal bone, and the pharyngeal tubercle on the basiocciput (fig. 48.8). The firm superior attachment of the superior constrictor maintains an opened nasopharynx even when the muscle constricts. This "ensured" opening of the soft tissue res-

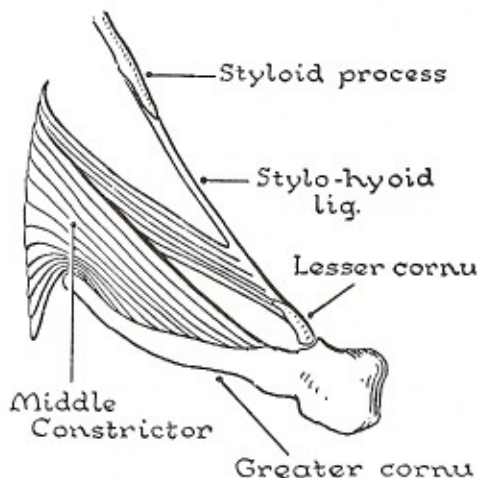


Figure 48.5. Angular origin of middle constrictor.

piratory passages posterior to the bony-lined nasal cavities is an anatomical feature that one sees throughout the descending bronchial tree. Cartilaginous plates and rings are present in the larynx, trachea, and bronchi to maintain the patent respiratory passages to the level of the bronchioles.

An important orifice on the lateral wall of the nasopharynx is the opening of the **auditory (Eustachian) tube** (see figs. 48.6 and 48.12). The mucous membrane of the nasopharynx bulges above the opening of the auditory tube. The superior and posterior aspects of this tubal elevation are most prominent due to the underlying cartilaginous extensions of the auditory tube. Extending inferiorly from the base of the posterior aspect of the tubal elevation is a fold of mucous membrane, the **salpingopharyngeal fold**, which overlies the descending salpingopharyngeal part of the palatopharyngeal muscle. Tonsillar tissue in the submucosal tissue of this region is referred to as the **tubular tonsil**. It may enlarge in upper respiratory infections and cause the closure of the pharyngeal opening of the auditory tube. This may lead to middle ear infections due to inadequate drainage of the middle ear and mastoid air cells.

The **(naso-)pharyngeal tonsils** lie in the submucosa

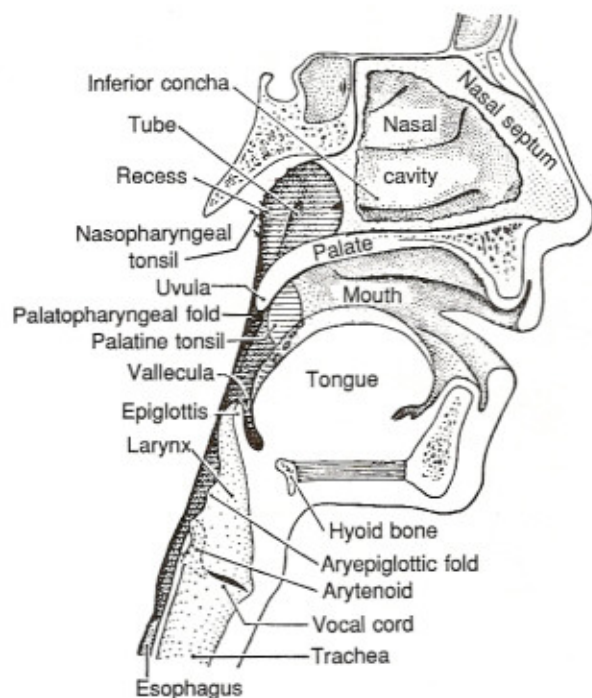


Figure 48.6. Interior of pharynx (side view).

that lines the posterior and superior walls of the nasopharynx. They are termed "adenoids," when they become enlarged or overgrown due to upper respiratory infections. Since they lie superior to the soft palate, severe enlargement may render flap-valve function of the palate ineffective during breathing. Children with prominent "adenoids" may become "mouth breathers" to bypass the obstruction in the respiratory passage between the nasopharynx and the oropharynx. Excessive mouth breathing in children can induce changes in the growth of the facial bones and produce undesirable hygienic and cosmetic effects. Removal of the "adenoids" is indicated in some patients with persistent mouth breathing habits. The **palatine tonsil** is what is commonly termed the "tonsil." The palatine tonsils are found in the oropharynx inferior to the soft palate.

The **Oropharynx** is situated inferior to the soft palate and superior and posterior to the root of the tongue (fig. 48.6). It is continuous with the oral cavity anteriorly and its demarcation from the oral cavity is marked by the presence of the **palatoglossal arches** (anterior pillars of the fauces) on the lateral walls. This is the site of the **buccopharyngeal membrane** in the embryo that separates the ectodermally lined stomodeum from the endodermally lined foregut.

The palatoglossal arches are folds of mucous membrane overlying the underlying **palatoglossal muscles**. These muscles are depressors of the soft palate and are innervated by the vagus nerve. They lie anterior to the palatine tonsil and attach to the lateral aspect of the tongue

at the junction of its anterior two-thirds and posterior one-third segments. The posterior palatopharyngeal arch is a fold of pharyngeal mucous membrane overlying the **palatopharyngeal muscle** posterior to the palatine tonsil. The palatopharyngeus is one of the two internal longitudinal muscles of the pharynx (the other is the stylopharyngeus) (fig. 48.7). The palatopharyngeus has a superior attachment to the soft palate and lateral wall of the nasopharynx around the posterior lip of the auditory tube (the salpingopharyngeal component). The inferior attachment of the palatopharyngeus is its insertion into the thyroid cartilage. It functions as an elevator of the larynx during swallowing and a depressor of the palate during respiration. The palatopharyngeus is innervated by the vagus nerve.

The palatine tonsil is contained in the triangular depression that lies between the palatine arches formed by the palatopharyngeal fold and the palatoglossal fold. This depression is called the **fauces**, and the folds (arches) are termed the pillars of the fauces. They are very obvious landmarks in an examination of the lateral walls of the oral cavity. The mucous membrane of this region is innervated by sensory branches of the glossopharyngeal nerve (IX). Stimulation of this mucous membrane produces a "gag reflex" and is a specific test for the afferent (sensory) component of nerve IX. Caution must be taken not to stimulate the soft palate or lateral pharyngeal wall posterior to the palatopharyngeal fold. These areas of mucous membranes have sensory innervations by V² and X respectively and will also induce a "gag reflex" if stimulated. One must specifically stimulate the area of the "tonsillar bed" or fauces to isolate the clinical test for the sensory component of the right or left 9th nerve (IX). The skeletal motor component of nerve IX is to the stylopharyngeus. It is difficult to test this muscle in a unilateral fashion to assess the right or left 9th nerve (IX). The action of each stylopharyngeus is to assist in elevation of the larynx. Since this movement involves the bilateral action of the right and left stylopharyngeal muscles and the right and left palatopharyngeal muscles (innervated by nerve X), observing laryngeal elevation when a patient swallows does not clearly reflect the action of a single muscle or cranial nerve function. The parasympathetic secretomotor component of nerve IX may be tested by observing parotid secretion from either the right or left parotid papilla lateral to the upper 2nd molar in the oral cavity. This is the only exit site for the parotid secretion. A visible secretion of saliva can be readily stimulated before mealtime by activating the taste receptors in the mouth or olfactory receptors in the nose.

The **laryngopharynx** lies posterior to the superior opening of the laryngeal cavity at the vertebral level of C3-4. Figure 48.6 depicts a lateral view of the superior laryngeal opening (the aditus), which is commonly seen in radiographs, while Figure 48.7 shows the coronal view that is seen in the laryngoscopic examination.

The inlet of the larynx is oval and obliquely oriented. Anteriorly, the opening is bounded by the flexible epi-

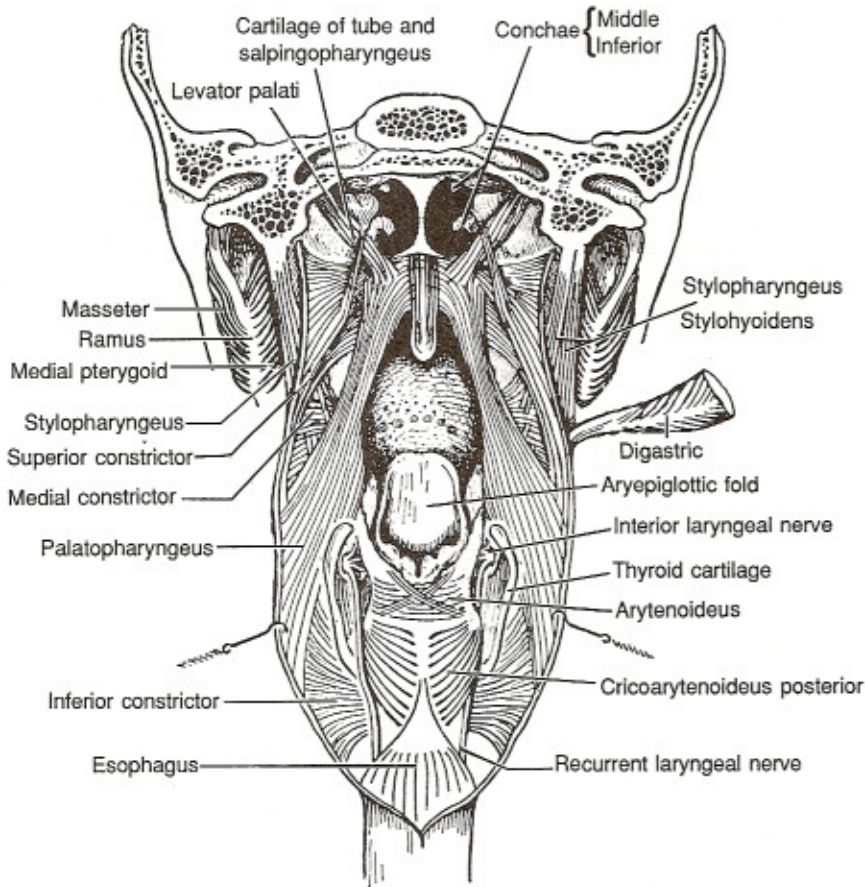
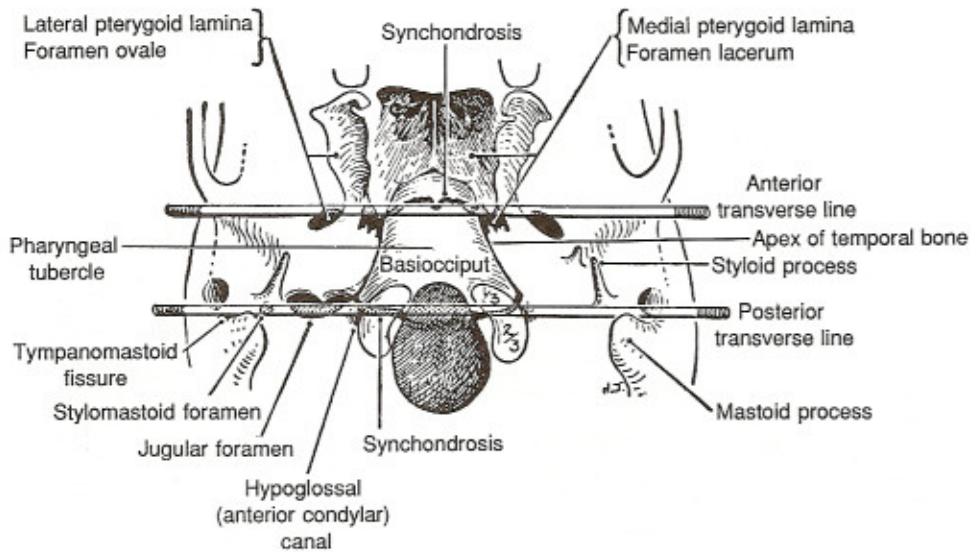


Figure 48.7. The muscles of the pharynx (from behind). ST-PH, stylopharyngeus; ST-HY, stylohyoid.



Figures 48.8. The anterior and posterior transverse lines on the exterior of the base of the skull.

glottis. The posterior limit of the inlet of the larynx is formed by the mucous membrane covering the arytenoid cartilages and the muscles that attach to the superior aspects of these cartilages. Between the epiglottis and the arytenoid cartilages are the lateral walls of the larynx. These lateral walls are formed by the mucous membrane, which overlies the aryepiglottic muscles and small corniculate and cuneiform cartilages of the larynx. These lateral walls are thus termed the **aryepiglottic folds**. This inlet to the larynx is effectively closed during swallowing by elevation of the larynx, contraction of the aryepiglottic muscles, and a postero-inferior tilting of the epiglottis. Food and drink are thereby diverted to the lateral sides of the aryepiglottic folds and into the pharynx below the laryngeal inlet. During breathing the larynx descends, and the tongue protrudes forward to open the laryngeal inlet and permit an unobstructed flow of air to enter the laryngeal cavity.

The mucous-membrane-lined spaces anterior to the epiglottis and lateral to the aryepiglottic folds are therefore important pathways for a bolus of food during swallowing. Food or particles lodged in these spaces can cause a "coughing reflex" in response to the persistent sensory stimulation of this mucosa.

Between the anterior surface of the epiglottis and the posterior surface of the base of the tongue are two fossae called the **valleculae** (fig. 48.6). A midline glosso-epiglottic fold of mucous membrane separates the right and left depressions that form the vallecula. The vallecular fossae communicate with the **piriform recesses** on the lateral aspect of the aryepiglottic folds. Figure 48.7 illustrates the area of the piriform recesses with the mucous membrane removed. The important relationship that is shown in this illustration is the position of the underlying **internal laryngeal nerve** of X, which is the sensory (afferent) root of the "coughing reflex." This nerve also innervates the mucous membrane that lines the internal aspect of the larynx, superior to the vocal cords. Therefore, aspiration of foreign material into the superior compartment of the laryngeal cavity will also induce a "coughing reflex" through this neurological pathway.

Palate

The palate develops in the embryo to separate the nasal and oral cavities. The anterior aspect of the palate is a bony partition formed by the **palatine processes of the maxilla** and the **horizontal processes of the palatine bone** (fig. 48.9). This **hard palate** is covered superiorly by the mucous membrane of the floor of the nasal cavity and inferiorly by the mucous membrane covering the roof of the oral cavity. These mucous membranes are very closely

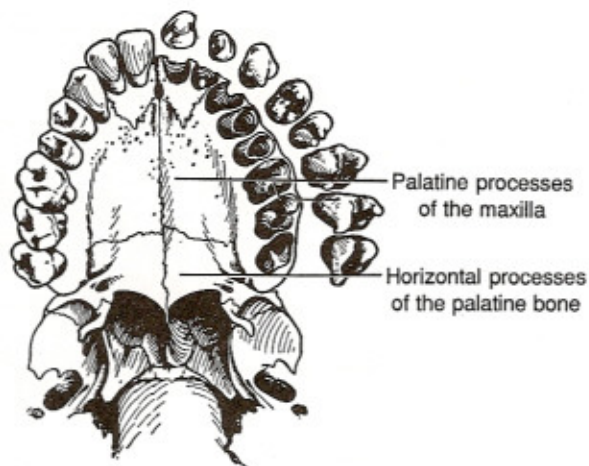


Figure 48.9. Hard palate.

associated with the bony palate and serve as a dual purpose **mucoperiosteum** to maintain the bone and line the adjacent cavities with epithelium. The mucosa on the roof of the oral cavity is markedly thickened by stratified squamous epithelium and serves as a masticatory mucosa. Elevated transverse ridges (*rugae*) are evident in the anterior one-third of the oral hard palate (fig. 48.10).

The palate extends posteriorly from this bony partition as a flexible **soft palate**, separating the nasopharynx and oropharynx. The soft palate is composed of a central con-

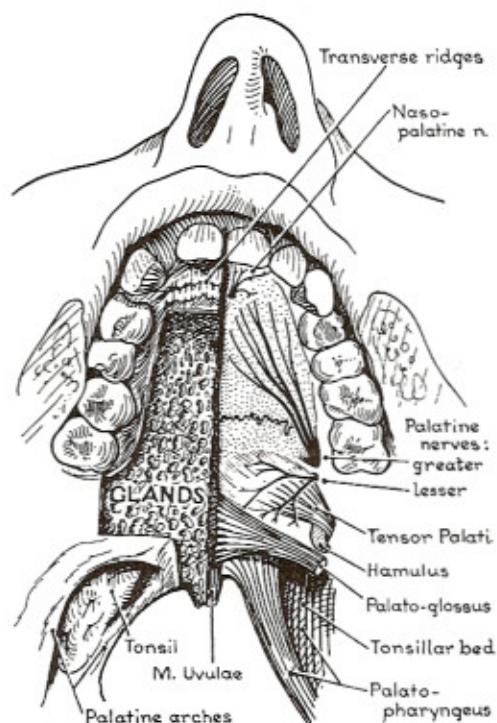


Figure 48.10. Dissection of the palate and palatine arches. The upper pole of the tonsil is deeply buried.

nective tissue aponeurosis, a number of skeletal muscles, and the overlying mucous membrane on the nasal and oral surfaces (fig. 48.11). The soft palate can be elevated during swallowing to close off the nasopharynx and divert the swallowed material inferiorly into the laryngopharynx and the esophagus. Depression of the soft palate occurs during respiration to open the respiratory passages from the nasopharynx to the inlet of the larynx.

The innervation of the mucous membrane of the palate is by the maxillary division of the trigeminal nerve (V^2). The mucosa on the oral surface of the anterior one-third of the hard palate is innervated by the **nasopalatine nerve** (fig. 48.10), which reaches the oral mucosa through the **incisive foramen** in the maxillary portion of the hard palate. This is the terminal branch of the nerve that also innervates the inferior aspect of the nasal septum and is described in the chapter on the nasal cavities. The posterior two-thirds of the hard palate is innervated by the **greater palatine nerve**, which branches from V^2 in the region of the pterygopalatine ganglion (fig. 48.12). The greater palatine nerve descends through the **greater palatine canal** of the palatine bone and enters the oral mucosa via the **greater palatine foramen** at the posterolateral aspect of the hard palate (fig. 48.10). The mucosa membrane of the soft palate received its sensory innervation through the **lesser palatine nerves**. These nerves parallel the course of the greater palatine nerves but open onto the oral mucosa of the palate via the **lesser palatine foramina** on the horizontal plates of the palatine bone (figs. 48.10 and 48.12).

Parasympathetic secretomotor fibers to the mucous and serous glands of the palate also accompany these sensory branches of V^2 . The preganglionic secretomotor fibers are contained in the **greater (superficial) petrosal nerve (VII)**, which synapses on the postganglionic secretomotor neurons in the pterygopalatine ganglion (fig. 48.12). Taste fibers from palatal taste buds also course with these general sensory palatal neurons to the level of association of V^2 with the pterygopalatine ganglion in the **pterygopalatine fossa**. The taste fibers, like the preganglionic secretomotor fibers, are also associated with nerve VII, and they are contained in the greater superficial petrosal nerve.

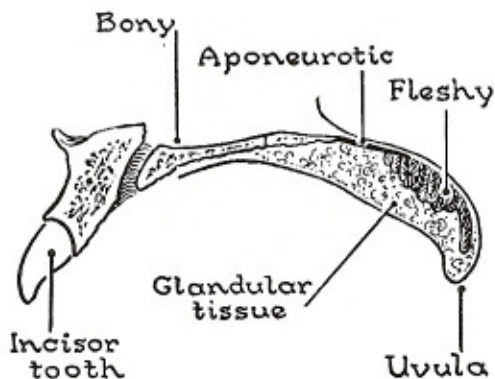


Figure 48.11. The palate on sagittal section.

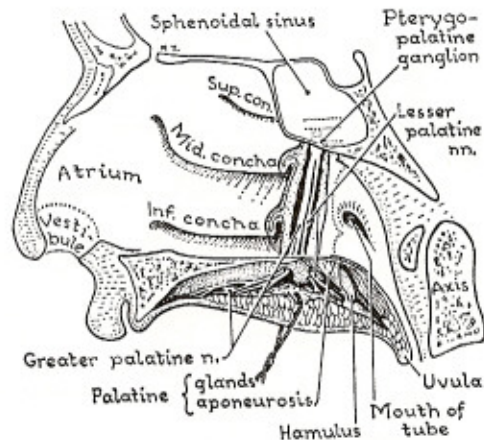


Figure 48.12. Exploration of greater palatine canal. Dissection of undersurface of palate.

The cell bodies of these taste fibers are located within the geniculate ganglion. The V^2 general sensory fibers enter the foramen rotundum to reach their cell bodies in the large trigeminal ganglion within the middle cranial fossa.

This detailed sensory innervation is particularly important to dentists and surgeons who wish to anesthetize these individual branches prior to commencing surgical procedures on the palatal soft tissues.

The arterial supply to the palate parallels the sensory innervation with one significant exception. The greater palatine artery supplies the oral mucosa of the entire hard palate and then ascends through the incisive foramen to supply a portion of the nasal septum as well. Thus, the nasopalatine and greater palatine nerves overlap within the mucous membrane on the oral surface of the hard palate while the **greater palatine artery** anastomoses with the **sphenopalatine artery** in the mucosa that covers the midline nasal septum in the nose. This interrelationship of the arteries in the nose is readily apparent because of the common occurrence of "nosebleeds" (epistaxis) at this point of arterial anastomosis.

MUSCLES OF THE SOFT PALATE

The muscles of the soft palate are depicted in Figure 48.13. They are associated with both the superior aspect and the inferior aspect of the palate. Their functions are to elevate and depress the palate as well as influence the size of the opening of the auditory tube. Opening the auditory tube will assist in maintaining an equilibrium between the air pressure within the middle ear and that in the nasal cavity (fig. 48.14). Testing the movement of the palate is also the way a clinician tests the pharyngeal branch of nerve X in a clinical examination. A clear understanding of these small muscles and their function is necessary for good and proper clinical practice.

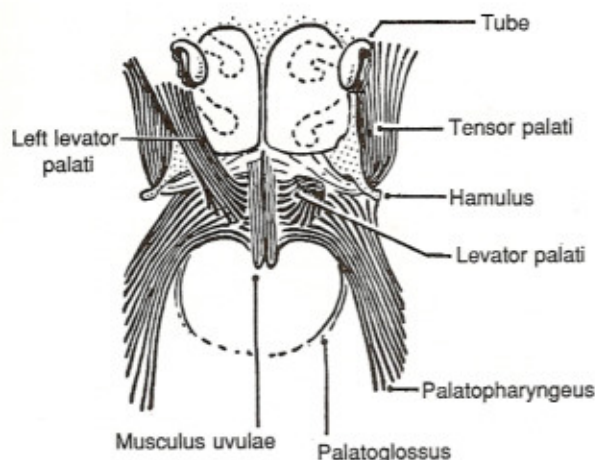


Figure 48.13. Five muscles of soft palate on each side.

Levator Palati and Tensor Palati Muscles (figs. 48.13 and 48.15)

These two palatal muscles arise from the base of the skull and insert into the palatal aponeurosis on the superior surface of the soft palate. The levator palati arises from the apex of the petrous bone and descends to the palate between the two cartilaginous laminae of the auditory tube. The levator palati raises a fold of mucous membrane that appears to be "poured out" of the ostium of the auditory tube as it opens into the nasopharynx. The levator palati is innervated by the pharyngeal branch of the vagus nerve and is the basis for accessing this branch of nerve X in the physical examination. Look at Figure 48.13. If a patient were asked to say "Ah," both the right and left levator palati would contract, and normally, the palate would be elevated by the bilateral pull of the right and left levator palati muscles. The midline terminal projection of the soft palate (the uvula in fig.

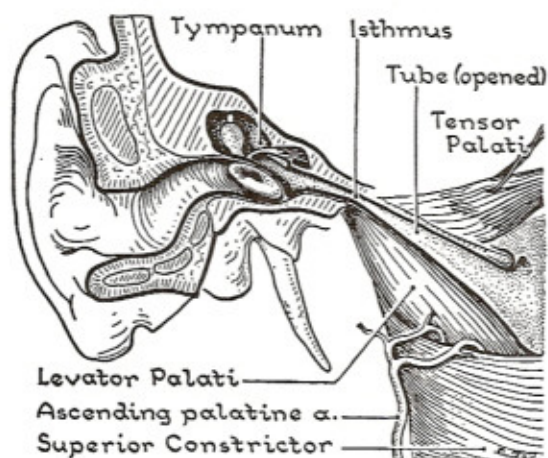


Figure 48.14. Auditory tube (pharyngotympanic tube), after removal of membranous and bony lateral wall.

48.11) would therefore rise in the midline of the oral cavity and could be visualized by the physician as one looked into the mouth. If the right levator palati were inactive (as shown by the cut muscle in fig. 48.13) due to a damaged right nerve X, the pull of the intact left levator palati would cause the uvula to shift to the left side. Therefore the **clinical test** for the pharyngeal branch of nerve X is to ask the patient to say "Ah" and observe if the palate rises in the midline (normal) or deviates away from the side of the damaged nerve X or its damaged pharyngeal branch. This test can assess the intactness of X at the level of the base of the skull, when the vagus exits the jugular foramen and enters the carotid sheath.

The **tensor palati** muscle also arises from the base of the skull but anterior to the levator palati and the anterior aspect of the cartilaginous auditory tube (figs. 48.13 and 48.15). The area of origin for the **tensor palati** is the **scaphoid fossa** at the base of the medial pterygoid plate on the sphenoid bone. The muscle descends vertically and its resulting tendon wraps around the hamulus of the medial pterygoid plate to insert into the soft palatal aponeurosis in the horizontal manner. Shortening of the muscle in the vertical plane therefore causes a "tensing" of the soft palate through this hamular "pulley mechanism" (fig. 48.13). The tensor palati is the only palatal muscle that is not innervated by X. The tensor palati is innervated by V³. The dual action of the levator palati moving the posterior cartilaginous plate of the auditory tube and the tensor palati moving the anterior cartilaginous plate of the auditory tube during swallowing effects an opening of the orifice of the auditory tube (figs. 48.14 and 48.15). This explains why one wishes to swallow, yawn, or move the palate when it is necessary to relieve

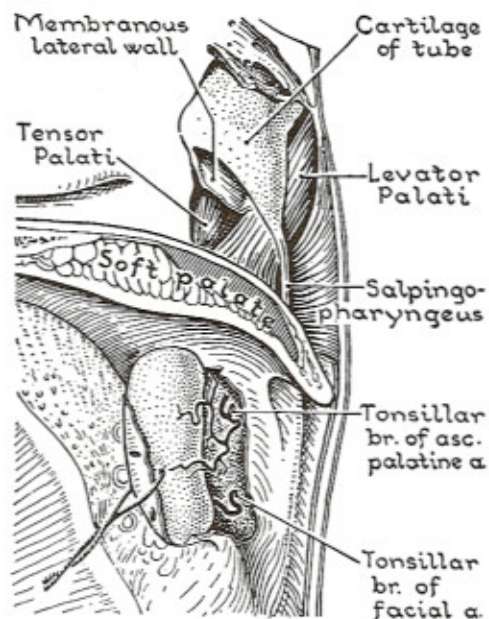


Figure 48.15. Second stage in the removal of the tonsil. Dissection of nasopharynx. (Dissections by Dr. P. G. Ashmore.)

a difference in pressure within the middle ear and the nasal cavity.

The **palatoglossus**, **palatopharyngeus**, and **stylopharyngeus** are related to the inferior aspect of the soft palate as they insert into the oropharynx and laryngopharynx. The **palatoglossus** muscle underlies the palatoglossal fold anterior to the tonsillar bed (fig. 48.16). It is innervated by the vagus nerve and assists in depressing the soft palate. The **palatopharyngeus** is a more prominent muscle and has two major components. The salpingopharyngeal part attaches superiorly to the posterior laminae of the cartilaginous portion of the auditory tube. It descends and fuses with the palatopharyngeal portion of the muscle that arises from the superior and inferior aspect of the soft palate (fig. 48.17). The palatopharyngeus muscle creates the palatopharyngeal fold (fig. 48.16), as it raises the mucous membranes of the oropharynx posterior to the tonsillar bed. It inserts onto the lamina of the thyroid cartilage and assists the **stylopharyngeus** in elevating the larynx during swallowing. The palatopharyngeus is innervated by X, while the stylopharyngeus is the only skeletal muscle innervated by IX.

The palatine tonsils are frequently removed in patients with persistent upper respiratory infections. The important blood vessels that supply the tonsils penetrate the lateral pharyngeal wall and enter the tonsil on its deep surface. Figures 48.15 and 48.16 show two major blood vessels on the deep lateral aspect of the tonsil: the tonsillar branch of the ascending pharyngeal artery and the tonsillar branch of the facial artery. Tonsillar branches of the lingual artery may also enter the gland at its inferior pole. These vessels may be the source of extensive bleeding in tonsillectomies and are sometimes "tied off" or cauterized to control postsurgical hemorrhage.

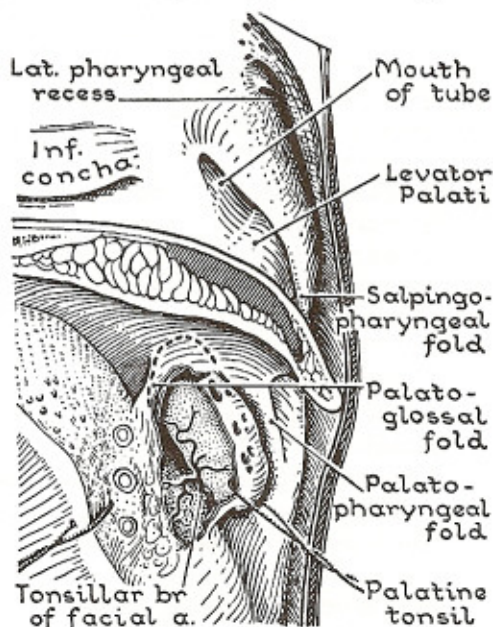


Figure 48.16. First stage in the removal of the tonsil. The side wall of the pharynx.

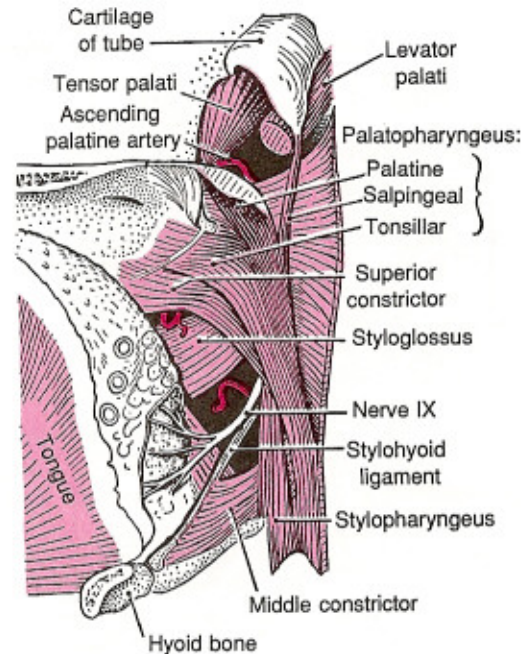


Figure 48.17. A stage in the dissection of the side wall of the pharynx from within, showing particularly the relations of the tonsil (by Dr. B. L. Guyatt).

The "tonsillar bed" in the lateral wall of the oropharynx lies in the submucosa of the pharynx. An internal fascia lining the constrictor muscles, the **pharyngobasilar fascia**, underlies the tonsil. The outer layer of fascia on the pharyngeal constrictor is the **buccopharyngeal fascia**, and this is a part of the visceral fascia of the neck. Infections of the tonsils or surgical procedures on the tonsils may compromise these fascial floors of the tonsillar bed and allow infections to spread into the **lateral pharyngeal space**, which is illustrated in Figure 48.18.

This space is lined with areolar fascia, filled with fat, muscles, and the structures contained within the carotid sheath. The space is continuous with the **retropharyngeal space**, which lies posterior to the pharynx and anterior to the **prevertebral fascia** that surround the spinal column and its associated muscles. Infections may spread in these fascial compartments by expansion (bacterial growth and exudate formation) and by gravity. They spread inferiorly into the triangles of the neck, deep to the investing fascia, and can eventually enter the upper extremity along the axillary sheath. They can also enter the thorax along the pathway of the carotid sheath. The latter can explain how pericarditis (inflammation of the pericardium) and infections of the posterior mediastinum can result from infections in the head and neck.

PALATAL DEVELOPMENT AND DEFECTS

Facial development occurs between the 5th and 8th weeks of embryonic life. The nasal and oral cavity are

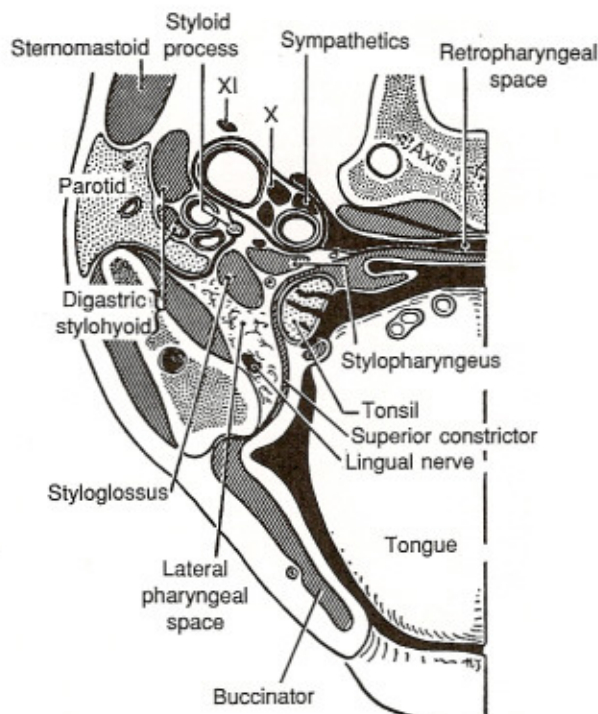


Figure 48.18. Cross-section of the head, at the level of the parotid gland and the tonsil.

separated by the development of the hard and soft palate. Figure 48.19 shows the initial phases of palatal development prior to fusion (approximately the 7th week). The maxillary processes of the right and left side are joined anteriorly in the midline by the **intermaxillary segment**. This intermaxillary segment consists of the **globular processes** and the **premaxilla**. The globular processes give rise to the philtrum portion of the developing upper lip. The premaxilla forms the portion of the maxillary arch containing the four incisor teeth and the palatal bone between these teeth and the future incisive foramen. The secondary palate is formed from the development and

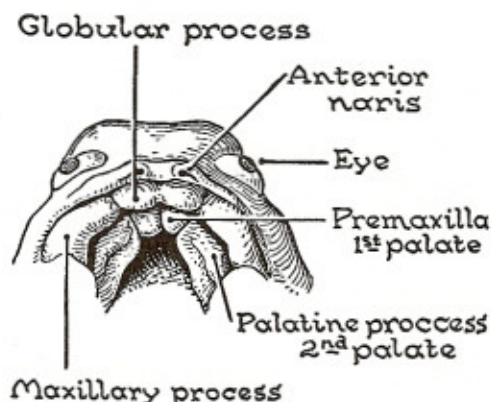


Figure 48.19. The palate develops from 3 shelves— anterior, right, and left.

fusion of the palatal shelves on the medial aspects of the maxillary processes. Fusion of these palatal shelves in the midline between the 8th and 11th week of embryonic life will complete the formation of the hard and soft palate.

Palatal fusion begins at the site of the future incisive foramen, which is at the junction of the anterior one-third and posterior two-thirds of the future hard palate. The resulting fusion then proceeds in two opposing directions from this initial site. Anteriorly, the premaxilla fuses first with the secondary palatal shelves of each side, and then the globular process of the intermaxillary segment fuses with the maxillary process. Failure of fusion in this process can result in a complete cleft from the lip to the incisive foramen or any segment of this interval from the lip toward the incisive foramen. Some newborns may have a normal fusion of the bony components and only demonstrate the cleft in the lip. Cleft lips may be bilateral or unilateral in their occurrence.

Posteriorly, the fusion proceeds from the incisive foramen region to the uvula. The entire process takes from the 8th to the 11th week. The hard palate fuses prior to the fusion of the soft palate. Complete or partial clefts of this fusion are also possible. The most severe cleft palate condition is a combination of the nonfusion of the two processes. This creates a cleft lip, maxillary arch, and a hard and soft palate defect. It produces an unsightly appearance and also creates problems for suckling and swallowing. It is a common congenital malformation and may be treated successfully by surgical correction.

Clinical Mini-Problems

- Which cranial nerve causes a "gag reflex" when stimulated in the mucosa of the tonsillar bed?
 - What other cranial nerves will induce a "gag reflex" when stimulated in the palatal and pharyngeal regions?
- Which two muscles "flanking" the nasopharyngeal opening of the auditory tube assist in opening the tube during swallowing?
 - What nerve(s) supply these muscles?
- Which two arteries anastomose on the nasal septum?
- Which cranial nerve would be damaged if a patient's palate deviated to the right when the patient said "Ah"?
 - What other prominent clinical symptom would likely be recognized in this nerve injury?
- Which muscle(s) cause elevation of the larynx during swallowing?
 - What is (are) their nerve supply.

(Answers to these questions can be found on p. 588.)