Sinonasal Physiology & Function

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ENT R2
Physiology of Paranasal sinuses

- **Functions of Paranasal Sinuses:**
  1. Air-conditioning and humidification.
  2. Increase surface area for olfaction.
  3. Provide resonance to voice.
  4. Thermal insulators.
  5. Lighten the skull bones.
  6. Trauma protection.
  7. Contribute to facial growth.
Physiology of Nose

- **Functions of the nose:**
  1. Respiration.
  2. Air conditioning.
  3. Protection of lower airway.
  5. Olfaction.
Respiration

- Nose is the natural pathway for breathing.
- Mouth breathing is an acquired act through learning.
- The nose permits breathing and eating to go on simultaneously.

- During quiet Inspiration:
  - Inspiratory air current passes through middle part of nose between the turbinates and nasal septum.
  - Very little air passes through inferior meatus or olfactory region of nose, weak odorous substances have to be sniffed before they can reach the olfactory area.
During expiration:
Air current follows the same course as during inspiration, but the entire air current is not expelled directly through the nares.
Friction offered at limen nasi converts it into eddies under cover of inferior and middle turbinates and this ventilates the sinuses through the ostia.
Respiration

- **Ventilation of Sinuses:**
- Takes place through their ostia.
- During inspiration, air current causes negative pressure in the nose.
- During expiration, positive pressure is created in the nose and this sets up eddies which ventilate the sinuses.
Respiration

- Ventilation of sinuses is paradoxical; they are emptied of air during inspiration and filled with air during expiration.
- Reverse of what takes place in lungs which fill during inspiration and empty during expiration.
**Respiration**

- PO2 is lower in sinuses than in the nose and lowest in frontal sinuses.

- If ostium blocked -> oxygen tension drops further -> ciliary motion impaired -> stasis of secretions.
**Respiration**

- **Nasal cycle:**
- 80% of population
- Nasal airflow is regulated by the volume of the venous sinusoids in the nasal erectile tissue located mainly in the inferior turbinate.
- Nasal mucosa undergoes rhythmic cyclical congestion and decongestion.
- When one nasal chamber is working, total nasal respiration, equal to that of both nasal chambers, is carried out by it.
- Nasal cycle varies every $2\frac{1}{2}-4$ hours and
- Total nasal resistance remains **constant** throughout the cycle.
Respiration

- **Regulation of Nasal microvasculature:**
- **Sympathetic:**
  - Provides vasoconstrictor tone to arteries and capacitance veins.
  - Norepinephrine (Mainly)

- **Parasympathetic:**
  - Controls secretions and provides vasodilatation.
  - Acetylcholine (Mainly).
Respiration

- **Airflow Resistance:**
  - Nose accounts for 50% of total airway resistance.

- 3 area of airway resistance within nose:
  1. **Nasal vestibule:**
     - Provide 1/3 of resistance.
     - Susceptible to collapse from the negative pressure created during inspiration.
     - Facial muscles attached to the nasal vestibule contract during inspiration to prevent collapse.
2. Internal nasal valve:
- Narrowest part with cross-sectional area of 0.73 cm²
- Highest resistance.
- Susceptible to congestion from septal and inferior turbinate venous sinusoids.

3. Turbinated Nasal cavity:
- Minimal resistance compared to others
Respiration

- **Nasal airflow controlling factors:**
- Autonomic regulation.
- Nasal cycle.
- Exercise (epinephrine release causes decongestion)
- Nitric oxide
- Head and body position (altered venous pressure)
- Sex hormones (pregnancy, puberty, and menstruation lead to increased nasal obstruction)
Respiration

- **Rhinomanometry**
- Measure nasal resistance (pressure and airflow).
- **Normal** value of nasal resistance in adults has been reported (0.25 Pa/cm³/s).
- For a patient to be **symptomatic**, total nasal resistance should be > 0.3 Pa/cm³/s.
**Anterior Rhinomanometry:**

Measures Nasopharyngeal pressure and flow through **Transnasal probe** into Nasopharynx from one nostril at a time while closing other nostril.

Limitations: septal perforations, incomplete occlusion, floppy septum and the nasal cycle, *it is very non-physiologic to do one side at a time.*
**Posterior Rhinomanometry:**
- Measures Nasopharyngeal pressure and flow with a pressure detector placed Transorally to the nasopharynx with bilateral nasal flow.
- To differentiate between mucosal hypertrophy and structural defects causing nasal obstruction, nose should be decongested; if $<35\%$ improvement in resistance on rhinometry, it’s likely structural defect.
Acoustic rhinometry

Indirectly measure nasal cross-sectional area.

Acoustic pulses enter nasal passage through a nose piece, impact nasal structures, and are reflected back to a microphone.
Air-conditioning of Inspired Air

- Nose is the air-conditioner for lungs.
- Filters and purifies the inspired air and adjusts its temperature and humidity.

**Temperature control**
- Regulated by large surface of nasal mucosa.
- Middle and inferior turbinates and adjacent parts of the septum is highly vascular with cavernous venous spaces or sinusoids which control the blood flow, and size of turbinates.
- This also makes an efficient "radiator" mechanism to warm up the cold inspired air to near body temperature (37°C).
Air-conditioning of Inspired Air

- **Humidification**
- Nasal mucous membrane adjusts the relative humidity of the inspired air to 85% or more.
- Water is provided by the nasal mucous membrane which is rich in mucous and serous secreting glands.
- About 1000 ml of water is evaporated from the surface of nasal mucosa in 24 hours.
Protection of Lower Airway

1- Filtration and purification:
- Nasal vibrissae filters particles up to 3 μm.
- Nasal mucus traps particles as fine as 0.5 μm.
- Particles smaller than 0.5 μm pass through the nose into lower airways without difficulty.

2- Mucociliary mechanism:
- Nasal mucosa is rich in goblet cells and seromucinous glands.
- Mucous blanket is a continuous sheet spread over the normal mucosa.
Protection of Lower Airway

- **Mucous blanket consists of:**
  1. Superficial mucus layer.
  2. Deep serous layer
  3. Cilia.

- The outer mucus layer which is secreted by the goblet cells floats on the inner layer and is propelled by the tips of the beating cilia.
- The inner serous layer is secreted by the subepithelial seromucinous glands.
Protection of Lower Airway

- Cilia are constantly beating within serous layer and moving the mucous blanket in only one direction towards the nasopharynx to be swallowed.
- Moves at a speed of 1 cm/min.
- Complete sheet of mucus is cleared into the nasopharynx every 10-20 minutes.
Protection of Lower Airway

- Sinuses mucociliary clearance:
- Mucus travels to the ostium in a spiral manner.
- Cilia are more marked near the ostia to help in drainage.
- Cilia propel mucus into the meatuses then nasopharynx.
- Sinuses essentially sterile as bacteria are promptly taken out.
Protection of Lower Airway

- Mucociliary clearance of maxillary and sphenoid sinuses is towards the natural ostium.
- Mucociliary clearance of frontal and ethmoid sinuses is downwards and aided by gravity.
- Mucus in the frontal sinus drains toward the ostium only from the lateral side, mucus medial to the ostium must course superiorly to join the lateral flow toward the ostium.
Nitric Oxide (NO) is produced in sinuses and functions as:

1. Vasodilator leading to increased congestion
2. Increased mucociliary clearance and motility
4. Contributes to plasma protein extravasation during allergic reaction
5. Immune modulation
6. Bronchodilator
Protection of Lower Airway

- **Factor affecting ciliary movements:**
  - Drying
  - Drugs (Adrenaline)
  - Excessive heat or cold (Temp < 18°C)
  - Alternation in the neutral PH of nasal secretions.
  - Ciliary structural abnormality (Dynein arm defect)
  - Smoking
  - Infections
  - Noxious fumes like sulphur dioxide and carbon dioxide.
The physiology of normal sinuses is maintained by:

1. Normal sinus secretion.
2. Properly functioning cilia.
Protection of Lower Airway

- **Saccharin test:**
  - Measures mucociliary transit time.
  - Saccharin pellet is placed in anterior nasal cavity, dissolves, transported to Nasopharynx and Oropharynx where the sweet taste is detected.
  - Normal transit time is $< 20$ mins
Protection of Lower Airway

3- Enzymes and immunomodulators
- Nasal secretions contain Lysozyme, glycoproteins, IgA, IgE, lactoferrin and interferon which provide immunity against upper respiratory tract infections.

- Major composition of nasal mucus:
  - 95% Water.
  - 3% Glycoprotein
  - 2% Salts
  - IgA, Lysozyme, Lactoferrin
Protection of Lower Airway

4- Sneezing

- Protective reflex induced by allergens, ammonia, viral infections, exercise and other irritants which stimulate Trigeminal afferents.

- Complex efferent input result in:
  - Slow inspiratory phase.
  - Glottic and velopharyngeal closure
  - Increase subglottic pressure
  - Sudden glottic opening result in sneezing
Vocal Resonance

- Nose forms a resonating chamber for certain consonants in speech.
- In phonating nasal consonants (M/N/NG), sound passes through the nasopharyngeal isthmus and is emitted through the nose.
- When nose (or nasopharynx) is blocked, speech becomes denasal, i.e. M/N/NG are uttered as B/D/G respectively.
Olfaction

- Less developed in human.
- Recognition and learning come after age of 2 years.
- Required turbulent airflow from the anterior nares or the choanae.
- Pungent odors (vinegar, ammonia) are never used to test the sense of smell as they stimulate fibers of the Trigeminal nerve and cause irritation in the nose rather than stimulate the olfactory receptors.
- **Olfactory epithelium:**
  - Pseudostratified columnar epithelium in roof of the nose (cribiform plate; upper septum; superior and part of middle turbinate)
Olfaction

- Odorants have to be water soluble, or bound to odorant binding protein before binding to the receptors.
- The threshold of perception is lower than identification, a smell is sensed before it is recognized.
- Olfactory responses show marked adaptation and thresholds increase with exposure.
Olfaction

- **Intranasal Chemosensory Systems:**
  - Olfactory nerve (CN-I):
    - Major role.
    - Mediates smell and flavor.
  - Trigeminal nerve (CN-V):
    - Found throughout nasal mucosa.
    - Mediate somato-sensory sensation (burn, irritation, cooling, tickling)
    - Induces reflexive responses (mucous secretion, halting inhalation to prevent injury)
    - Noxious stimuli
Olfaction

- **Nervus Terminalis (CN-o):**
  - Unclear role in humans.
  - Loose plexus of nerve fibres present in all mammals.
  - Distinguished by the presence of ganglia.
  - Related to reproduction and pheromone detection
**Olfaction**

- **Olfactory Disorders**
- Impair quality of life, pose safety risks and interfere with one's profession.
- **Anosmia**: No sense of smell.
  - Ex: Trauma, congenital.
- **Hyposmia (Microsmia)**: Decreased sense of smell.
  - Ex: Smokers, postmenopausal, elderly.
- **Hyperosmia**: Heightened sense of smell (sensitive to odors).
  - Ex: Hunger, cystic fibrosis, addison's disease.
Olfaction

- **Presbyosmia**: Age related smell loss.
- **Dysosmia**: Distorted smell perception.
  - Ex: During degeneration and recovery.
- **Parosmia/cacosmia**: Change in quality of olfactory cue.
  - Ex: Intracranial tumors should be excluded.
- **Phantosmia**: Perception of odors that are not present.
  - Ex: Olfactory hallucinations.
Any Questions ?!

Thanks!
References