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1. Discuss the anatomy of the tongue and comment on its applied anatomy

The tongue is the muscular organ found in the vertebrate mouth. It is attached via muscles to the hyoid bone, mandible, styloid process, palate, and pharynx and divided into two parts by the V-shaped sulcus terminalis. These two parts, an anterior two thirds and a posterior one third, are structurally and developmentally distinct. The foramen cecum at the apex of the sulcus terminalis indicates the site of embryonic origin of the thyroglossal duct.

The following papillae cover the tongue and are used for taste perception:

1. **Vallate papillae**are arranged in a V-shape anterior to the sulcus terminalis and studded with numerous taste buds. Innervation is by the glossopharyngeal nerve (CN IX).
2. **Fungiform papillae** are mushroom-shaped papillae with erythematous domes, located on the lateral aspects and at the apex of the tongue.
3. **Filiform papillae** are slim, cone-shaped projections organized in rows parallel to the sulcus terminalis.
4. **Foliate papillae** are rarely found in humans (vestigial).

Another important part of the tongue is the lingual tonsil, a collection of nodular lymphatic tissue towards the posterior one-third of the dorsum of the tongue.

**Structure and Function**

The functions of the tongue include taste, speech, and food manipulation in the oral cavity.

* **Taste Functions**

Chemicals that interact with the taste buds in the tongue are referred to as "tastants." Taste buds themselves are found within the various papillae of the tongue. Tastants interact with gustatory cell receptors in the taste buds, resulting in transduction of a taste sensation. The five broad categories of taste receptors are (1) sweet, (2) salty, (3) sour, (4) bitter, and (5) umami. The lingual papillae are divided into the vallate (or circumvallate), fungiform, filiform, and foliate papillae. More than half of the taste buds are located on the vallate papillae at the junction of the oral and oropharyngeal tongue or tongue base.

* **Speech Functions**

Speech is produced in part by manipulation of the tongue in the mouth against the teeth and palate within the oral cavity. The intrinsic muscles of the tongue are involved primarily in shaping the tongue for speech.

* **Food Manipulation Functions**

The tongue moves food around the mouth within the oral cavity by pressing it against the hard palate and out to the sides to enable mastication. It enables the formation of the food bolus in the oral preparatory phase of swallowing. It also takes part in the oral phase of swallowing by elevating and sweeping posteriorly to propel the food bolus past the anterior tonsillar pillar, triggering the swallowing reflex.

**Blood Supply and Lymphatics**

Blood supply to the tongue is predominantly from the lingual artery, a branch of the external carotid artery between the superior thyroid artery and the facial artery, which departs at the level of the greater horn of the hyoid bone within the carotid triangle. After branching from the external carotid artery, the lingual artery passes deep to the hyoglossus muscle and superficial to the middle pharyngeal constrictor muscle. It then gives rise to the following four arteries:

1. The **suprahyoid artery**supplies the omohyoid, sternothyroid, and thyrohyoid muscles. They anastomose with the corresponding vessels from the opposite side.
2. The **dorsal lingual arteries**arise beneath the hyoglossus muscle and pass to the posterior part of the dorsum of the tongue. They supply the mucous membrane of this region as well as the glossopalatine arch, lingual tonsils, soft palate, and epiglottis. They anastomose with their corresponding vessels on the opposite side.
3. The **sublingual artery** branches at the anterior border of the hyoglossus muscle before passing between the genioglossus muscle and mylohyoid muscle to the sublingual gland. It supplies the sublingual gland before giving branches to the mylohyoid muscle. One branch from the sublingual artery passes posterior to the alveolar process of the mandible and anastomoses with the corresponding artery from the other side. A second branch of the sublingual artery pierces the mylohyoid muscle and anastomoses with the submental branch of the facial artery.
4. The **deep lingual artery**, which is the termination of the lingual artery, passes between the genioglossus muscle and inferior longitudinal muscle.

**Nerves**

The hypoglossal nerve (CN XII) provides motor innervation to all of the intrinsic and extrinsic muscles of the tongue except for the palatoglossus muscle, which is innervated by the vagus nerve (CN X). It runs superficial to the hyoglossus muscle. Lesions of the hypoglossal nerve cause deviation of the tongue to the ipsilateral (i.e., damaged) side.

Taste to the anterior two-thirds of the tongue is achieved through innervation from the chorda tympani nerve, a branch of the facial nerve (CN VII). General sensation to the anterior two-thirds of the tongue is by innervation from the lingual nerve, a branch of the mandibular branch of the trigeminal nerve (CN V3). The lingual nerve is located deep and medial to the hyoglossus muscle and is associated with the submandibular ganglion.

On the other hand, taste to the posterior one-third of the tongue is accomplished through innervation from the glossopharyngeal nerve (CN IX), which also provides general sensation to the posterior one-third of the tongue.

Taste perception also is performed by both the epiglottis and the epiglottic region of the tongue, which receives taste and general sensation from innervation by the internal laryngeal branch of the vagus nerve (CN X). Damage to the vagus nerve (CN X) causes contralateral deviation (i.e., away from the injured side) of the uvula.

**Muscles**

The tongue's intrinsic muscles include the following:

1. The **superior longitudinal lingual** muscle, which shortens the tongue and curls it upward.
2. The **inferior longitudinal lingual** muscle, which shortens the tongue and curls it downward.
3. The **transverse lingual** muscle, which elongates and narrows the tongue.
4. The **vertical lingual** muscle, which flattens the tongue.

The tongue's extrinsic muscles include the following:

1. The **genioglossus** muscle, which protrudes the tongue, and is innervated by the hypoglossal nerve (CN XII).
2. The **styloglossus** muscle, which draws up the sides of the tongue to create a trough for swallowing following adequate mastication. The pair of styloglossus muscles works together on each side to retract the tongue. The styloglossus muscle is innervated by the hypoglossal nerve (CN XII).
3. The **hyoglossus** muscle, which depresses and retracts the tongue and is innervated by the hypoglossal nerve (CN XII).
4. The **palatoglossus** muscle, which elevates the posterior tongue, closes the oropharyngeal isthmus, aids in the initiation of swallowing, and prevents the spill of saliva from the vestibule into the oropharynx by maintaining the palatoglossal arch. It is the only extrinsic muscle of the tongue that is not innervated by the hypoglossal nerve; instead, it is innervated by the vagus nerve (CN X).

**Physiologic Variants**

* **Ankyloglossia ("tongue-tie")** occurs due to an abnormal length of the frenulum linguae which causes limited manipulation of the tongue during speech and results in a speech impediment. In the most common form of ankyloglossia, the frenulum extends to the tip of the tongue. Ankyloglossia can be corrected by surgically severing the lingual frenulum.
* **Fissured tongue ("scrotal tongue," "plicated tongue")** occurs when several small furrows present on the dorsal surface of the tongue. It can be an oral manifestation of psoriasis. It is generally painless and benign, and is often associated with other syndromes (e.g., Down syndrome).
* **Geographic tongue ("migratory glossitis")**is a benign, asymptomatic condition characterized by the presence of large red patches with a greyish-white border covering the dorsum of an otherwise normal tongue. It is caused by inflammation of the mucous membrane of the tongue, which results in loss of lingual papillae. The lesions are known to migrate over time. The name arises from the map-like appearance of the tongue in this condition.

**Surgical Considerations**

Thyroglossal duct cysts can develop when there is a remnant at the point of embryologic origin of the thyroid gland, the foramen cecum. The thyroid gland begins to develop in the floor of the embryologic pharynx at the point called the foramen cecum, which is located at the dorsum of the posterior tongue. The developing gland then relocates to its ultimate destination in the anterior neck by migrating down the thyroglossal duct anterior to the hyoid cartilage and thyroid cartilage before stopping anterolateral to the superior aspect of the trachea. The thyroglossal duct ordinarily disappears, but remnants of its epithelium may remain, allowing for the potential development of a thyroglossal duct cyst in this area. These cysts generally occur in the neck, close to or inferior to the body of the hyoid bone. They form a swelling at the anterior midline of the neck that is painless, fluctuant, and moves upon swallowing. Thyroglossal ducts cysts typically are removed surgically.

**Applied Anatomy**

The tongue tends to fall posteriorly, thus obstructing the airway. Paralysis or total relaxation of the genioglossus muscle presents a risk of suffocation, which can occur during general anesthesia. An artificial airway is made using intubation, which prevents the tongue from falling backward and blocking the airway.

* Ludwig angina infection, once established, evolves to include the tongue. The tongue may enlarge to two or three times its usual size and tends to distend posteriorly into the hypopharynx, superiorly against the palate, and anteriorly out of the oral cavity. Any immediate posterior extension of this process will ultimately involve the epiglottis. The styloglossus muscle creates the connection between the submandibular parapharyngeal spaces, otherwise known as the buccopharyngeal gap, as it leaves the tongue and passes in between the middle and superior constrictor muscles before attaching to the styloid process. Cellulitis of the submandibular space may spread into the pharyngeal space and, from there, into the retropharyngeal space of the mediastinum.
* Dysgeusia, or a pure taste disorder, is rare and is usually associated with olfactory disorders.

1. write an essay on the air sinuses

The nasal cavity is a roughly cylindrical, midline, airway passage that extends from the nasal ala anteriorly to the choana posteriorly. It is divided in the midline by the nasal septum. On each side, it is flanked by the maxillary sinuses, and roofed by the frontal, ethmoid, and sphenoid sinuses, in an anterior to posterior fashion. While seemingly simple, sinonasal anatomy is composed of intricate and subdivided air passages and drainage pathways that connect the sinuses.

**Structure and Function**

There are 4 paired sinuses in humans. They are all in line with pseudostratified columnar epithelium.

* The maxillary sinuses: Largest of the paranasal sinuses, located under the eyes in the maxillary bones.
* The frontal sinuses: Located superior to the eyes within the frontal bone
* The ethmoid sinuses: Formed from several discrete air cells within the ethmoid bone between the nose and eyed
* The sphenoid sinuses: Located within the sphenoid bone

The function of the paranasal sinuses is debated. However, they are implicated in several roles:

* Decreasing the relative weight of the skull
* Increasing the resonance of the voice
* Providing a buffer against facial trauma
* Insulating sensitive structures from rapid temperature fluctuations in the nose
* Humidifying and heating inspired air
* Immunological defense

To develop a strong understanding of paranasal sinus anatomy, it is also important to understand the anatomical relationships of the sinuses to surrounding structures. The lateral nasal wall contains many structures and recesses that are important for understanding paranasal sinus anatomy.

* Turbinates: Three to 4 bony shelves covered by erectile mucosa, serve to increase the interior surface area
* Meatuses: Three spaces located beneath each turbinate. The superior meatus provides drainage for the sphenoid and posterior ethmoid sinuses. The middle meatus provides drainage for the frontal, anterior ethmoid, and maxillary sinuses. The inferior meatus contains the orifice of the nasolacrimal duct
* Uncinate process: A sickle-shaped, thin, bony part of the ethmoid bone, covered by mucoperiosteum, medial to the ethmoid infundibulum and lateral to the middle turbinate
* Ethmoid infundibulum: This is a pyramidal space facilitating drainage of the maxillary, anterior ethmoid, and frontal sinuses. The superior attachment of the uncinate process determines the spatial relationship of the frontal sinus drainage (discussed in another section)
* Semilunar hiatus: This is a gap that empties the ethmoid infundibulum and is located between the uncinate process and the ethmoid bulla
* Osteomeatal complex (OMC): Region referring to the anterior ethmoids containing the ostia of the maxillary, frontal, and ethmoid sinuses. This is located lateral to the middle turbinate. While not a discrete anatomic structure, it is instead a collection of several middle meatus structures including the middle meatus, uncinate process, ethmoid infundibulum, anterior ethmoid cells, and ostia of the anterior ethmoid, maxillary, and frontal sinuses.
* Nasal Fontanelles: Area of the lateral nasal wall where no bone exists. The natural ostium of the maxillary sinus is located in the anterior fontanelle.

**Maxillary Sinus**

The maxillary sinus is located under the eyes in the maxillary bone. Adjacent structures include the lateral nasal wall, the orbital floor, and the posterior maxillary wall which contains the pterygopalatine fossa. The maxillary sinus is innervated by the infraorbital nerve (CN V2). The maxillary and facial arteries supply the sinus, and the maxillary vein supplies venous drainage. As mentioned already, the maxillary sinus drains into the ethmoid infundibulum. There is typically only one ostium per maxillary sinus; however, cadaver studies have shown 10% to 30% have an accessory ostium. The size of the maxillary sinus at adult stage is approximately 15 mL, making it the largest paranasal sinus.

**Frontal Sinus**

The frontal sinus is located superior to the orbit and within the frontal bone. The typical volume at the adult stage is 4 to 7 mL. The frontal sinus drains into the frontal recess via the middle meatus. As noted previously, this drainage can be variable, either medial or lateral to the uncinate, depending on its attachment. The frontal sinus vasculature consists of the supraorbital and supratrochlear arteries and ophthalmic and supraorbital veins. Similarly, it's innervation is provided by the supraorbital and supratrochlear nerves (CNV1). Several anatomical spaces/structures are important to frontal sinus anatomy:

* Frontal recess: Drainage space between the frontal sinus and semilunar hiatus that is bounded by the posterior wall of the agger nasi cell, lamina papyracea, and the middle turbinate.
* Frontal sinus infundibulum: Space that drains into the frontal recess that is located superior to the agger nasi cells
* Frontal cells: anterior ethmoid cells that pneumatize the frontal recess. These cells may cause obstruction or persistent sinus disease. They are located posterior and superior to the agger nasi cell, and there are 4 types as classified by Bent and Kuhn:

1. Type I: Single cell above the agger nasi cell but below the floor of the frontal sinus
2. Type II: Multiple cells above the agger nasi, may extend into the frontal sinus
3. Type III: Single large cell that extends supraorbitally through the floor of the frontal sinus, attaches to the anterior table
4. Type IV: Single isolated cell that is contained within the frontal sinus

**Sphenoid Sinus**

The sphenoid sinuses are located centrally and posteriorly within the sphenoid bone. They drain into the sphenoethmoidal recess located within the superior meatus. The sphenopalatine artery supplies the sinus, and venous drainage is via the maxillary vein. Innervation is provided by the sphenopalatine nerve, which is comprised of parasympathetic fibers and CN V2. The typical adult size is 0.5 to 8 mL. Several important structures have a close anatomical relationship to the sphenoid sinus. The carotid artery is located adjacent to the lateral wall of the sinus, and in 25% of patients, it is dehiscent in this area. The optic nerve is also located adjacent to the lateral wall of the sinus and can be dehiscent in up to 5% of individuals.

**Ethmoid Sinuses**

* There are 3 to 4 cells at birth and develop into 10 to 15 by adulthood for a total volume of 2 to 3 mL. They are located between the eyes. The anterior ethmoids drain into the ethmoid infundibulum, in the middle meatus. The posterior ethmoid sinuses drain into the sphenoethmoidal recess located in the superior meatus. The ethmoid sinuses are supplied by the anterior and posterior ethmoid arteries, respectively. These arteries are branches of the ophthalmic artery, which is a branch off of the internal carotid artery. This is an important anatomical relationship to realize because endovascular embolization of the ethmoid arteries should be avoided when treating epistaxis due to the possibility of retrograde movement of the embolization material into the ICA resulting in possible CVA. Ethmoid sinus venous drainage is by the maxillary and ethmoid veins. The anterior and posterior ethmoid veins provide innervation.
* The complex ethmoidal labyrinth can be reduced into a series of lamellae based on embryologic precursors. These lamellae are obliquely oriented and lie parallel to each other.

1. The first lamella is the uncinate process.
2. The second lamella corresponds to the ethmoid bulla.
3. The third lamella is also known as the basal or ground lamella of the middle turbinate. This lamella serves as the division of the anterior and posterior ethmoids. The anterior part inserts vertically into the crista ethmoidalis. The middle portion attaches obliquely into the lamina papyracea. The posterior third attaches to the lamina papyracea as well but in a horizontal fashion.
4. The fourth lamella is the superior turbinate.

* The agger nasi cell is the most anterior of the anterior ethmoid cells. It is found anterior and superior to the middle turbinate attachment to the lateral wall. The posterior wall of the agger nasi cell forms the anterior wall of the frontal recess.
* The ethmoid bulla is the largest of the anterior ethmoid cells that lies above the infundibulum. This structure is important because the anterior ethmoid artery courses over the roof of this cell.

**Blood Supply and Lymphatics**

The major artery of the maxillary sinus is the internal maxillary artery, a branch of the external carotid artery. The ethmoid and frontal sinuses have a variety of blood supplies, including meningeal vessels for the cribriform plate above the ethmoid sinuses, as well as the posterior wall of the frontal air cells. The sphenoid sinuses may derive blood supply from small branches of the cavernous internal carotid arteries. Rarely, an aneurysm of the internal carotid artery may invaginate into the sphenoid sinus, making endovascular coiling the preferred technique for aneurysm obliteration.

**Nerves**

The major nerve running below the frontal sinus is the first division of the fifth cranial nerve. The major nerve of the inferior aspect of the maxillary sinus is the second division of the fifth cranial nerve. This nerve has sensory but no specific motor functions, as opposed to the third division of cranial nerve five, the latter of which has both sensory (primarily skill of the jaw and the teeth) and motor functions (primarily muscles of mastication).

**Muscles**

The frontalis muscle runs over the frontal skull and sinus region and is part of the mechanism of facial expression. The levator muscles of the lips are anchored over the maxillary sinuses. The zygomatic projection of the maxilla is part of the anchorage of the masseter muscle, a powerful closure of the jaw.

**Physiologic Variants**

Nasal anatomy differs significantly among individuals; certain anatomic variations are relatively common. The variations may contribute to mechanical obstruction of the osteomeatal complex leading to rhinosinusitis.

Concha bullosa is defined as aeration of the middle turbinate. This variation can be either unilateral or bilateral. If large, a concha bullosa in the middle turbinate may lead to obstruction of the middle meatus or infundibulum.

The nasal septal deviation is an asymmetric bowing of the nasal cartilaginous septum. Such a bowing may compress the middle turbinate in a lateral fashion, which may lead to narrowing of the middle meatus. This variation is often congenital, but may also be secondary to nasal trauma.

The middle turbinate usually curves medially toward the nasal septum. However, when the turbinate curves laterally, the resultant anatomic variant is known as a paradoxical middle turbinate. Such a variant can narrow or obstruct the nasal cavity, middle meatus, or infundibulum.

The uncinate process is a structure that has multiple variations between individual patients. The superior attachment of the uncinate process has three major variations that help determine the anatomic configuration of the frontal recess and its drainage:

* An uncinate process that extends laterally to attach to the lamina papyracea or the ethmoid bulla, forming a terminal recess of the infundibulum with the frontal recess opening directly into the middle meatus
* An uncinate process that extends medially and attaches to the lateral surface of the middle turbinate, with the frontal recess draining into the infundibulum
* An uncinate process that extends medially and superiorly to directly attached to the skull base, with the frontal recess draining into the infundibulum
* Eighty percent of the time, the uncinate attaches to the lamina papyracea resulting in frontal sinus drainage medial to the uncinate, while 20% of the time, the uncinate attaches to either the skull base or middle turbinate, resulting in drainage lateral to the uncinate.

Haller cells are ethmoid air cells that extend laterally over the medial aspect of the roof of the maxillary sinus. If large enough, they may cause narrowing of the infundibulum. Onodi cells are lateral and posterior extensions of the posterior ethmoid cells. Horizontal septations around the sphenoid sinus delineate them. Importantly, these cells may surround the optic nerve tract, which can increase the risk of injury to the optic nerve during surgery.

Lastly, the height of the ethmoid roof can vary between patients and vary between each side in the same patient. When there is asymmetry of ethmoid roof height in a patient, the risk of intracranial penetration during FESS is higher.

These are only a few of the anatomic variations seen in sinonasal anatomy. While they represent the most common variations, the importance of having a sound understanding of the 3-dimensional anatomy is paramount to safe and effective endoscopic sinus surgery.

**Surgical Considerations**

Treatment of inflammatory disease of the paranasal sinuses involves both medical therapy and surgical treatment. There are several general guidelines for chronic sinusitis when considering surgical management:

* Preserve the mucoperiosteum and try not to leave the exposed bone
* Remove bony partitions and any osteitic bone in the area of disease as completely as possible
* Extend the dissection one step beyond the extent of disease if possible
* Preserve the middle turbinate if possible.

**Clinical Significance**

Paranasal sinuses are prone to inflammation and infection. If the paranasal sinuses become blocked from secretions or a mass, the drainage of mucus is interrupted, and sinusitis can result. The maxillary sinus may be involved from any process in the teeth or the gums. The frontal and maxillary sinuses may be involved in allergies. Depending on the cause, sinusitis is treated with corticosteroids, decongestant, nasal irrigation, and hydration. Rarely surgical intervention may be required to enhance drainage.

Malignancies of the paranasal sinuses are rare. The majority of cancers occur in the maxillary sinus and are more common in men than women. Maxillary sinus malignancies occur between ages 45 to 70, and the most frequent is a sarcoma. Even though metastases are rare, these malignancies are locally invasive and destructive. Diagnosis in most cases is delayed, and the prognosis is poor.

Acute rhinosinusitis (ARS) and chronic rhinosinusitis (CRS) are both defined as symptomatic inflammation of the nose and paranasal sinuses. The 2 are distinguished based on the duration of the complaints. Generally speaking, acute rhinosinusitis is widely considered to be an infectious disorder. On the other hand, chronic rhinosinusitis is typically defined as an inflammatory disorder. In ARS, the underlying etiology is typically viral or bacterial, and occasionally fungal. The pathogenesis of ARS involves infection followed by tissue invasion.

The most widely accepted classification system divides CRS into CRS with and without nasal polyps (CRSwNP and CRSsNP, respectively) based on nasal endoscopy. Originally, it was felt that CRSsNP was a disease process characterized by persistent inflammation that led to incomplete resolution of ARS. CRSwNP, on the other hand, was felt to be a noninfectious disease process with unclear etiology, perhaps related to atopy. Current research has instead revealed that the etiology and pathogenesis of either form of CRS is much more complex.