

RESPIRATORY SYSTEM

Anatomy



Sheet



Slide

Number:

1

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Introduction

Respiratory System Organs:

1)→ Starting from the **Nose** (nasal cavity).

2)→ **Pharynx** (Nasopharynx, oropharynx and laryngopharynx, previously discussed in the GI system).

3)→ **Larynx**, box of cartilage where the phonation or the articulation occurs since it contains true vocal cords that are responsible of speech.

4)→ **Trachea**

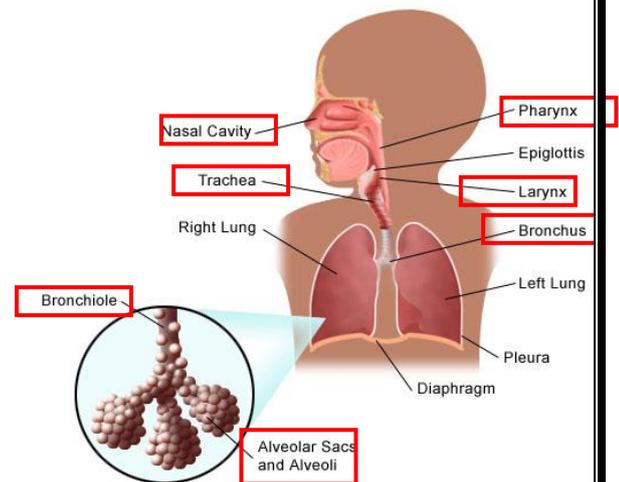
5)→ **Bronchi**, there is a main left bronchus and main right bronchus, both branch from the trachea "bronchi is the plural of bronchus"

6)→ **Bronchioles**, which are branches from main right and main left bronchi, bronchioles are located inside each lung.

7)→ **Alveoli**, bronchioles end in a cluster of air sacs, these air sacs are called aveoli, we have billions of alveoli in each lung and these alveoli are the place in which gases exchange occur ,they are surrounded by a very large network of blood capillaries to give a large surface area for gas exchange.

- note that, the alveoli are found inside the lung and the lung is surrounded by pleura (the pleura is the same as the pericardium so there is parietal and visceral pleura).

- note that each lung, right and left, has a hilum, *the place where the bronchi and blood vessels enter the lung and the veins exit*, the lung also contains nerves and lymphatic.



Clinical Correlation-1

The difference between bronchi and bronchioles is that bronchi contain cartilage while bronchioles don't. This is why bronchioles are susceptible to asthma, which is contraction of the smooth muscles of the **bronchioles** (cartilage helps in opening the bronchi but in the case of bronchioles the smooth muscle contraction results in obstruction of the air passage).

Functions of the respiratory system:

1. Gas exchange, which occurs in the alveolar-capillary membrane.

What is respiration?

Respiration is the process of breathing:

- **Inspiration:** filling of lungs with Oxygen, which needs effort (muscle contraction).
- **Expiration:** the exhalation of breath from the lung, which is usually passive. Any voice abnormalities, vocal cord movements (i.e. wheezing) are often heard during expiration.

Respiratory rate (RR)

A RR of (18-22 per minute) is the normal rate to begin with. However, this rate is variable upon physical activities, it increases in exercise and decreases in rest.

During rest, there's normal inspiration+normal expiration

During exercise, there's deep inspiration+deep expiration

Note that children has a high RR, more than 40 times per minute.

Clinical Correlation-2

First thing to check while being in the ER is the respiration, as if it has stopped for 2-5 minutes, then brain death is a consequence.

What can you do?

you may do a tracheostomy (an opening in the trachea) or if you are in the emergency room you may put nasolaryngeal tube (endotracheal tube), a tube in the trachea between true vocal cords for the respiration to continue, if it was above the vocal cords it may cause adduction and suffocation.

2. Regulation of blood Ph.

Gases in the blood, the amount of oxygen and CO₂ are always measured in arterial blood during normal gas analysis, hence the name "Arterial Blood Gases" not venous.

3. Filters the inspired air

The vestibule of the nose is the first structure to filter the air from dust, foreign bodies, viruses, and bacteria, the vestibule contains short, thick hair called **vibrissae** and are present on the anterior part of the nose.

4. Olfaction, Smell

It occurs in the nasal cavity since it contains receptors for smell>The roof of the nose contains bipolar cells for smell sensation and there are filaments of olfactory nerve (the first cranial nerve) starting from the roof of the nose and end in the **smell center** which retrieves this smell "translates the smell to find out the source".

5. Phonation, Sound production

Also, the larynx contains true vocal cords, that when vibrate, are responsible for phonation or speech.

6. Mucous Secretion

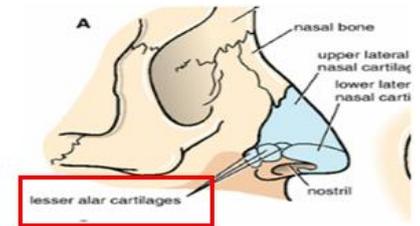
In the submucosa "one of the histological layers of the respiratory tract" there is gland responsible for secretion, filtration of dust and foreign bodies and moisturizing of air especially in the nose
Histological layers of respiratory tract: Mucosa, submucosa, supportive layer "cartilage or smooth muscle", adventitia.

7. Excretes small amounts of water and heat.

Starting from the first respiratory organ, the nose:

The Nose is mainly divided to:

- 1) External Nose.
- 2) Internal Nose (Nasal Cavity).



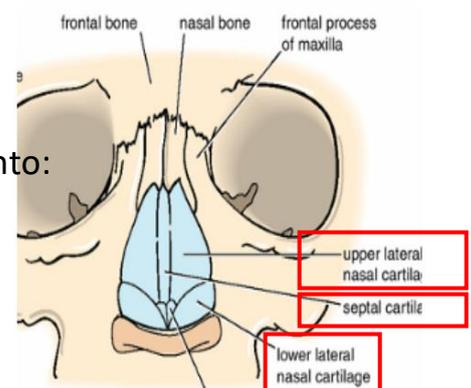
→ The nose can be generally described as two cavities separated by a septum, which is considered the medial wall of the nose.

1- External Nose

Has 2 main parts, cartilaginous and bony

Cartilaginous framework:

- **Septal cartilage** (middle wall)
- **Lateral nasal cartilage** (lateral wall) divides into:
 - 1-upper lateral cartilage
 - 2-lower lateral cartilage



- **Alar cartilage**,
it is covered by muscles, naris compressor muscle and naris dilator muscle.

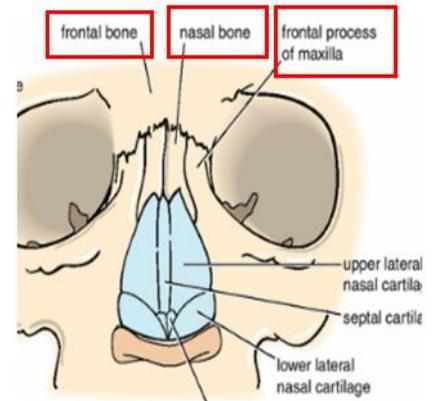
These muscles are the reason why rabbits and some humans have the ability to move their alar.

Note that the anterior 2/3 of the nose is made by the above cartilage, and it's movable.

Bony framework of the external nose:

- 1- The nasal bone.
- 2- Frontal process of maxilla against it superiorly

- there is maxillary process of frontal bone.*
- 2- Nasal part of frontal bone



The External nose blood supply

Before digginig into details, generally speaking, upper jaw and the upper part of the face get their blood supply from the maxillary artery.

The lower mandible gets its blood supply from the maxillary artery (and nerve supply from mandibular nerve).

The External nose blood supply is provided by:

1. **The ophthalmic artery:** *branch of the internal carotid artery from inside the skull.*

The ophthalmic artery travels through the orbital cavity through the optic canal, while accompanying the optic nerve.

2. **The maxillary artery** One of the terminal branches of external carotid artery, it branches in the parotid gland. Gives blood supply to the upper jaw and then enters the inferior orbital foramen to become the infraorbital artery.

Note that superficial temporal is a branch of the external carotid and it branches in the parotid gland as well.

3. **The facial artery** branch from external carotid artery

Also participates in the blood supply to the external nose. The facial artery gives rise to the superior or (upper) labial artery which gives rise to the nasal artery. **The facial artery supplies the ala and the lower part of the septum.**

Nerve supply of external nose:

- The External nose is supplied by:

1-Branches of the ophthalmic nerve.

Infratrochlear and **External nasal** which are **branches of the Ophthalmic Nerve**. Note that the external nasal is a **is a direct continuation of the anterior ethmoidal nerve**. The anterior ethmoidal comes from the ophthalmic nerve.

2-**Infraorbital branch of the maxillary nerve**, the maxillary nerve gives the infraorbital branch when traveling through the inferior orbital foramen.

Nasal cavity

1-Extends from the anterior nasal aperture (nostril/anterior nares) to the posterior nasal apertures (choana/posterior nares).

***Nostril**

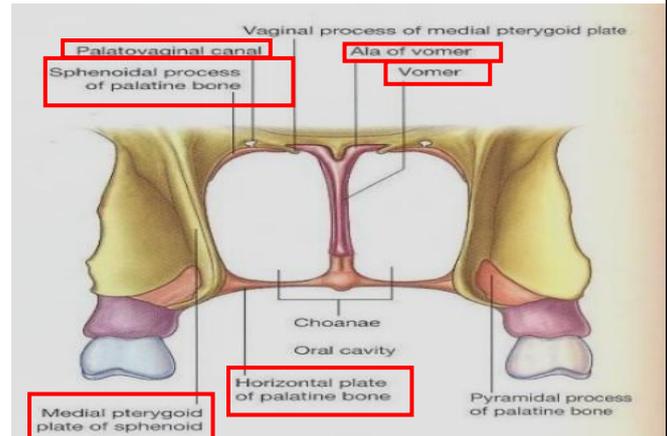
The anterior nares of the nasal cavity from which air comes in. Held open by the surrounding alar cartilage and septal cartilage. Can be widened further by the action of the related muscles of facial expression.

***Choana**

The posterior nares of the nasal cavity, it connects the nasal cavity with the nasopharynx, divided by the vomer (nasal septum).

Boundaries of the choana are :

- 1- Medially, the vomer and the vomer has a superior process called ala of vomer.
- 2- Anteriorly and inferiorly, horizontal plate of palatine bone
- 3- Laterally, Medial pterygoid plate
- 4- At the roof, there is a foramen called palatovaginal canal which leads to the nasopharynx
- 5- At the roof, Sphenoidal process of palatine bone



2-Bounded by medial wall, lateral wall, roof and floor:

1-The medial wall (nasal septum):

It is located in the middle dividing the nasal cavity into 2 cavities, it is made of:

- 1-Septal cartilage"anteriorly"
- 2- Vomer and the perpendicular plate of ethmoid bone "Posteriorly"

2-The lateral wall:

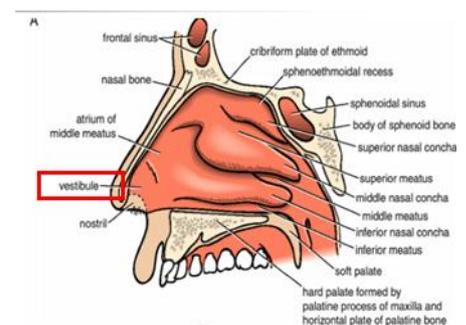
-Function of the lateral wall of nasal cavity:

It is responsible of warming and moisturizing of air since it contains large number venous plexus in the submucosa layer.

-Parts of the lateral wall:

1) Vestibule:

It is the area of the nasal cavity lying just above the nostril in the ala of the nose, its feature is that the mucosa is **stratified squamous keratinized** and contains hair follicles called vibrissae.



HISTOLOGY NOTE:

Generally speaking, the nasal cavity and respiratory tract are covered by pseudo stratified ciliated columnar epithelium epithelium type.

From this rule we exclude 2 structures:

- 1-The vestibule's epithelium is **stratified squamous keratinized epithelium with hair follicles" vibrissae"**
- 2-The roof of the nasal cavity just above the superior concha has is covered with (**pseudo stratified ciliated columner+bipolar cell**),since the it contains bipolar cells for smell sensation.

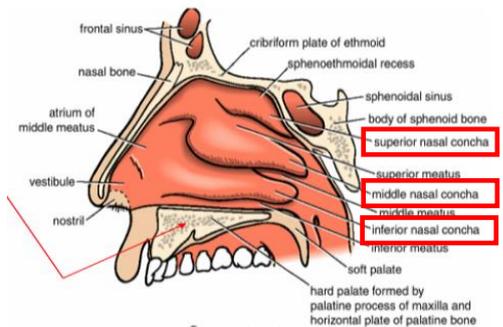
2) 3 Conchaes and 3 meatuses and 1 recess:

***The conchae**

It is a bulge of bone which is covered with mucosa, it functions to increase the surface area of the nasal cavity.

There are three conchaes on the lateral wall of the nasal cavity:

- Superior**, it originates from ethmoidal bone
- Middle**, it originates from ethmoidal bone
- Inferior**, separated from the upper two conchae, originates from is the maxilla



All Choncae extend medially across the nasal cavity, separating it into four air channels: 3 meatuses and one Sphenoethmoidal recess

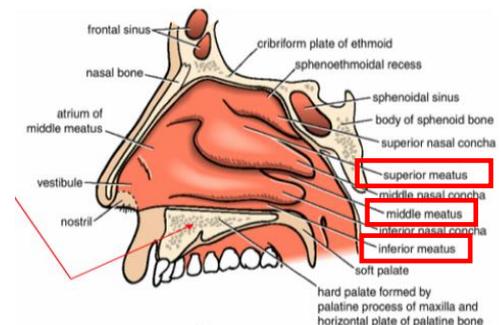
***The meatus**

Which is a groove that is located below a conchae"groove below the bulge"

the conchae is a shelf and below it a groove called meatus

There are three meatuses on the lateral wall of the nasal cavity, each meatus below a choncae:

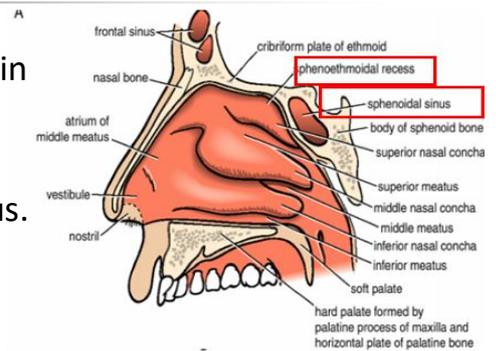
- Superior meatus**
- Middle meatus**
- Inferior meatus**



*The recess of the lateral wall of the nasal cavity

It is called sphenothmoidal recess, it's the recess in which sphenoid sinus open into the lateral wall of nasal cavity. And it drains the sphenoidal air sinus.

Drainage means allowing a passage pathway for the secretions of the sphenoidal air sinus if it got inflamed.



3) Antrum (atrium)

Located at the same level of middle meatus

-Drainage openings of paranasal sinuses and nasolacrimal duct into the lateral wall of nasal cavity:

- 1) The sphenoidal air sinus opens into sphenothmoidal recess
- 2) The nasolacrimal duct opens into the inferior meatus
- 3) The ethmoidal sinuses:

There are 3 ethmoidal sinuses on each side, meaning they are 6 in total, their drainage openings are:

*The posterior ethmoidal sinus opens in the superior meatus

*The anterior ethmoidal sinus opens in the middle meatus in the anterior part of hiatus semilunaris

* The middle ethmoidal sinus opens in the middle meatus in a bulge called bullae ethmoidalis which contains the sinus and the opening of the sinus.

4) The maxillary air sinus opens in the middle meatus into the inferoposterior part of hiatus semilunaris

5) The frontal air sinus opens into the middle meatus through the infundibulum and frontonasal duct

Note: Infundibulum is located anterior to hiatus semilunaris. So frontal drains in the infundibulum which is anterior to hiatus semilunaris. Anterior ethmoidal drains into the anterior part of hiatus semilunaris. "important"

All of the air sinuses have good drainage except the maxillary , a good drainage means even if there is an infection the secretion will flow down easily to the nose through drainage openings. Except for the maxillary sinus since the maxillary drainage opening is high up in the inferoposterior part of hiatus semilunaris.

| Superior meatus | Middle meatus | Inferior meatus | Sphenoethmoidal recess |
|---------------------------|--------------------------|-------------------|------------------------|
| posterior ethmoidal sinus | anterior ethmoidal sinus | nasolacrimal duct | sphenoidal air sinus |
| | middle ethmoidal sinus | | |
| | maxillary air sinus | | |
| | frontal air sinus | | |

-Bony support of the lateral wall:

- 1) Ethmoidal labyrinth and uncinated process
- 2) Perpendicular plate of the palatine bone
- 3) Medial plate of the pterygoid process
- 4) Medial surfaces of the lacrimal bones and maxillae
- 5) Inferior concha of maxilla

3-Floor:

- Made of the hard palate.
- The hard palate is composed of 2 parts:
 - 1-palatine process of maxilla
 - 2- horizontal plate of palatine bone

4-Roof:

1) Anterior part

Made of Nasal spine of the frontal bone and the nasal bones.

2) Middle part

Which contains the horizontal cribriform plate of ethmoid {cribriform means (غربالية) because of the fact that filaments of the olfactory nerve pass through it}

-Bipolar cell give rise to olfactory filaments which pass through the cribriform.

After their passage the filaments gather synapse in the olfactory bulb which is just located above cribriform, after their synapse olfactory nerves give rise to the olfactory tract.

The olfactory tract travels till it reaches the center of smell and you get the smell sensation.

3) Posterior part

1-Anterior surface of the sphenoid bone (body) and sphenoidal sinus

2-Ala of the vomer

3-Vaginal process of the palatine bone

3-Nasal cavity functions :

1. Respiratory

2. Olfactory

3. Resonance of voice

The part of the nasal cavity responsible for this function is the paranasal sinuses.

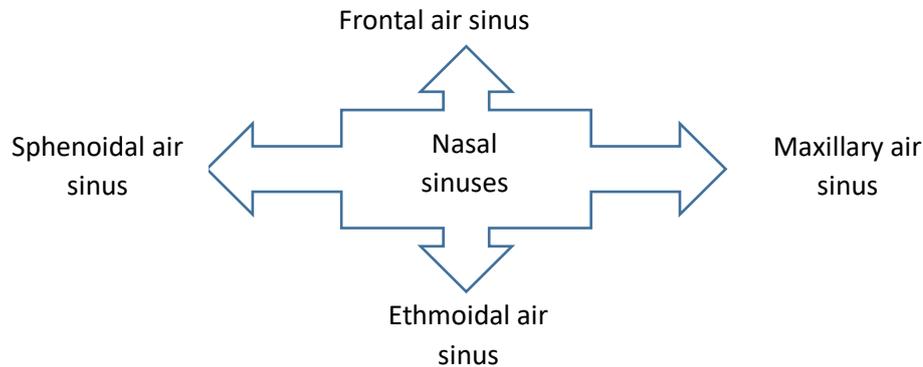
Paranasal sinuses:

-Paranasal sinuses are spaces inside some of the skull bones.

Note that not all skull bones have air sinuses

- They are the frontal, ethmoidal, maxillary, and sphenoid air sinuses

-*you can remember them as My (maxillary) Extremely (ethmoidal) Sweet (sphenoid) Friend (frontal)



- It is a cavity covered by thin mucosa and contains air, air that is found inside the sinus give the tone of the voice. That's why when a person has sinusitis (inflammation of air sinuses) you notice that his voice will change.

-Sinus's duct open in the lateral wall of the nose, that's why you may find a green-yellow secretion in your nasal cavity as a result of sinusitis, normally the secretions are watery.

4. Drains lacrimal fluid

The nasolacrimal duct starts from the lacrimal sac which is located at the medial side of the eye and filled with tears.

This nasolacrimal duct opens into the inferior meatus of the lateral wall of the nasal cavity, so when someone cries some of his tears go down on his cheek and most of the tears move into the nasal cavity through the nasolacrimal duct which opens into the inferior meatus.

Clinical Correlation-3

Some children are born with blockes nasolacrimal duct, either at the beginning, middle or end.

As a result, all of their tears are flushed on the cheeks.

A surgery is needed to open the blocked duct.

5. Protective :Sneezing/Filtration/Proteolytic enzymes/Warming and moistening the air

Mucous membrane

The respiratory mucous membrane is lined with pseudostratified ciliated columnar epithelium with goblet cells, except for 2 nasal structures:

1-The vestibule, which is lined with stratified squamous keratinized epithelium with hair follicles” vibrissa”.

2-The roof just above the superior conchae, which is lined with olfactory mucosa, olfactory mucosa is a mucosa lined pseudostratified ciliated columnar epithelium but what makes it different is that it contains olfactory nerve endings.

-Note that the mucous membrane is very thick around the conchae, that is the reason behind the feeling of nose obstruction in the case of rhinitis (inflammation in the mucosa of the nose), as the mucosa gets extremely thick.

Functions of the mucus membrane:

1-Heating and moisturizing air, this occurs due to the large number of veins plexuses in the submucosa.

2- Mucous traps foreign particles and organisms in the inspired air

Blood supply and nerve supply of the nasal cavity

When discussing the blood or nerve supply of the nose, we divide it into two major categories: Vessels and nerves that supply the septum and vessels and nerves that supply the lateral wall.

The lateral wall can be divided into 4 quadrants: Superior anterior, superior posterior, inferior anterior, and inferior posterior

1- Ophthalmic artery

Branches: Anterior ethmoidal artery and Posterior ethmoidal artery

Course: both originate from the ophthalmic in orbit, then:

1-anterior ethmoidal, accompanies the anterior ethmoidal nerve and descends through a slit-like foramen lateral to the crista galli.

2-posterior ethmoidal, descends into the nasal cavity through the cribriform plate

Blood supply:

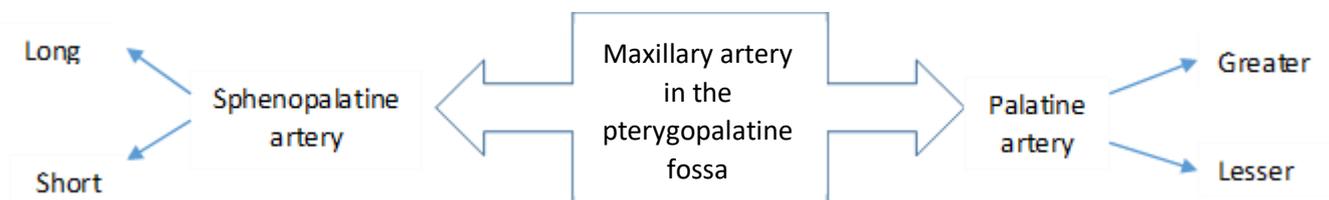
1-Anterior ethmoidal: medial (septal) and lateral wall of the nasal cavity (anterior- superior quadrant).

2-Posterior ethmoidal: gives branches to medial and lateral walls

1- Maxillary artery

Branches: 1-Sphenopalatine artery is one of maxillary artery branches which then gives Short sphenopalatine artery and long sphenopalatine artery

2-Palatine artery that divides later into Greater palatine artery and Lesser palatine are also branches of the maxillary artery



Course:

1- Sphenopalatine artery originates from maxillary artery in the pterygopalatine fossa, enters the nasal cavity by passing medially through the sphenopalatine foramen. After it passes through the foramen it gives long and short sphenopalatine branches. then:

* Short sphenopalatine artery

The short branch (Posterior lateral nasal branch) goes to the lateral side of the nose to supply it.

*Long sphenopalatine artery”

The long(Posterior septal nasal branch) passes over the roof of the cavity and onto the nasal septum to contribute to medial wall “septum” blood supply.

2- Greater palatine artery arises in the pterygopalatine fossa as a branch of the maxillary artery then enters the nasal cavity by passing up through the incisive canal of the hard palate

Note: lesser palatine is also a branch of the palatine artery, the latter is a branch of the maxillary. Lesser palatine goes through the lesser palatine foramina, and supply the soft palate .

Note:

Superior alveolar arteries are:

1-Post-superior alveolar artery branches from the maxillary.

2-Middle- superior alveolar artery.

*3-Ant- superior alveolar artery branches from the infraorbital, the latter is a branch from the maxillary, **the Ant- superior alveolar artery contributes to the blood supply of the nasal cavity.***

Blood supply:

1- *Short sphenopalatine artery supplies supply a large part of the lateral wall (post.superior quadrant)

*Long sphenopalatine artery supplies the medial wall”the most important branch going to the septum”

2-Great palatine artery Supplies the anterior regions of the medial wall and adjacent floor (posterior and antero-inferior quadrant)

3-Fascial artery

Branches: Superior labial ,lateral nasal.

Course: Fascial artery’s branches firstly move anterior to the nasal cavity until they reach the lateral wall and medial wall.

Blood supply:

1-Superior labial gives an alar branch supplies the region around the naris, and a septal branch that supplies anterior regions of the nasal septum.

2- Lateral nasal arteries supply blood of the external nose and give Alar branches that pass around the lateral margin of the naris and supply the nasal vestibule.

Epistaxis

- It is a bleeding from the nose
- Occurs after a hit on the nose, especially in children
- Cause:

Rupture of some of the the blood anastomoses in the anterior surface of nasal septum, especially in Kiesselbach's area which is an area that contains arterial anastomosis.

- Control of bleeding:

After very uncontrolled severe bleeding, we do cauterization of long sphenopalatine artery (nasopalatine which is a branch of the maxillary) and superior labial artery (which is a branch of the facial) since the most ruptured anastomosis in epistaxis is the anastomose of these 2 arteries.

**refer to slide 33 for summary of the blood supply

Venous drainage of the nasal cavity

-Considering the venous drainage, the nasal cavity is divided into anterior 1/3 and posterior 2/3.

- The anterior 1/3 drain into the facial vein
- The posterior 2/3 drain into lateral pterygoid plexus (lateral pterygoid plexus is located around the lateral pterygoid muscle) → the lateral pterygoid plexus drains into the maxillary → the maxillary joins the superficial temporal in the parotid gland to form retromandibular vein

Lymphatic drainage of the nasal cavity

- Anterior part drain into the submandibular lymph nodes

-Upper and posterior parts drain into → retropharyngeal lymph nodes which then → drain into upper deep cervical lymph nodes (which are located around the internal jugular vein).

Innervation of the nasal cavity

-3 types of innervation are found:

1)The olfactory nerve which is responsible for special smell sensation/olfaction; composed of axons from receptors in the olfactory epithelium at the top of each nasal cavity, pass superiorly through the cribriform plate to synapse within the olfactory bulb, then they form olfactory tract that travels holding smell signals to smell center in the temporal lobe

2) Branches of the ophthalmic and maxillary nerves supply general sensation to the nose(sensory).

*Branches of ophthalmic nerve:

they branch from the nasocilliary nerve from inside the eye, the latter is a branch of the ophthalmic

-Anterior ethmoidal nerve: It travels with anterior ethmoidal artery, gives sensory nerve branches for medial and lateral walls then continues forward on the undersurface of the nasal bone

-Posterior ethmoidal nerve: supplies the mucosa of the ethmoidal cells and sphenoidal sinus, then it ends in the ethmoidal and sphenoidal air sinuses

* maxillary nerve has branches that supply the lateral wall and the septum and their names correspond to the names of the arteries

3)Parasympathetic (secretomotor) comes through the facial nerve so the facial gives the secretomotor innervation for the mucous gland of the nose

Past papers

1)pseudostratified ciliated columnar epithelium lining all of the following except:

A-infraepiglottis

B-vestibular fold

c- Conducting bronchiole

d- Superior part of nasal cavity (or olfactory part)

e- Nasopharynx

2) All of the following nerves supply the lateral wall of the nasal cavity except:

a- anterior ethmoidal nerve

b- Posterior ethmoidal nerve

c- Anterior palatine nerve

d- Posterior superior lateral nasal nerve

e- Anterior superior alveolar

3) Epistaxis in the Killip's area most common artery?