Anatomy and Physiology of the Nose and Paranasal Sinuses

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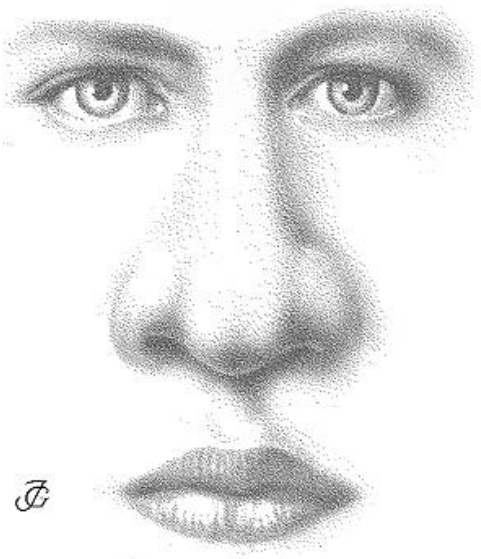
UNIVERSITÉ DE GENÈVE
FACULTÉ DE MÉDECINE

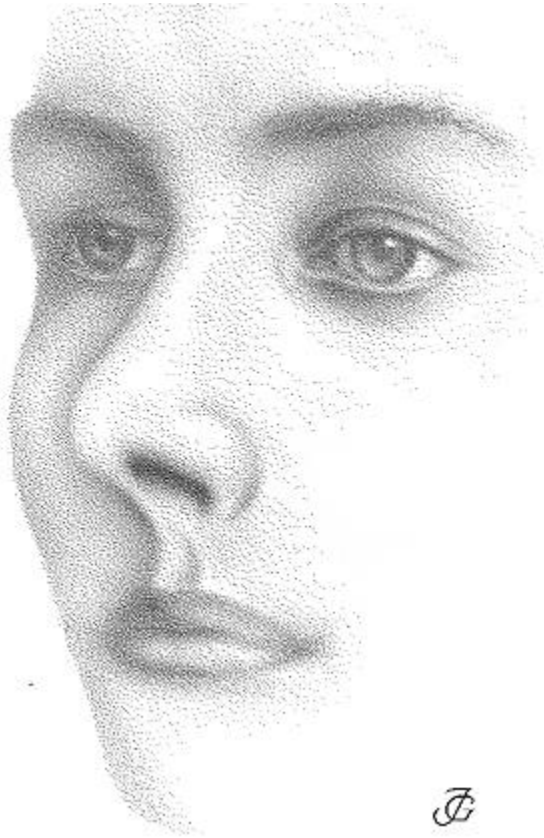
HUG Hôpitaux Universitaires Genève

Anatomy

External Nose



Large Nose



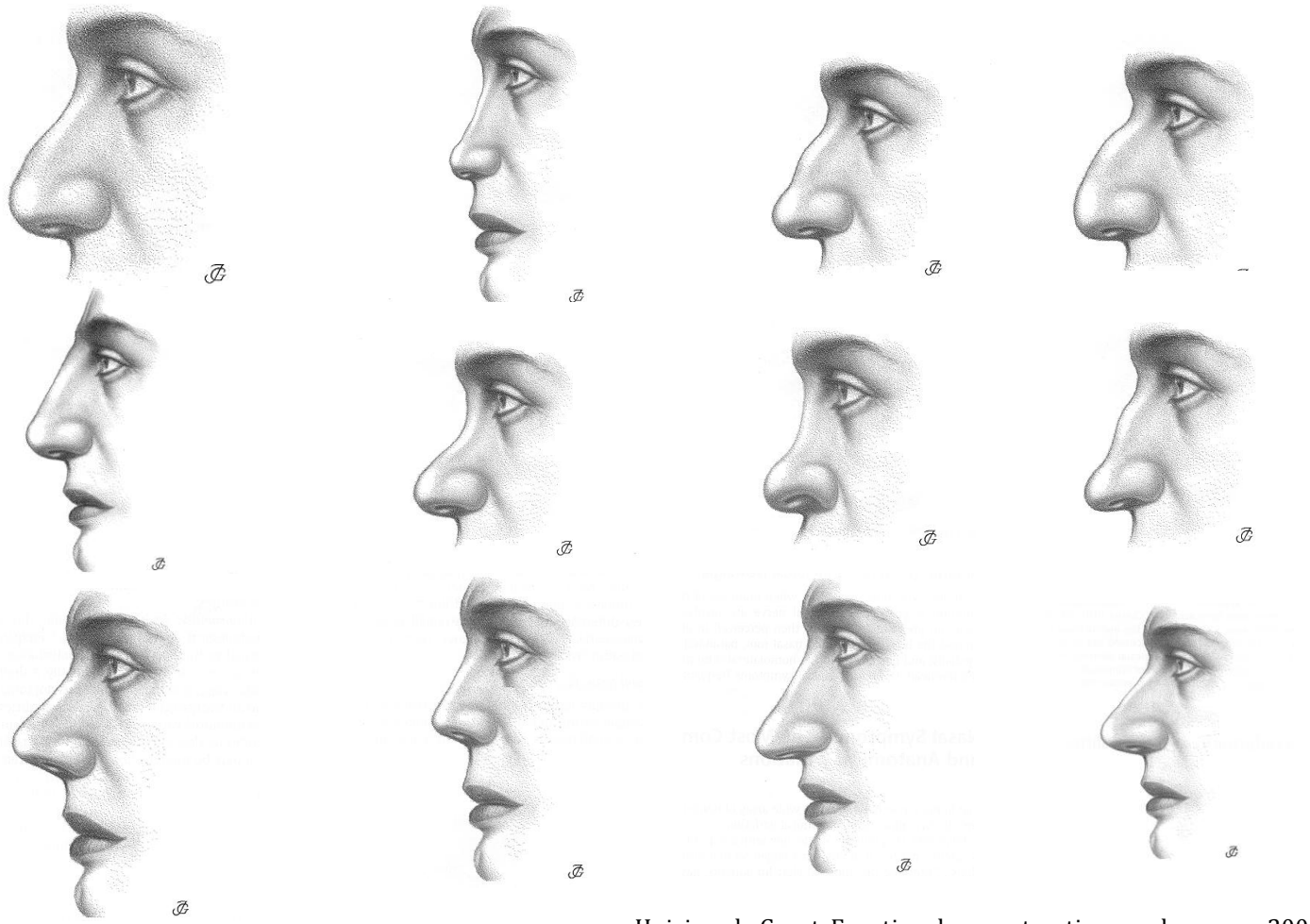
Thin Nose

Huizing, de Groot, Functional reconstructive nasal surgery, 2003, Georg Thieme Verlag

Anatomy

External Nose

Numerous anatomical variations!

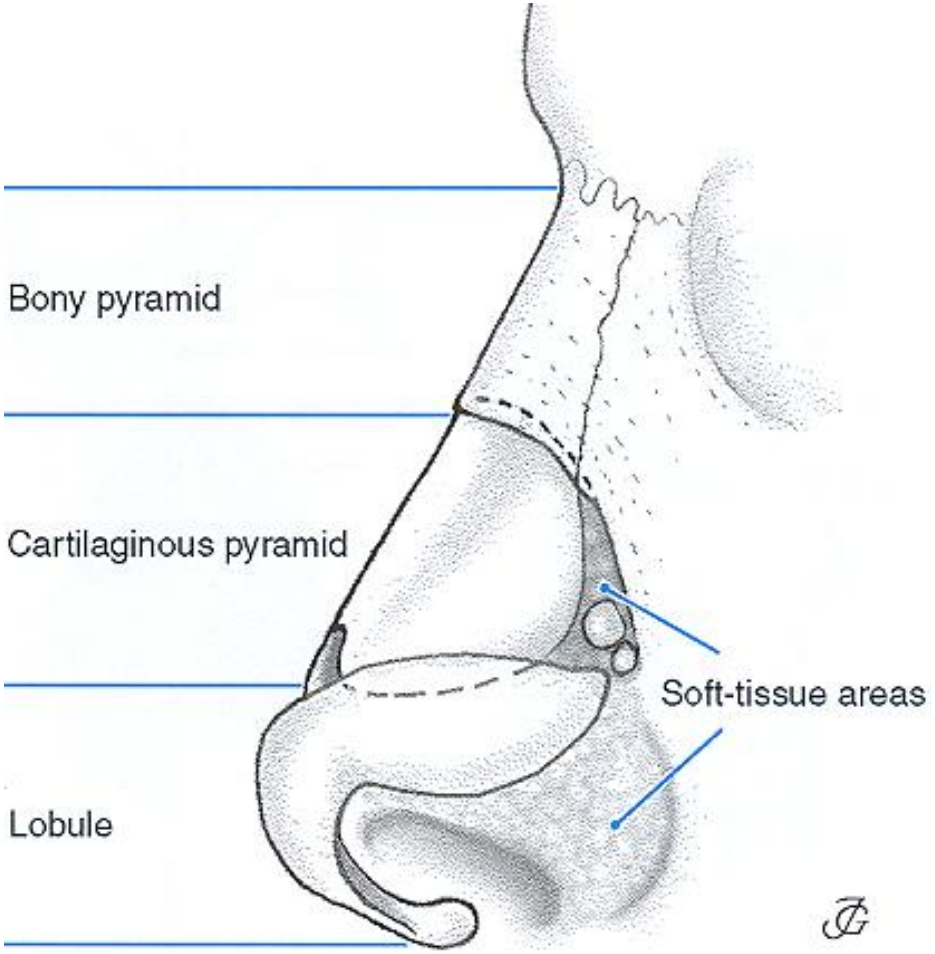


Huizing, de Groot, Functional reconstructive nasal surgery, 2003, Georg Thieme Verlag

Anatomy

External Nose

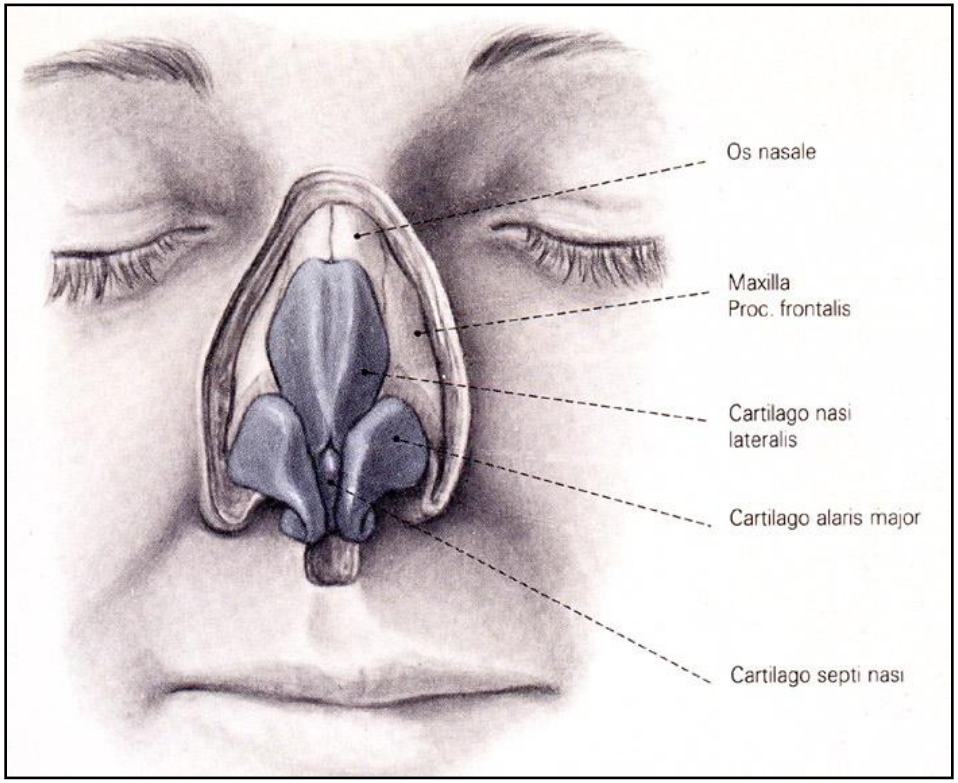
3 Parts:

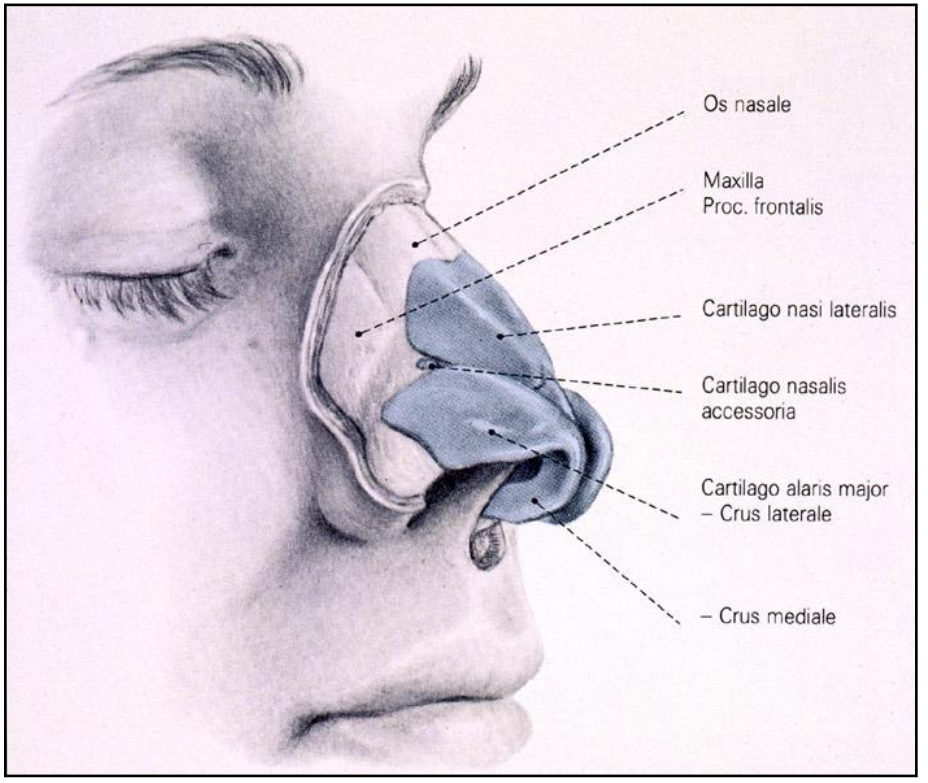


Huizing, de Groot, Functional reconstructive nasal surgery, 2003, Georg Thieme Verlag

Anatomy

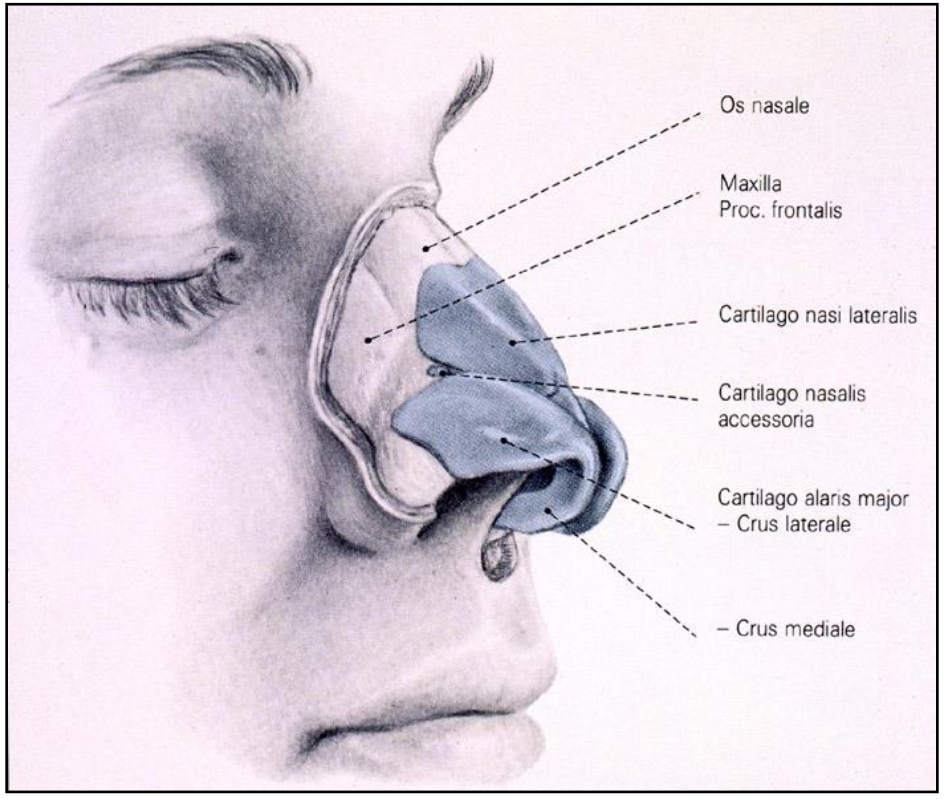
External Nose

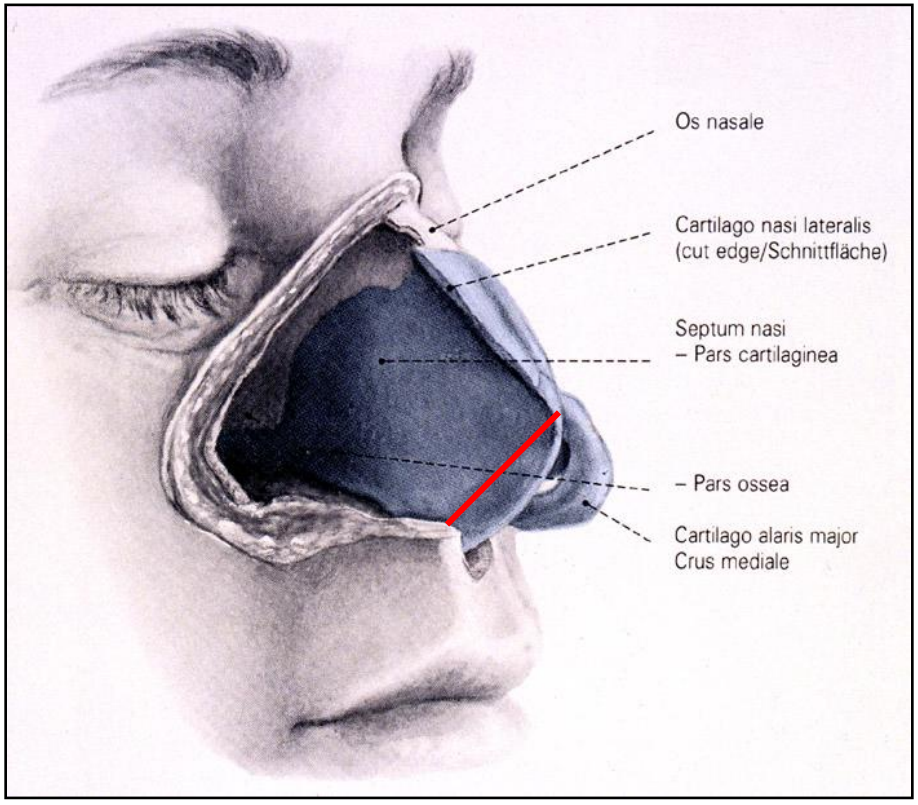




Anatomy

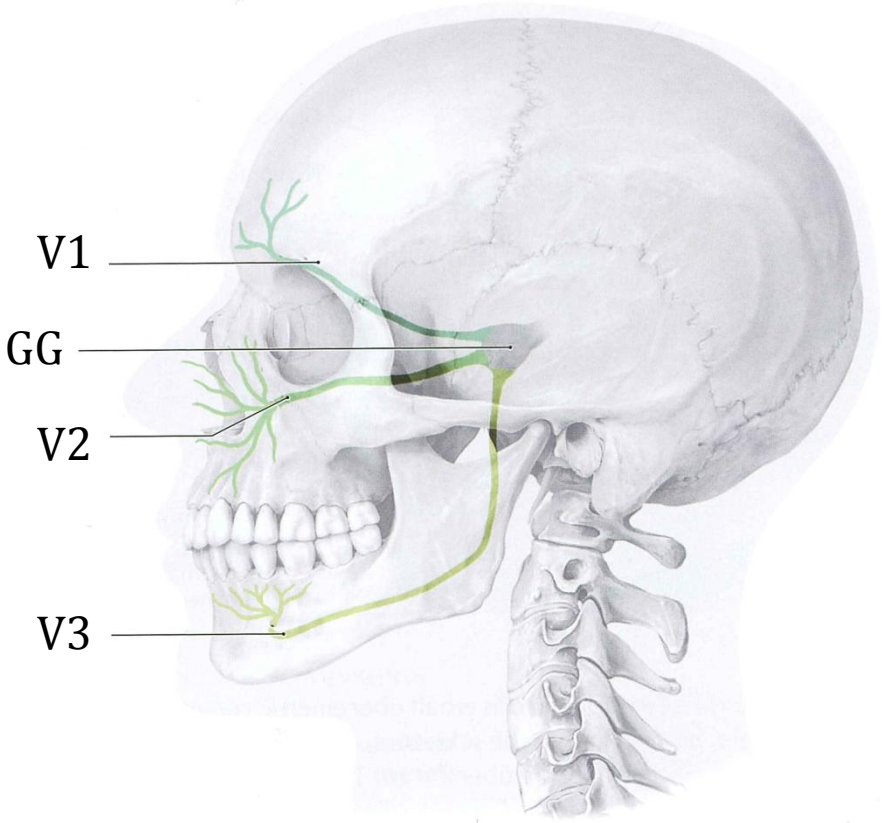
External Nose

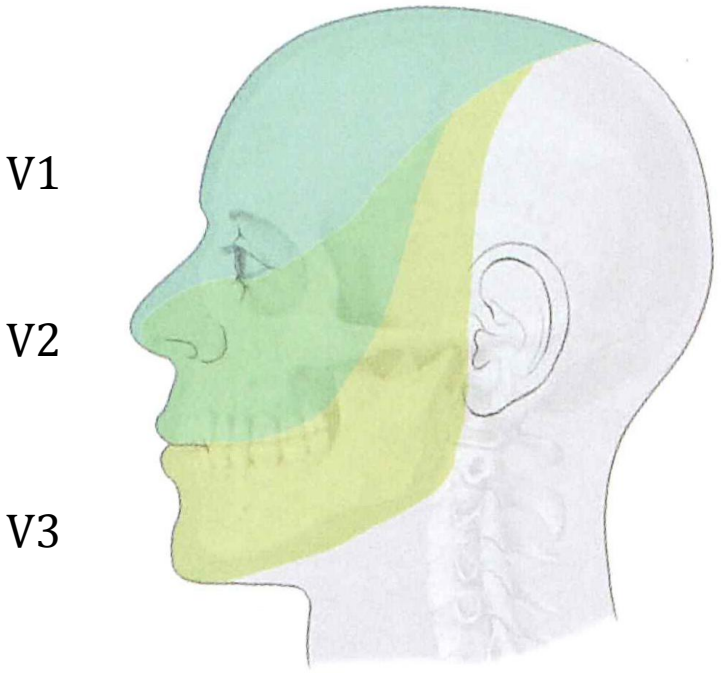




Anatomy

External Nose **Innervation**

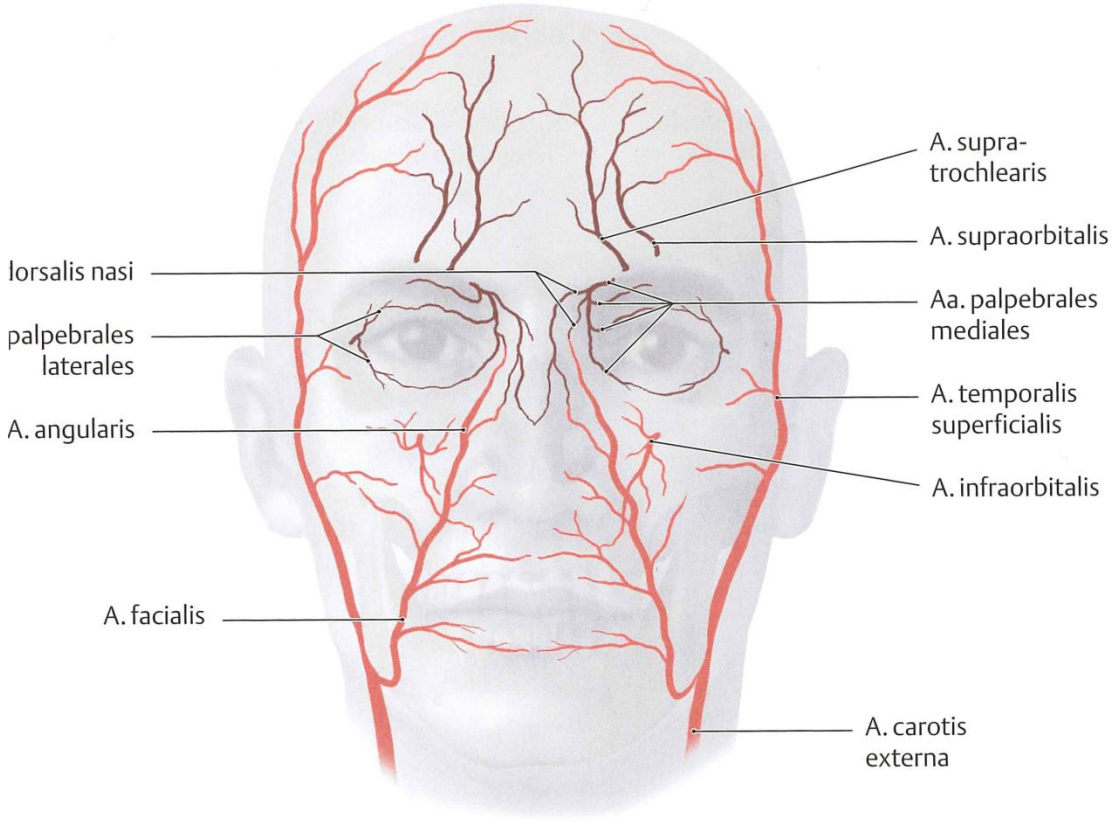




Trigeminal nerve

Anatomy

External Nose **Blood Supply**



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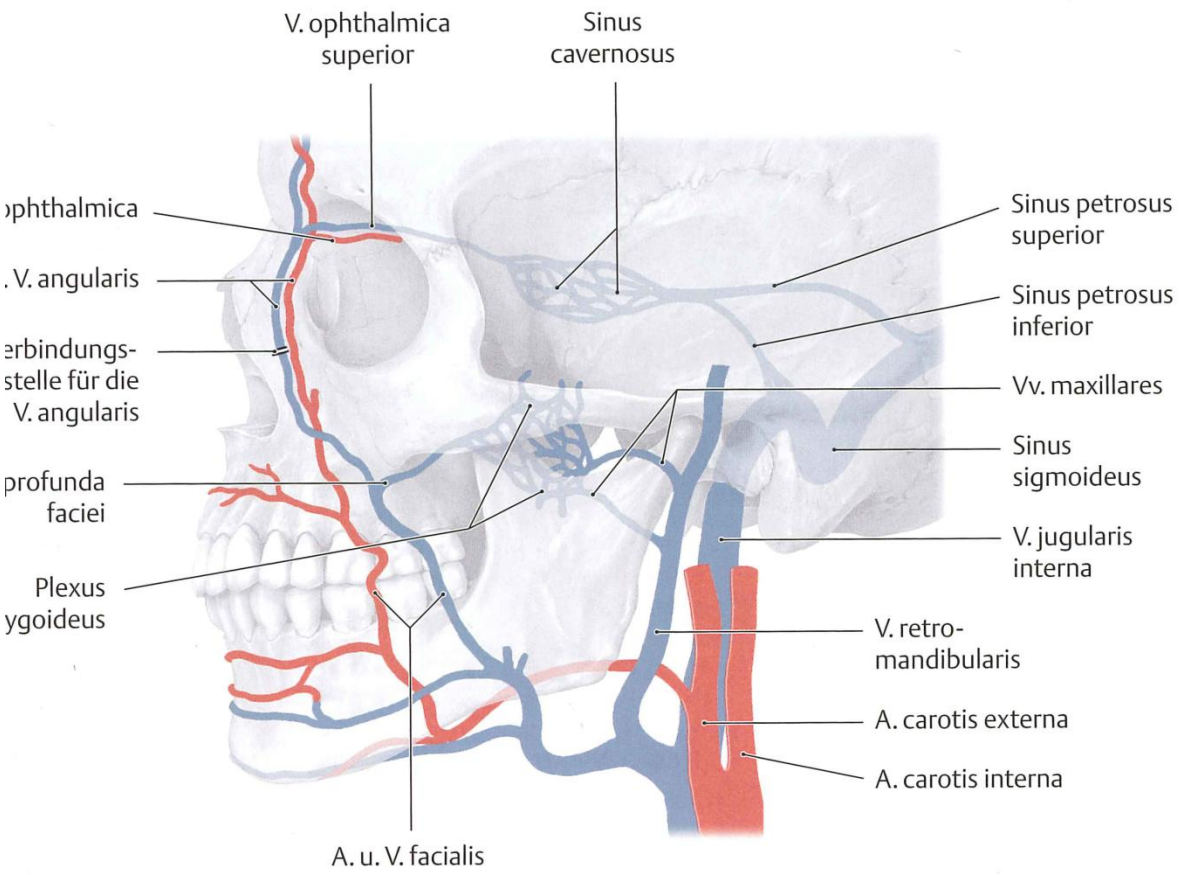
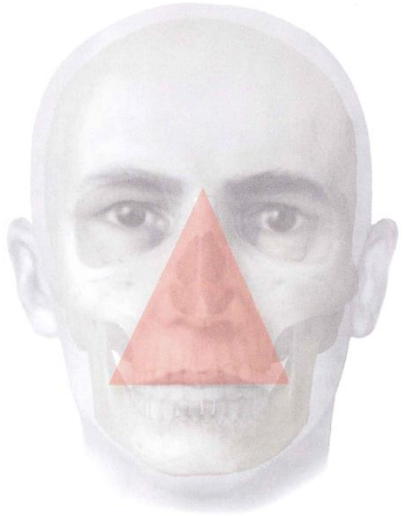
Anatomy

Blood Supply – Anastomoses !

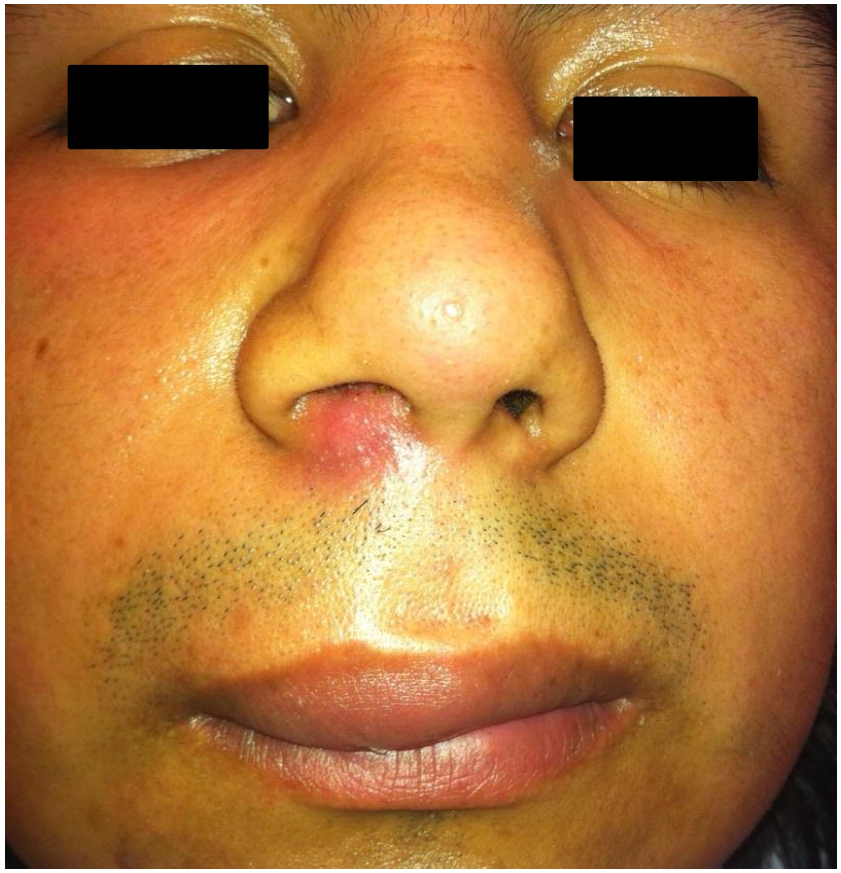




C Warndreieck des Gesichts
Im Bereich des sog. „Warndreiecks" bestehen venöse Verbindungen vom Gesicht zu den venösen Sinus durae matris. Da die Venen in diesem Bereich keine Klappen besitzen, ist die Gefahr einer Keimverschleppung nach innen besonders groß (Furunkel kann zu Meningitis führen! – s. S. 65).

Prometheus, Springer Verlag

Furuncle of the nose



Cause:

- Skin infection of the nasal vestibule / tip of the nose. Usually due to hair follicle

Symptoms:

- Swelling, Pain, Redness

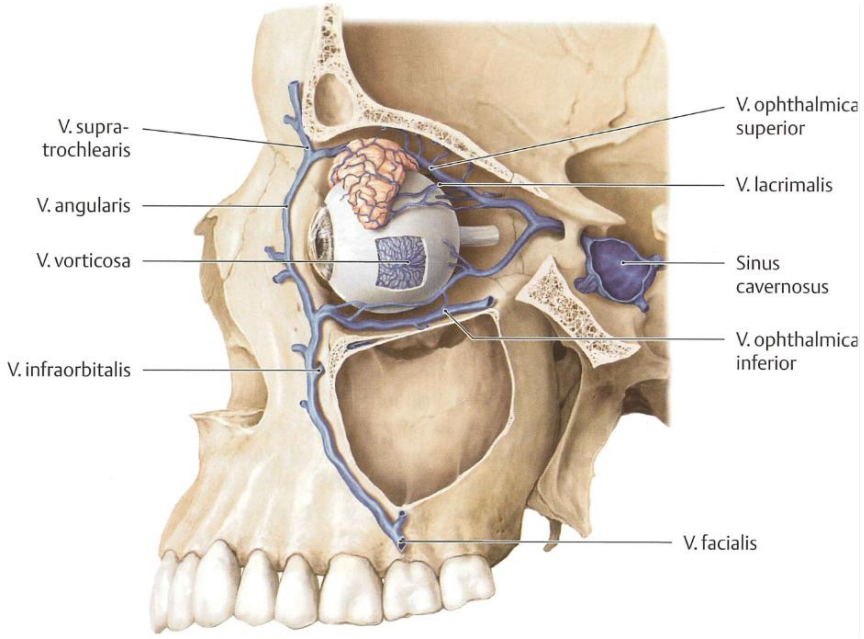
Danger:

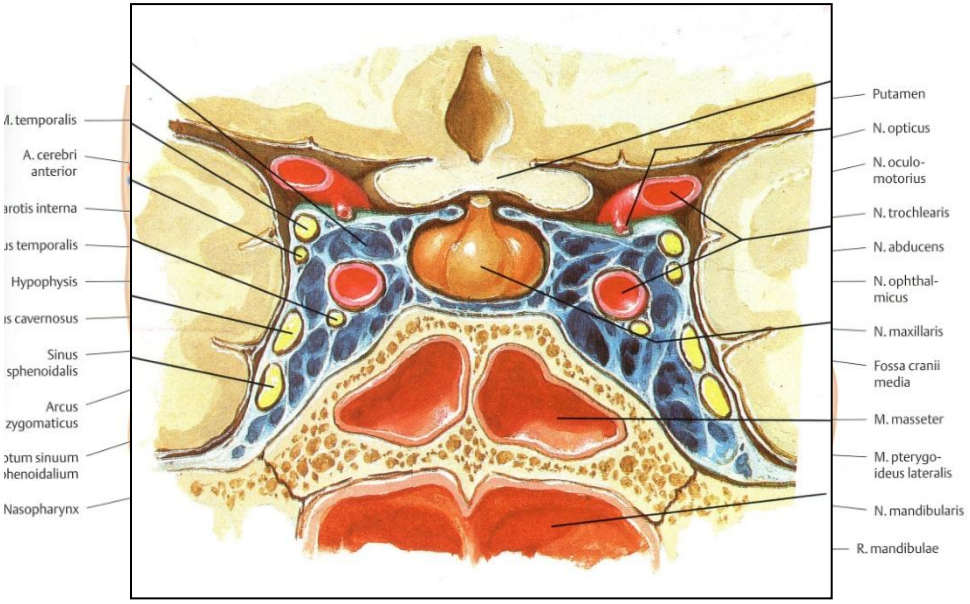
- Septic emboli via the angular vein / cavernous sinus drainage. Risk of cavernous sinus thrombosis

Treatement:

- Antibiotics i.v.; Rest; Incision-Drainage

Cavernous sinus thrombosis





Cause:

- Infection of region drained by the venous system reaching the cavernous sinus.
- Propagation of an infection by contiguity (sphenoid sinus)

Symptoms:

- Fever, Headache, Neurological deficits

Diagnostics:

- MRI

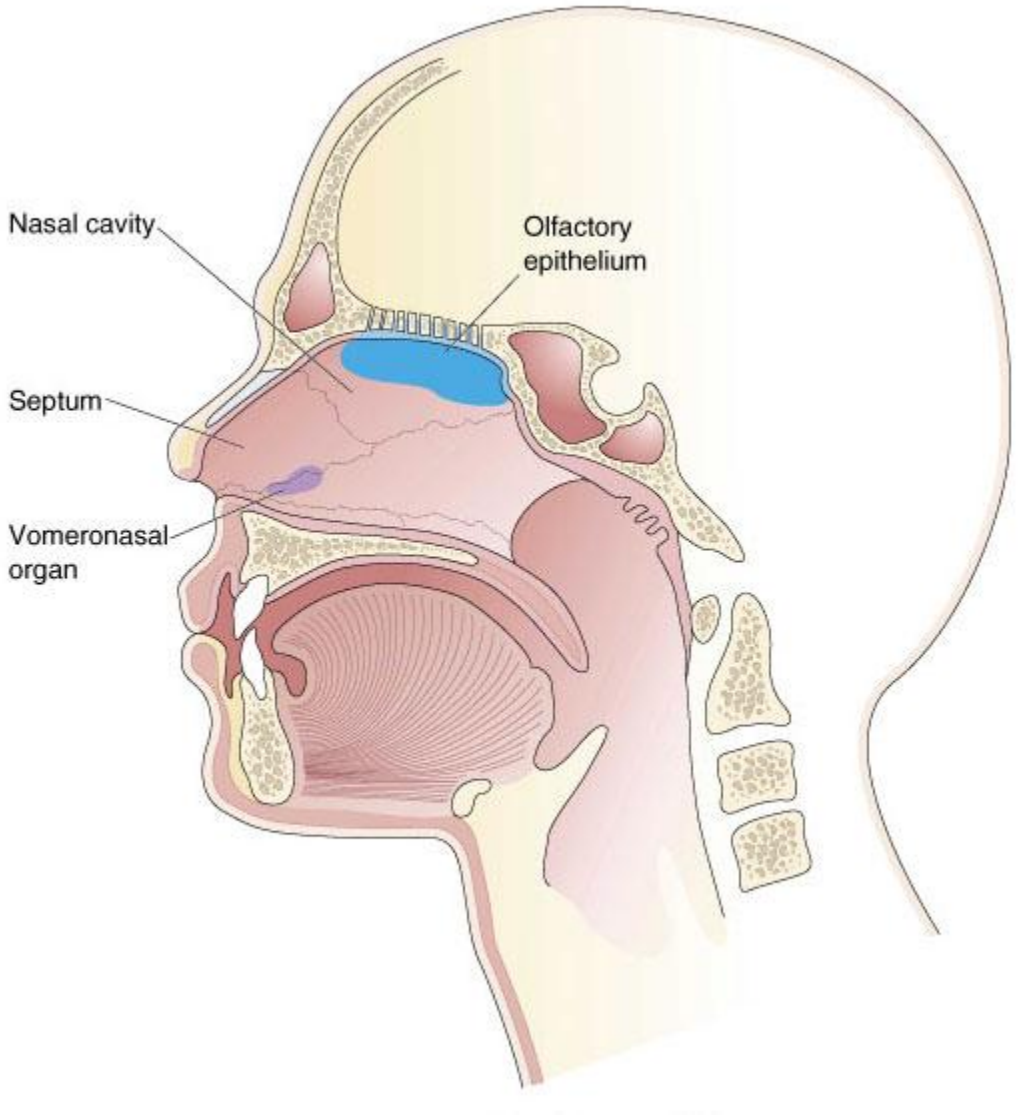
Treatement:

- Surgery of the infectious focus
- AB i.v.
- Steroids (controversy)
- Anticoagulation

VERY HIGH morbidity and mortality !!!

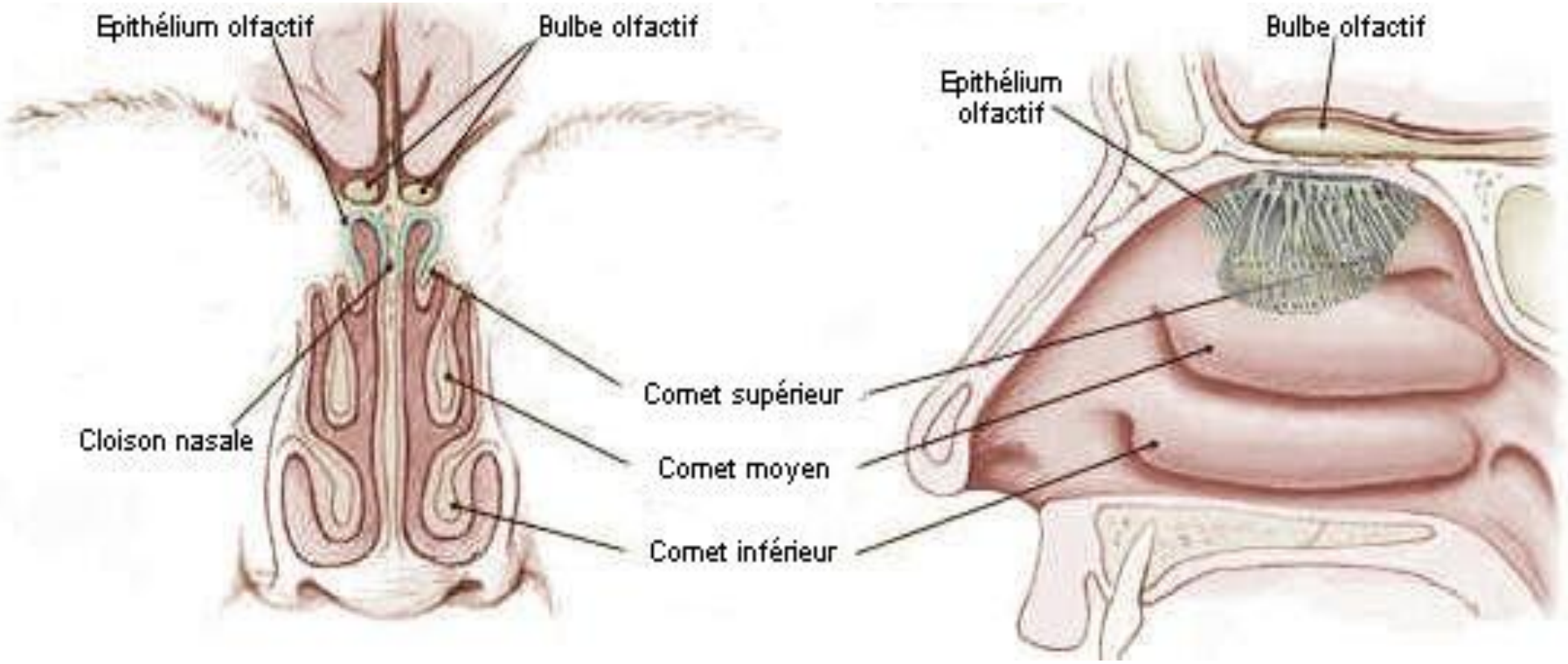
Anatomy

Internal Nose



Anatomy

Internal Nose **<u>Nasal cavity</u>:** septum and lateral walls

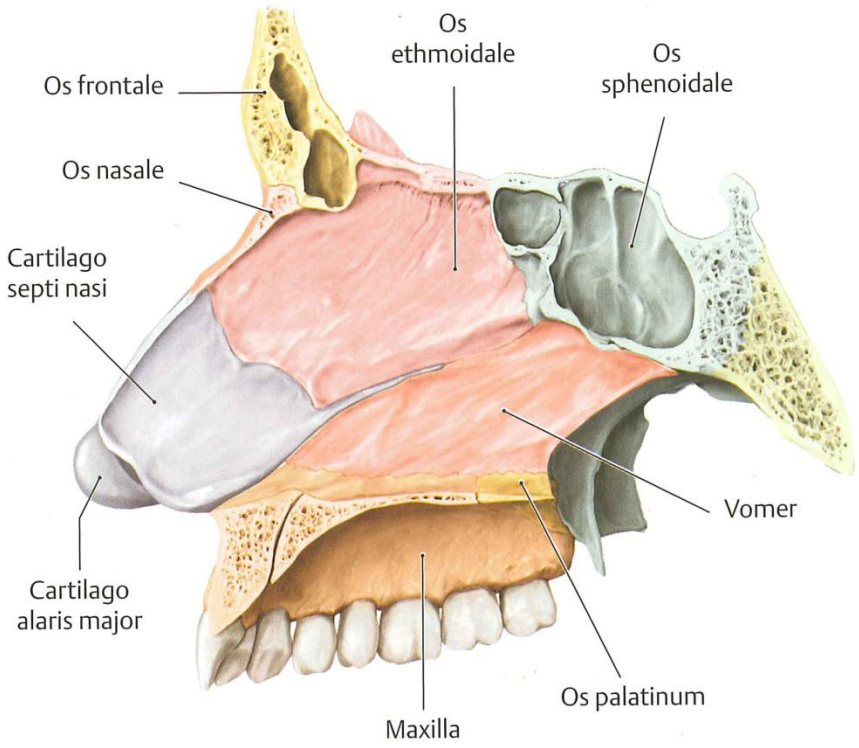


Front view

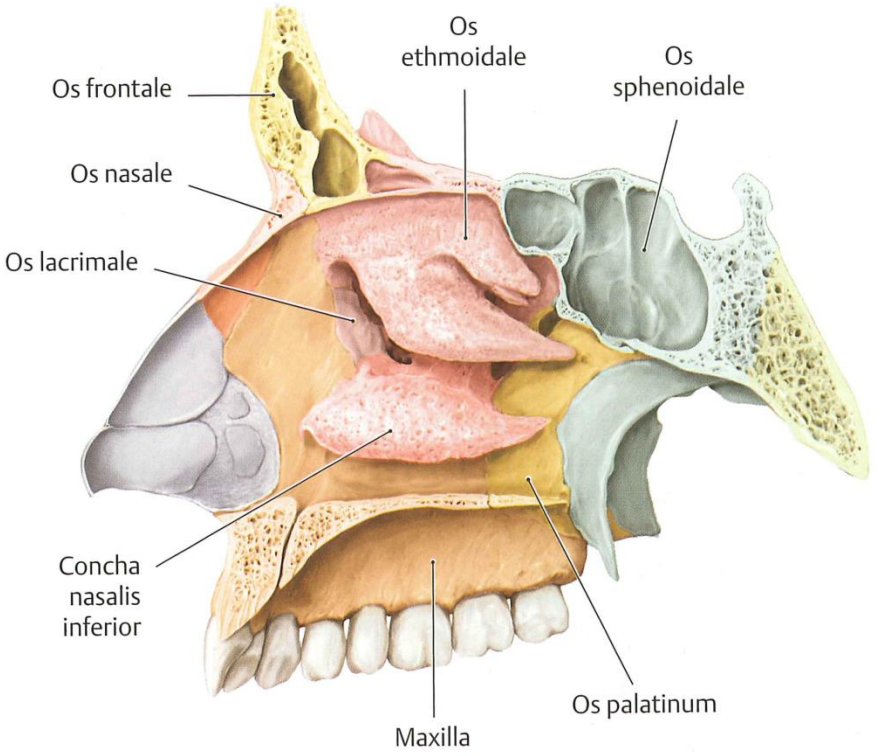
Side view

Anatomy

Internal Nose **<u>Nasal cavity</u>:** septum and lateral walls



Septum

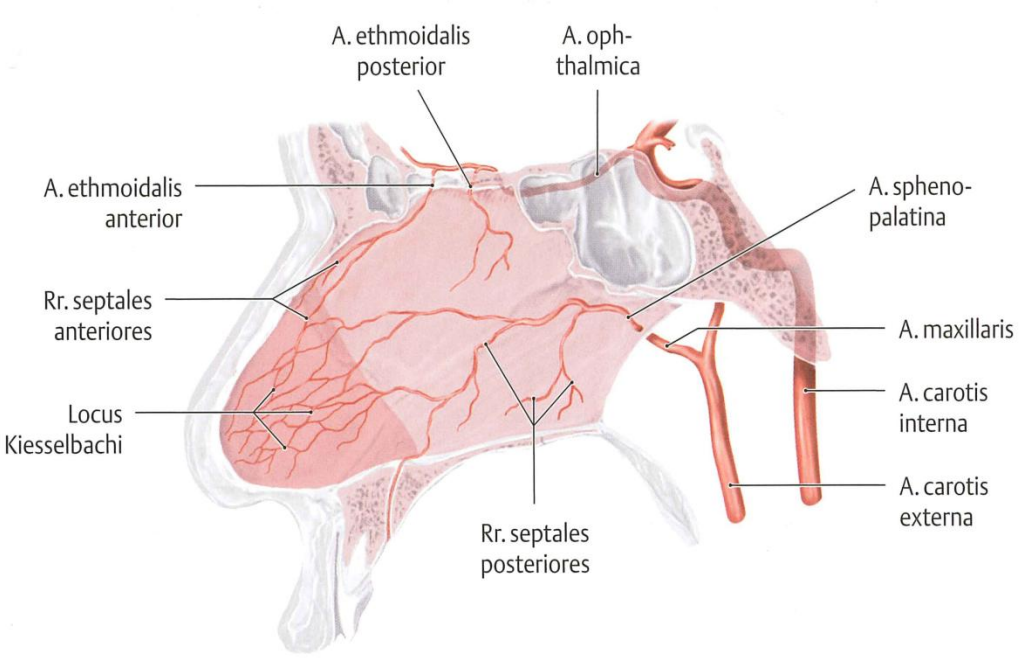


Lateral Wall

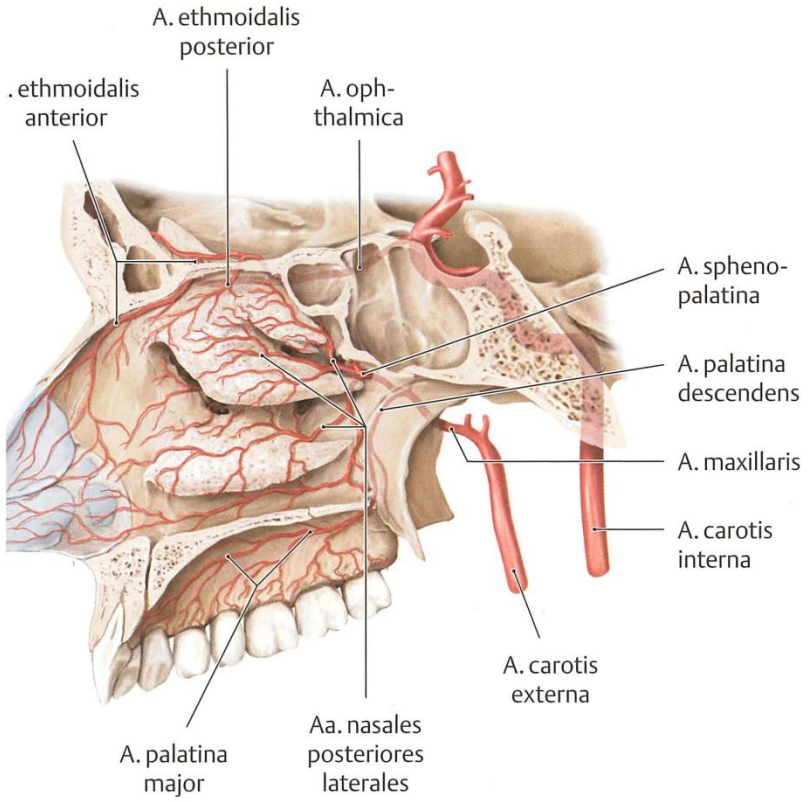
Anatomy

Internal Nose

<u>Nasal cavity</u>: Blood supply



Septum

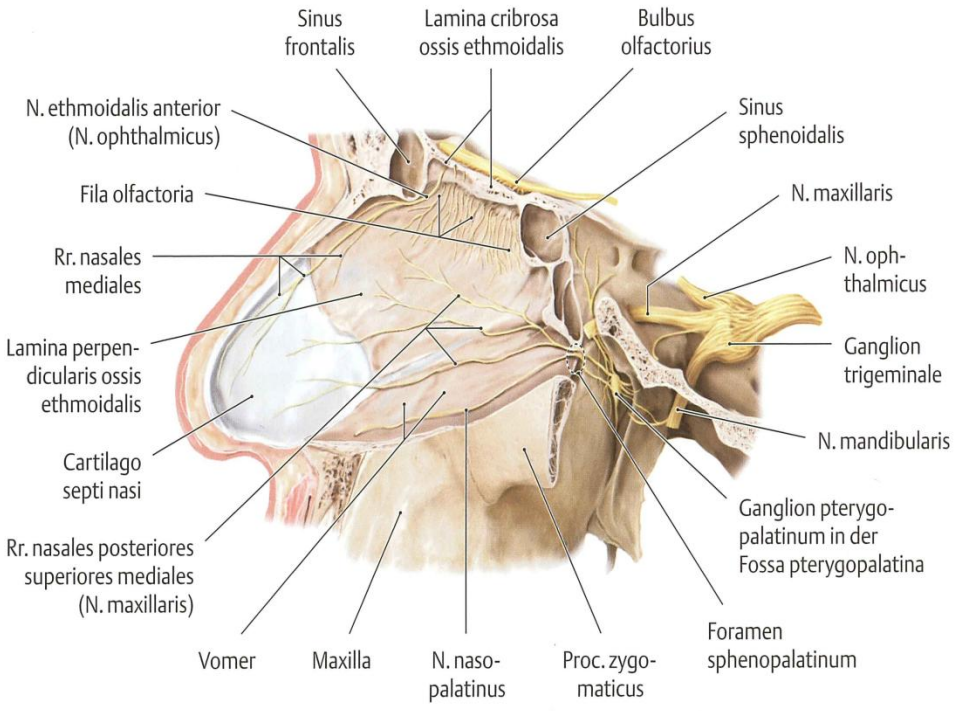


Lateral Wall

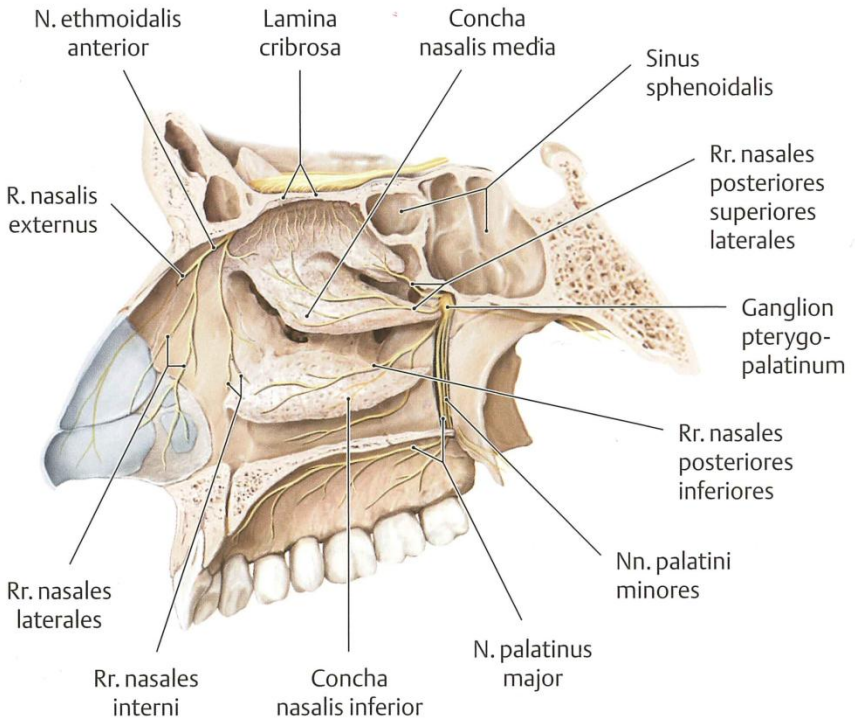
Anatomy

Internal Nose

<u>Nasal cavity</u>: Innervation



Septum

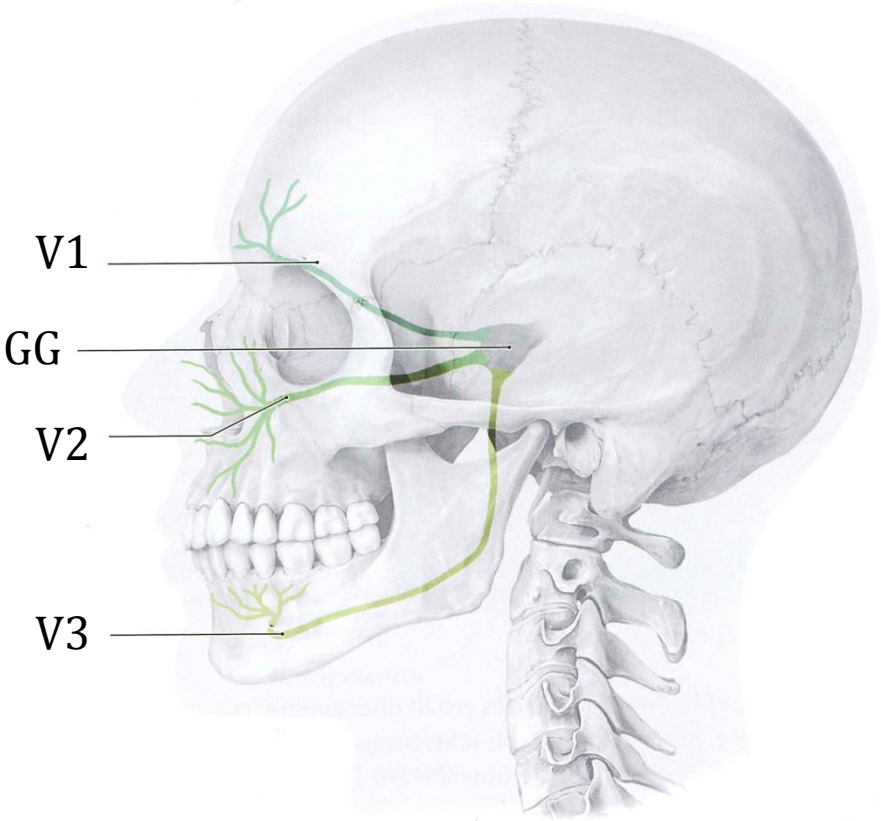


Lateral Wall

Anatomy

Internal Nose

<u>Nasal cavity</u>: Innervation



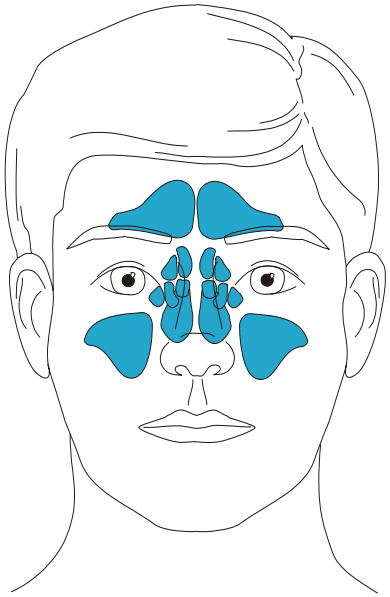
Trigeminal Nerve

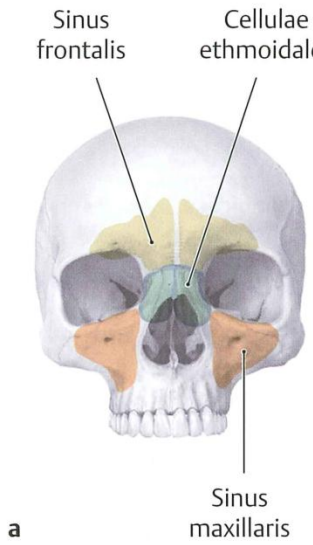
V1 and V2 = nasal cavity

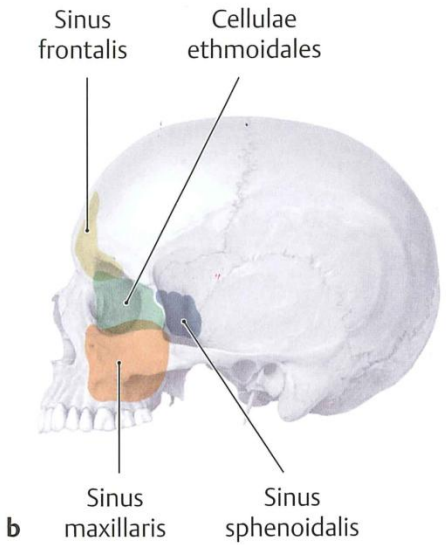
Anatomy

Internal Nose **Paranasal Sinuses**

Four paires of paranasal sinuses







- **Frontal sinus**
- **Maxillary sinus**
- **Ethmoidal cells**
- **Sphenoid sinus**

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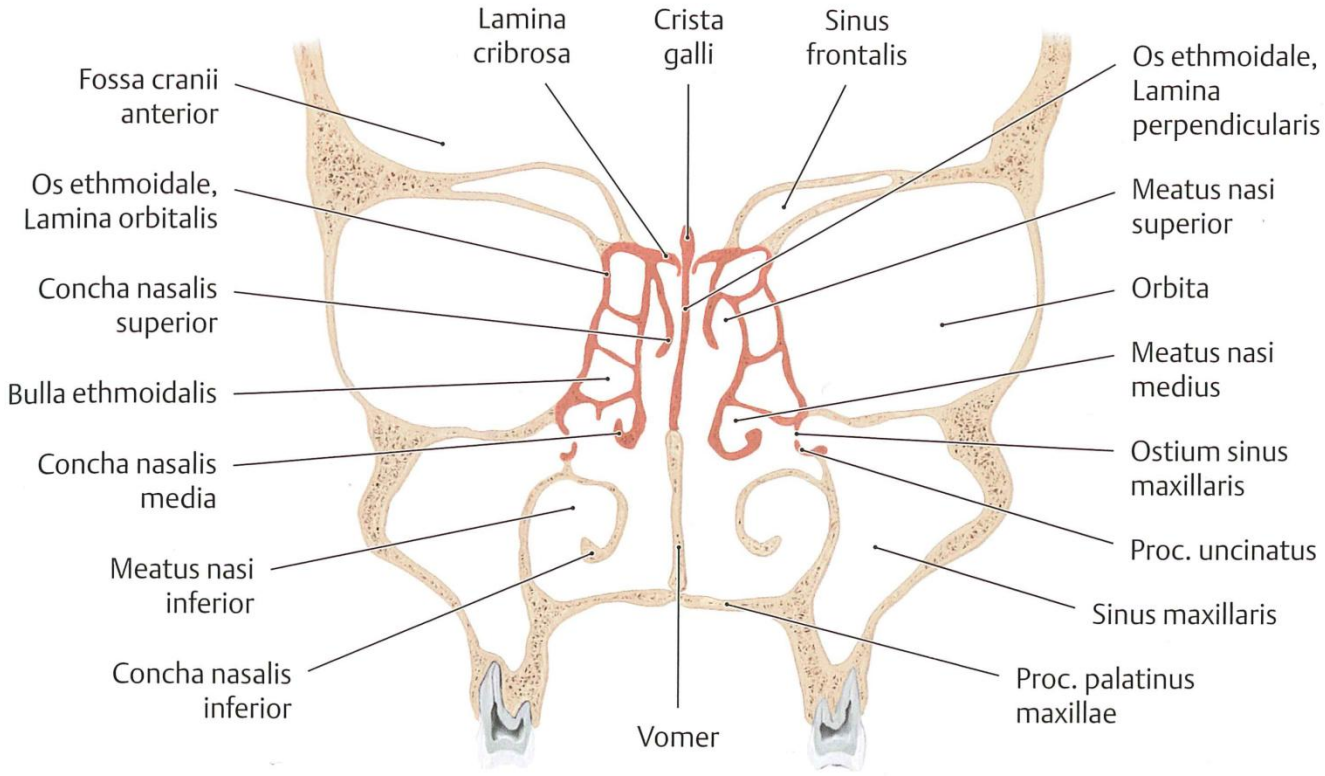
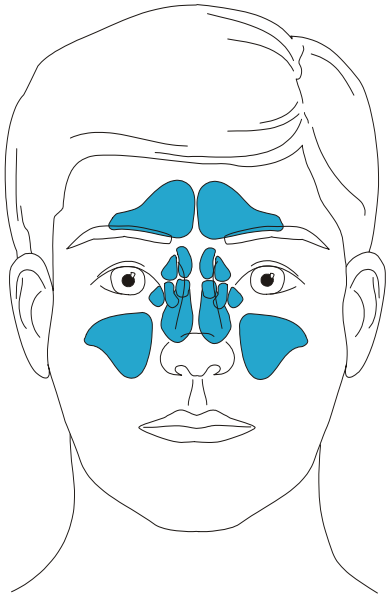
Anatomy

Internal Nose **Paranasal Sinuses**





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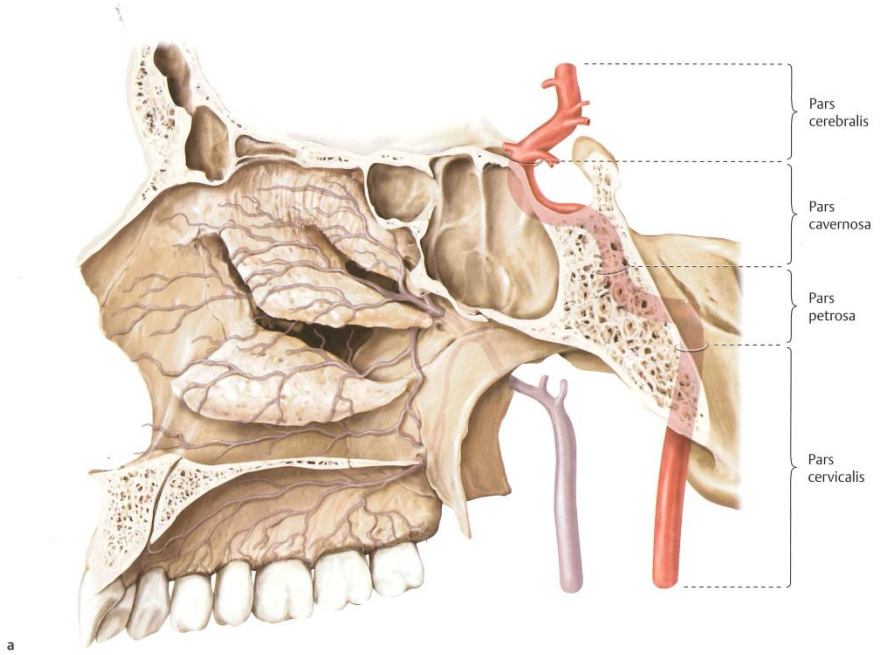
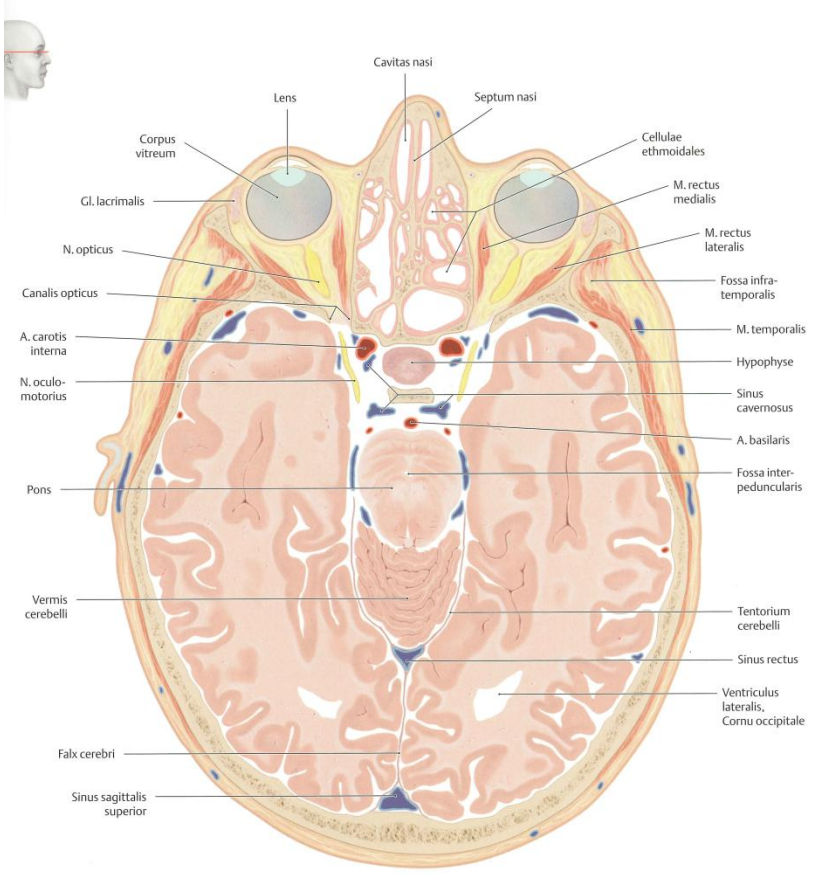
Anatomy

Sphenoid sinus – dangerous proximities



Carotid Artery



Optic nerve

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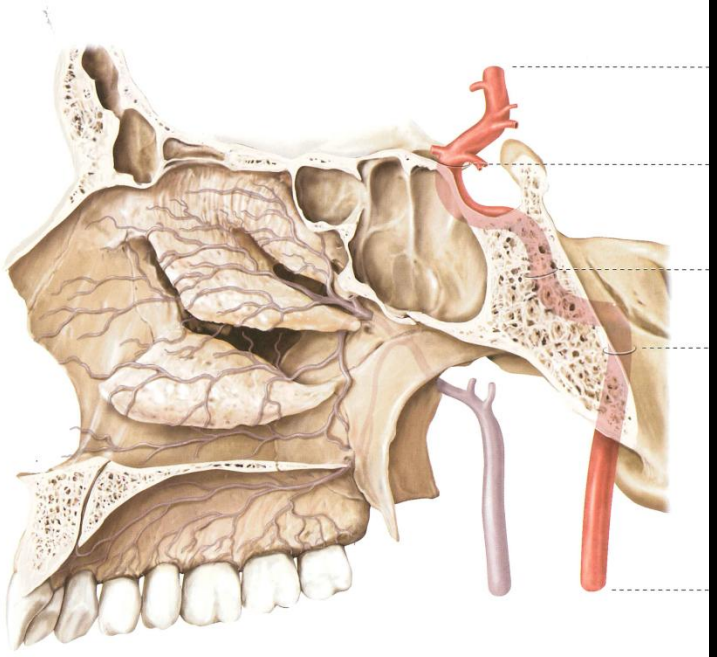
Anatomy

Sphenoid sinus – dangerous proximities



Carotid Artery

[redacted]

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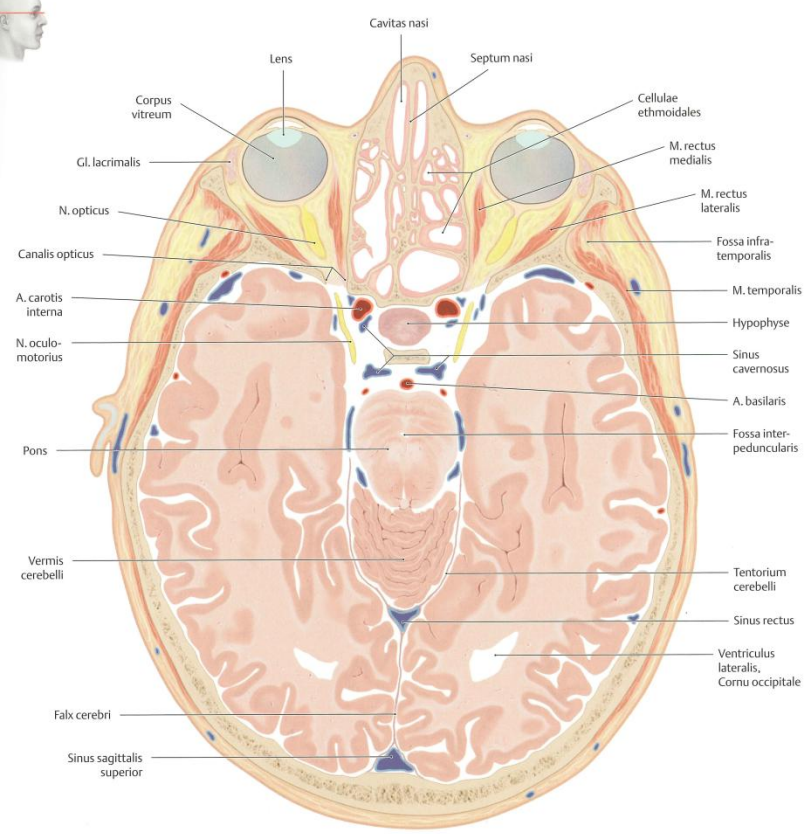
Anatomy

Sphenoid sinus – dangerous proximities



Optic nerve

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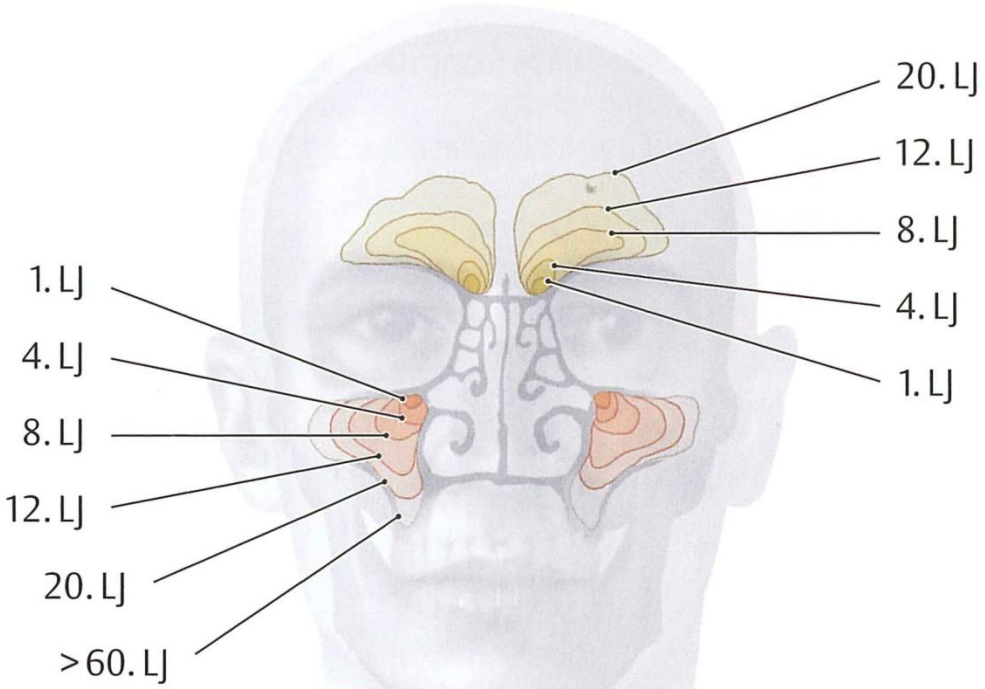
Anatomy

Internal Nose

Paranasal Sinuses : Developpement



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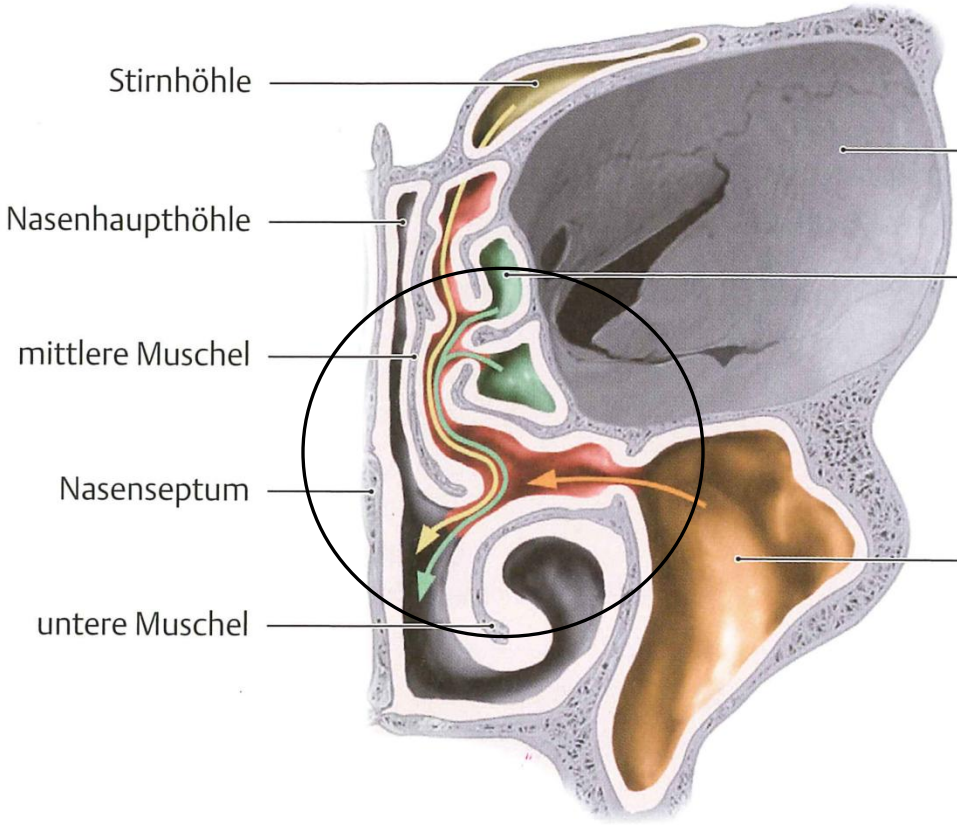
Anatomy

Internal Nose

Paranasal Sinuses: Drainage



Osteomeatal Complexe

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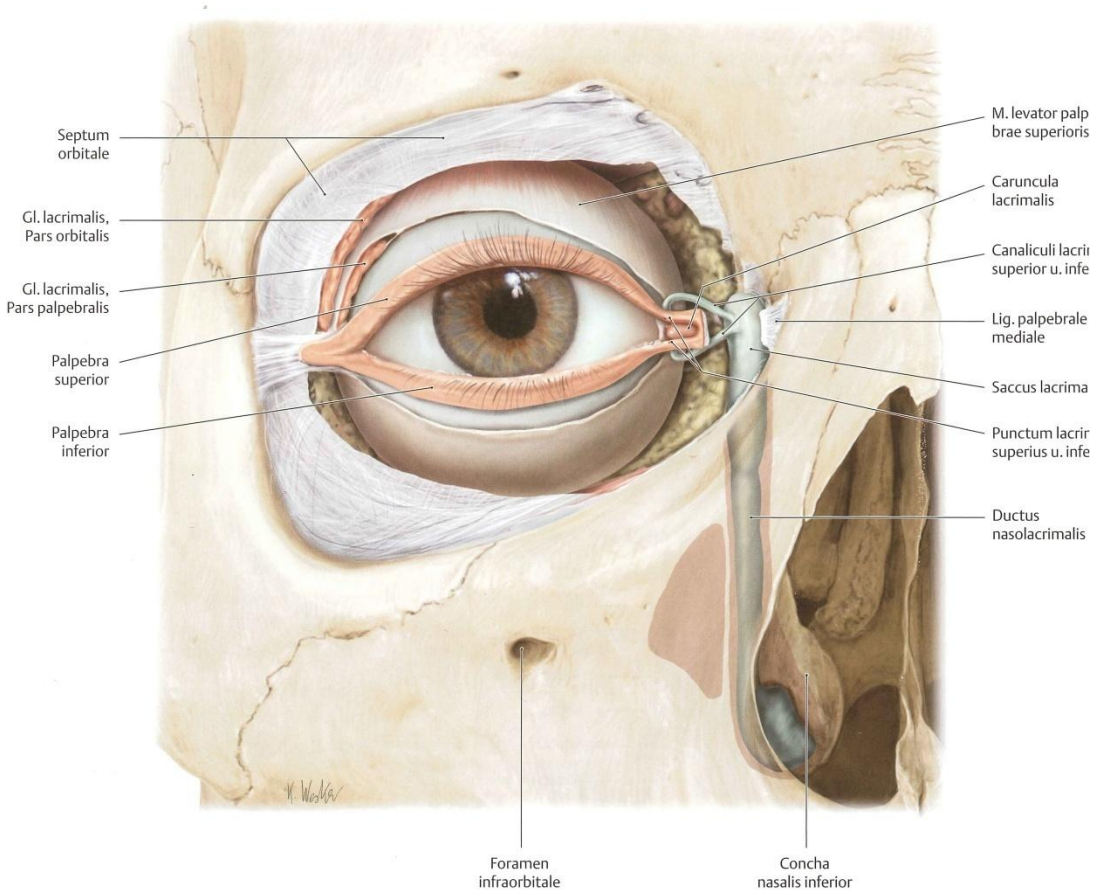
Anatomy

Drainage



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Anatomy

Internal Nose **Nasal Mucosa**

Respiratory epithelium

- Ciliated Cells
- Goblet Cells

Submucosal layer

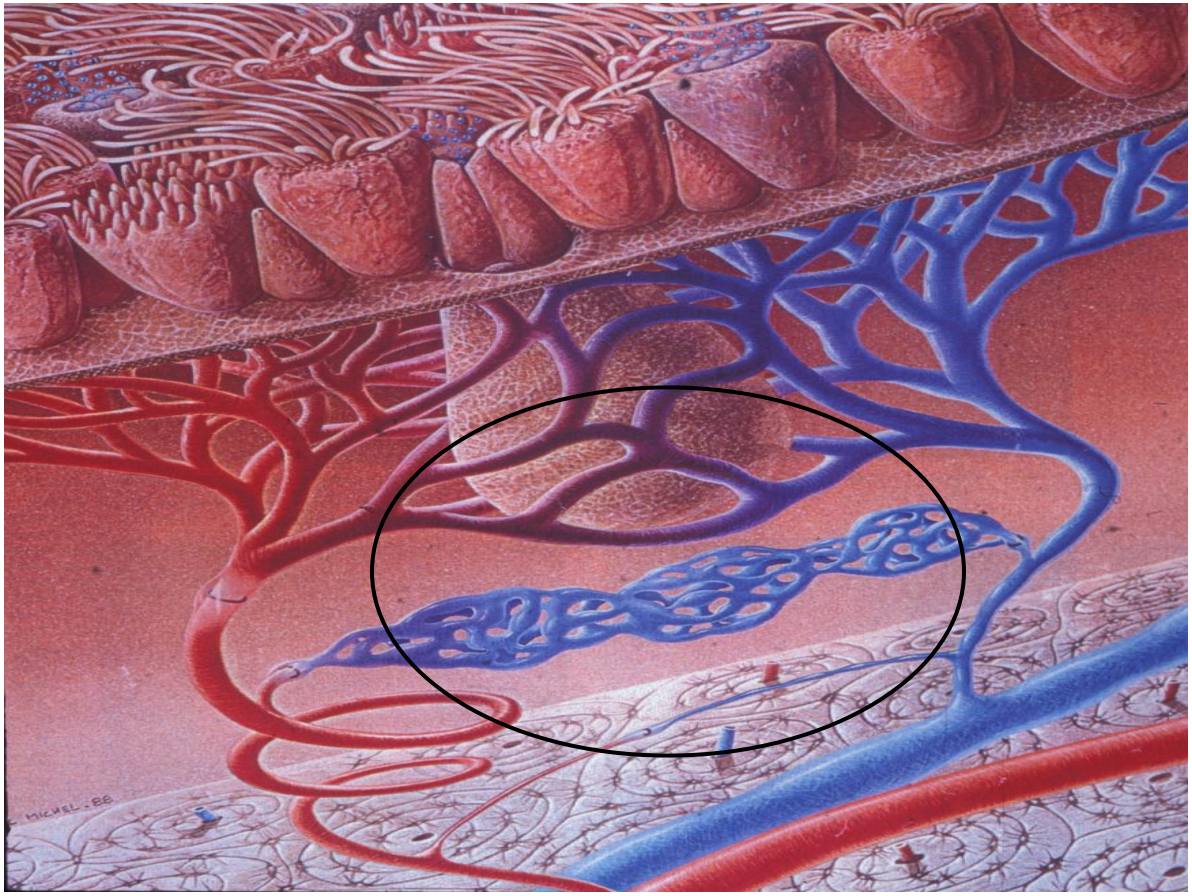
Anatomy

Internal Nose **Nasal Mucosa**

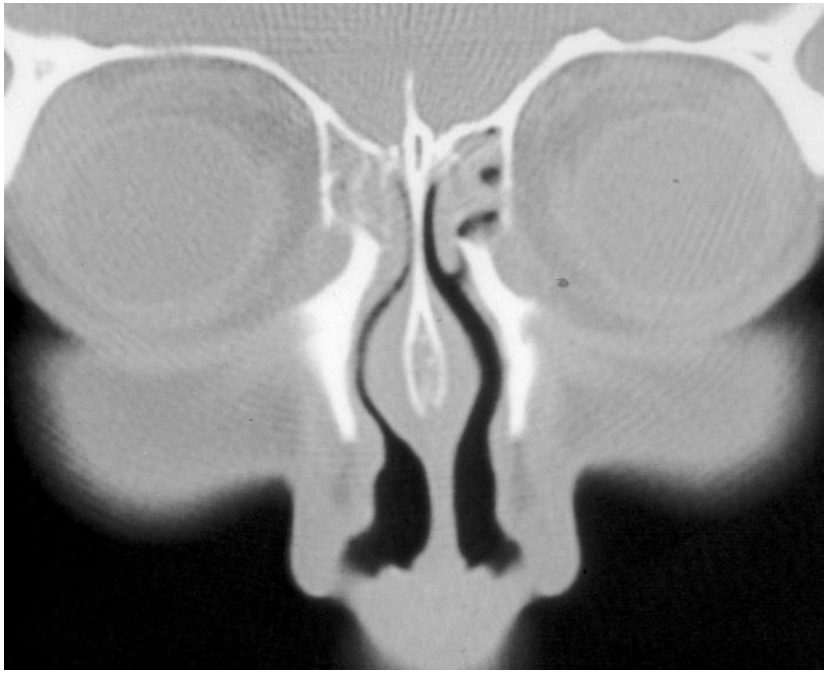
Respiratory epithelium

Submucosal layer

- Venous Sinusoïdes / Plexus
- Erectile Proprieties
- Capacitance vessels
- Congestion / Decongestion



Swell Bodies

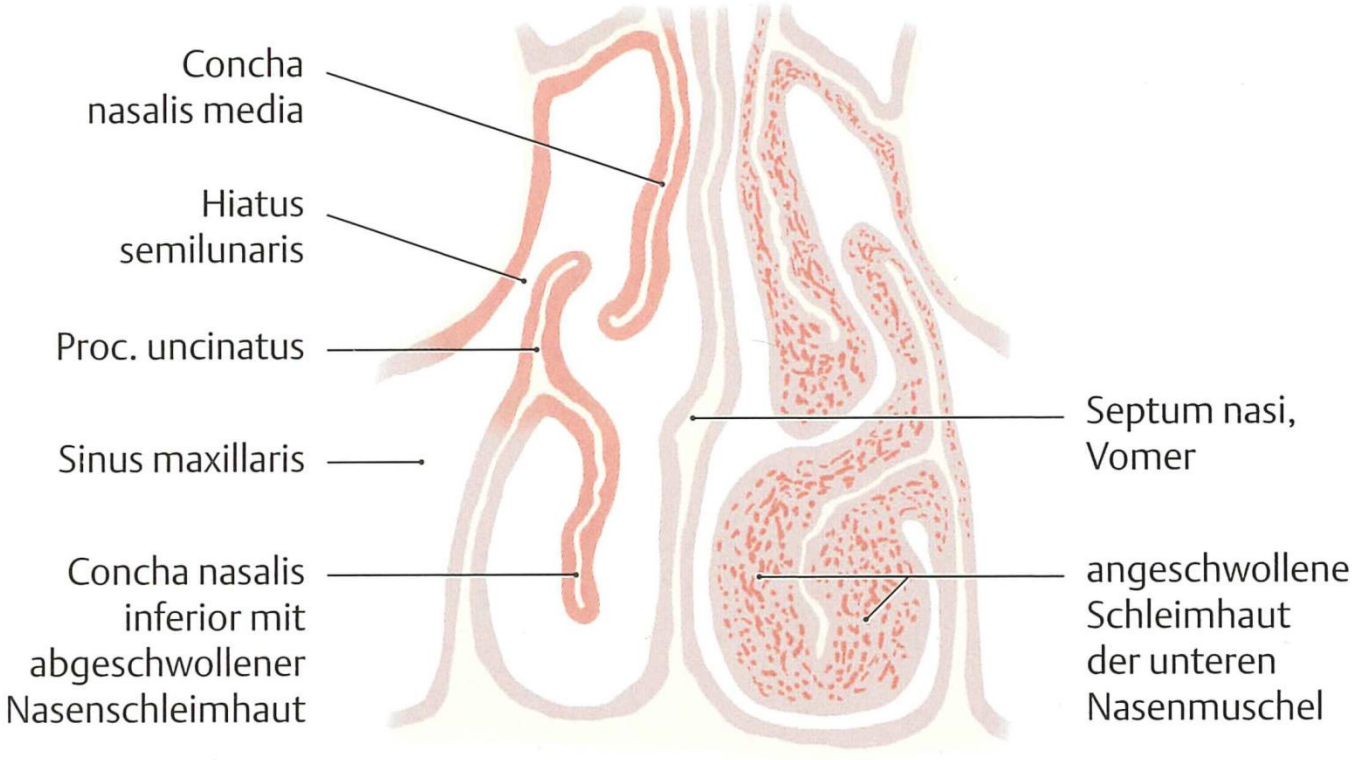


Septal Turbinate

Inferior > Middle Turbinate

Anatomy

Internal Nose **Nasal Mucosa**



decongested congested

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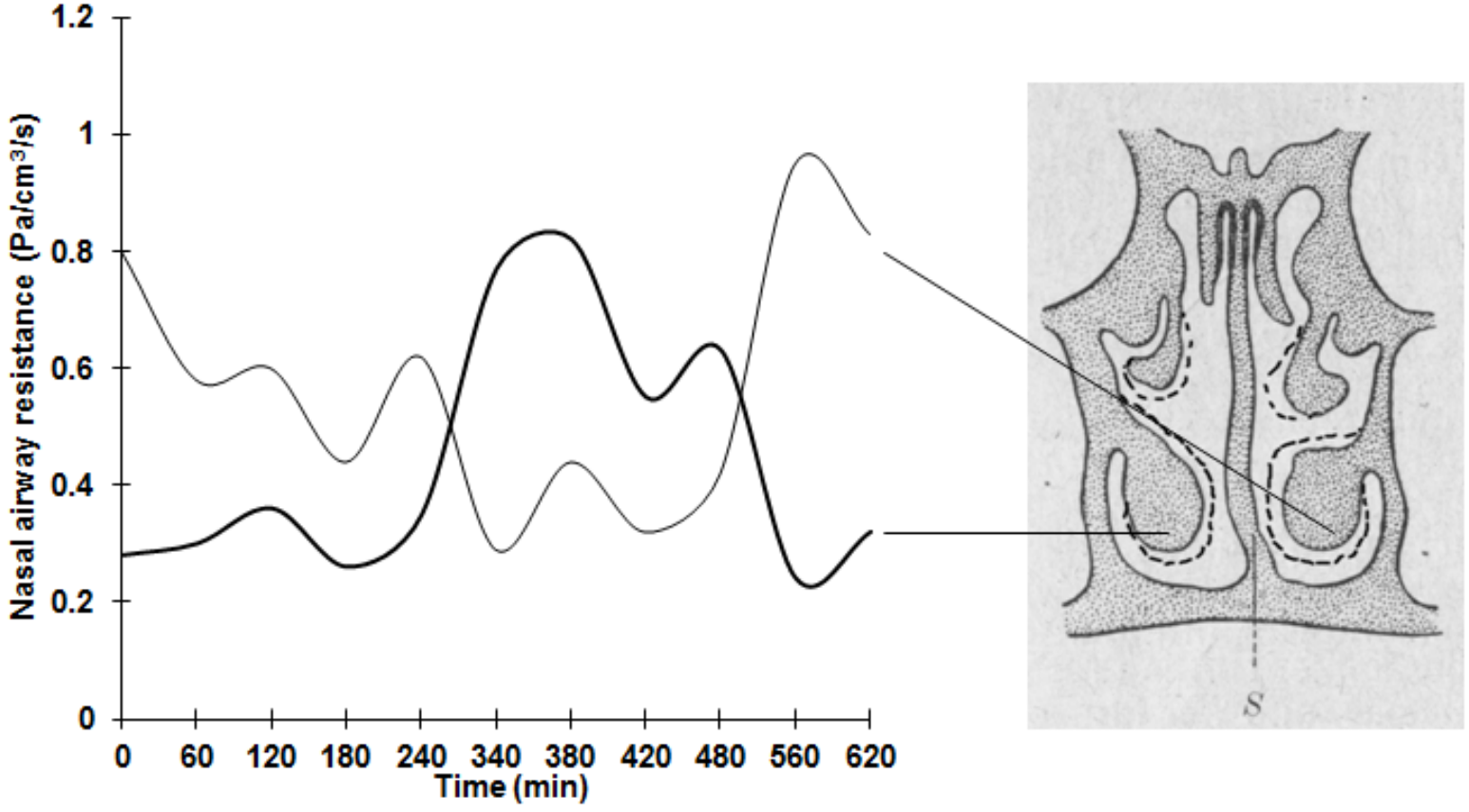
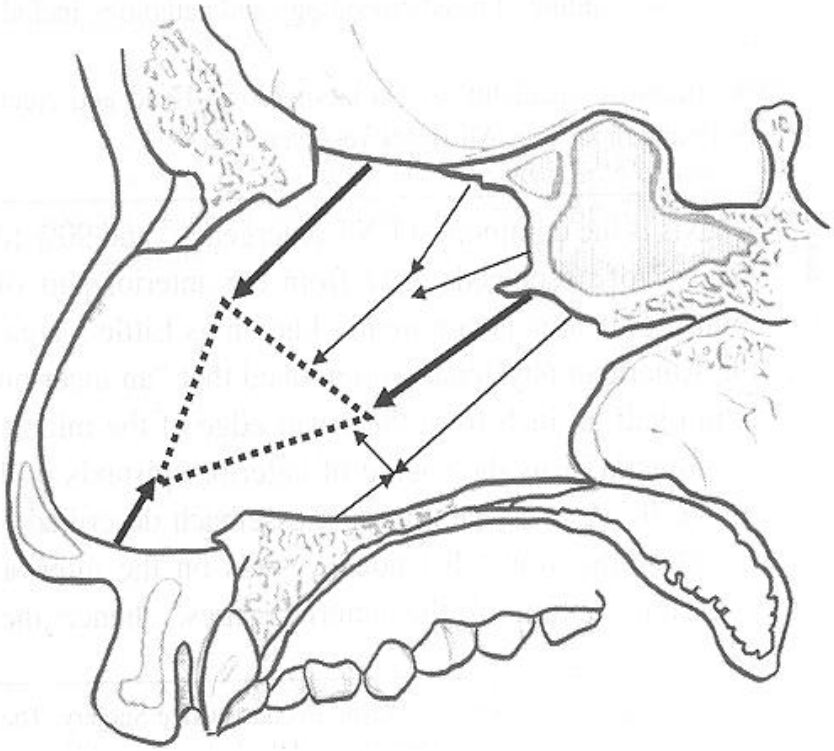
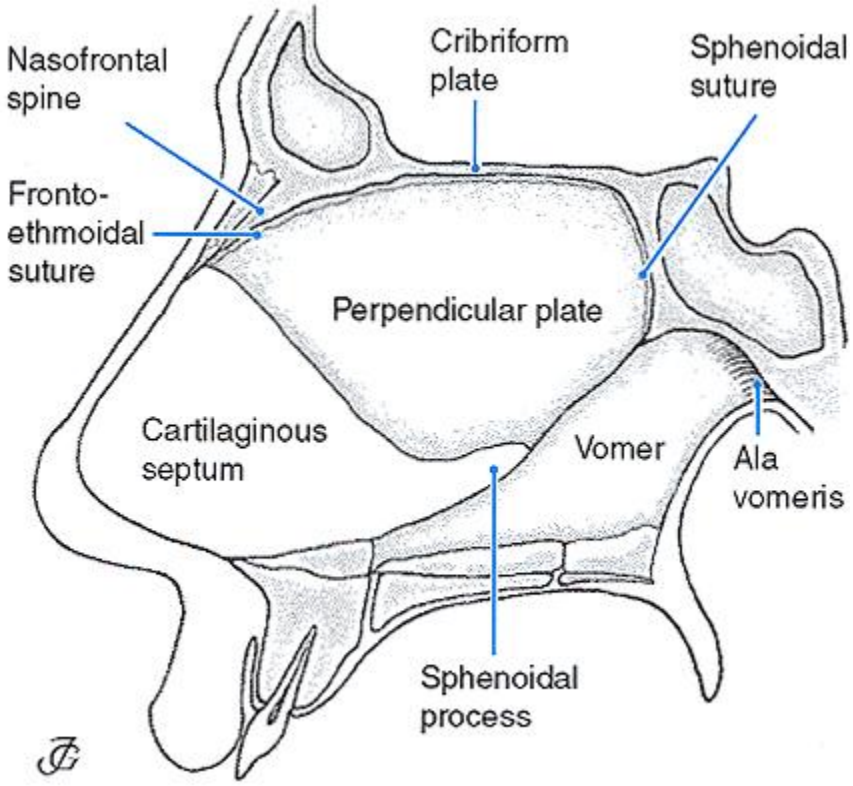
Nasal Cycle


1.2
1
0.8
0.6
0.4
0.2
0
Nasal airway resistance (Pa/cm³/s)
0
60
120
180
240
340
380
420
480
560
620
Time (min)
S

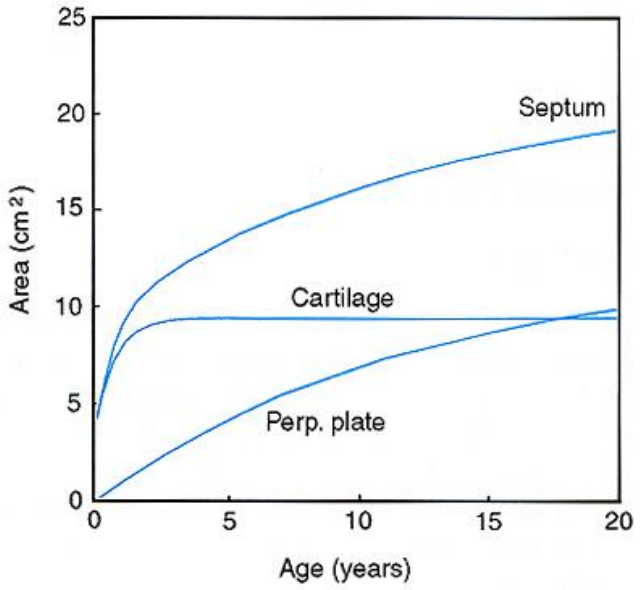
Septal Deviation



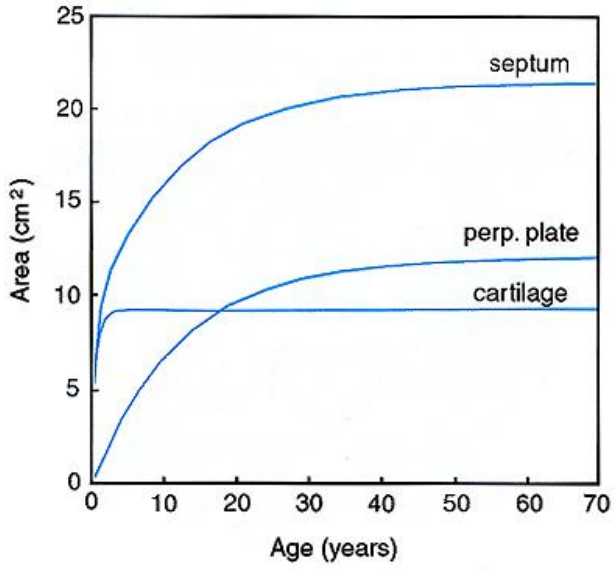


Septal Deviation

Growth curves

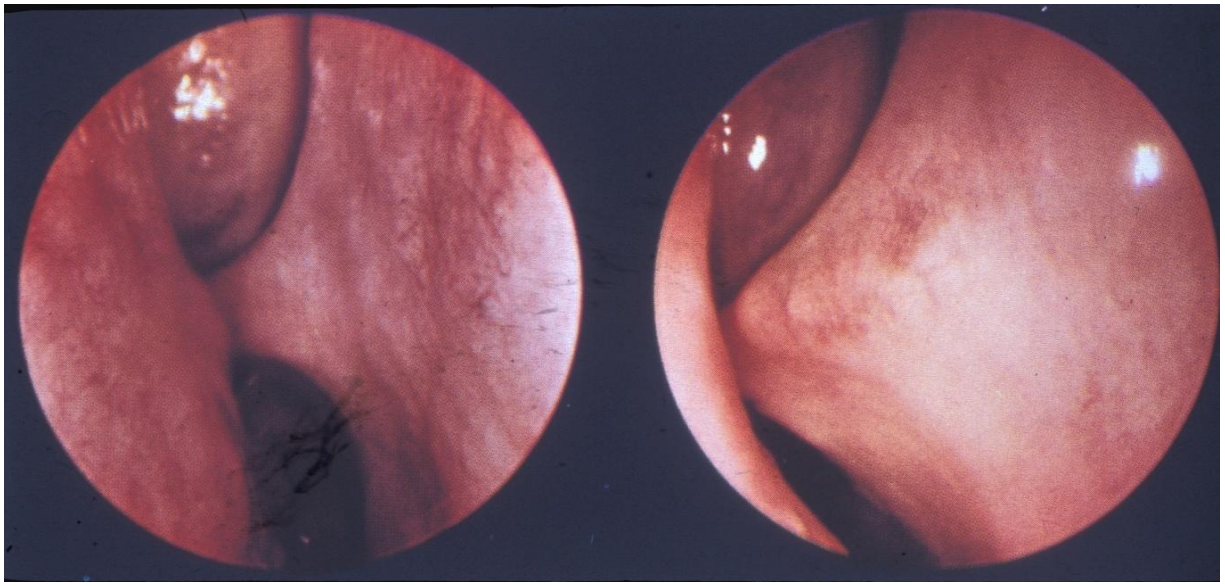


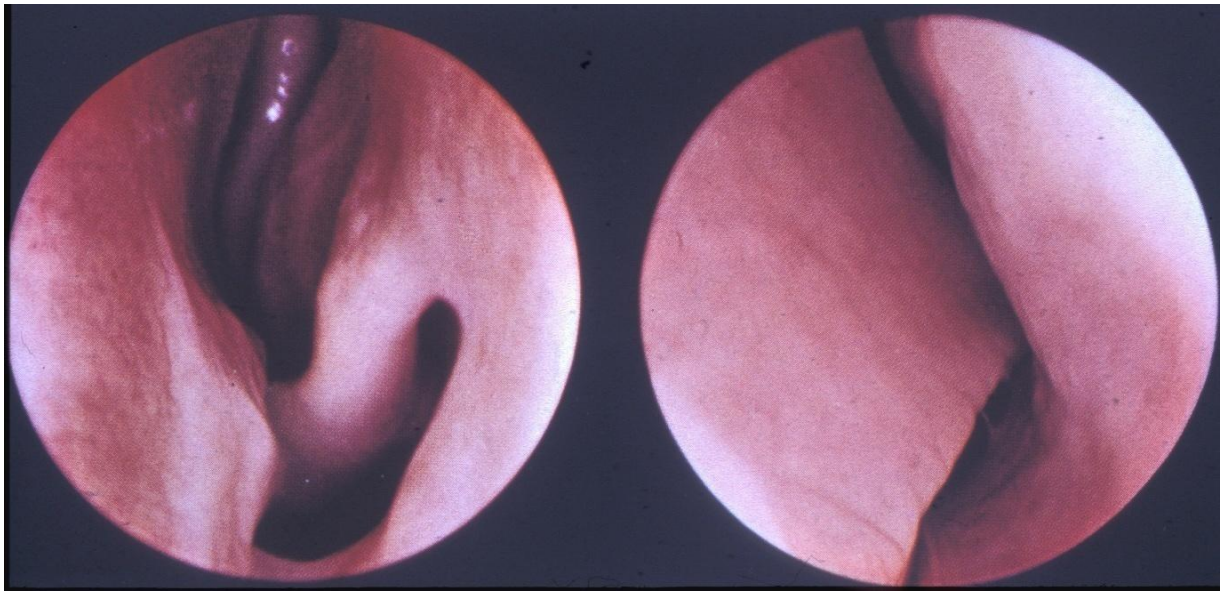
Bony and cartilagenous growth from 0 to 20 years (van Loosen et al. 1996)



Bony and cartilagenous growth from 0 to 70 years (van Loosen et al. 1996)

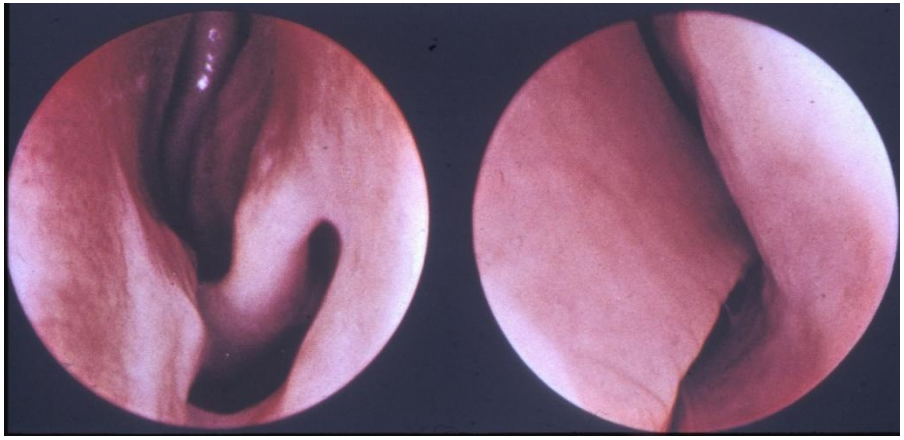
Septal Deviation

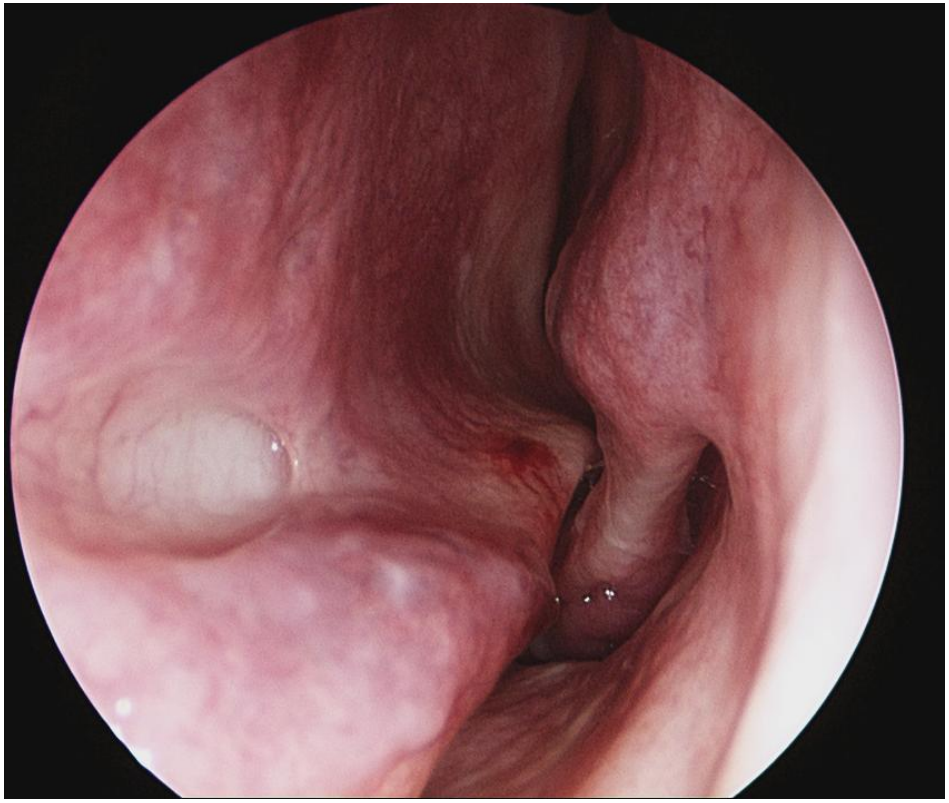




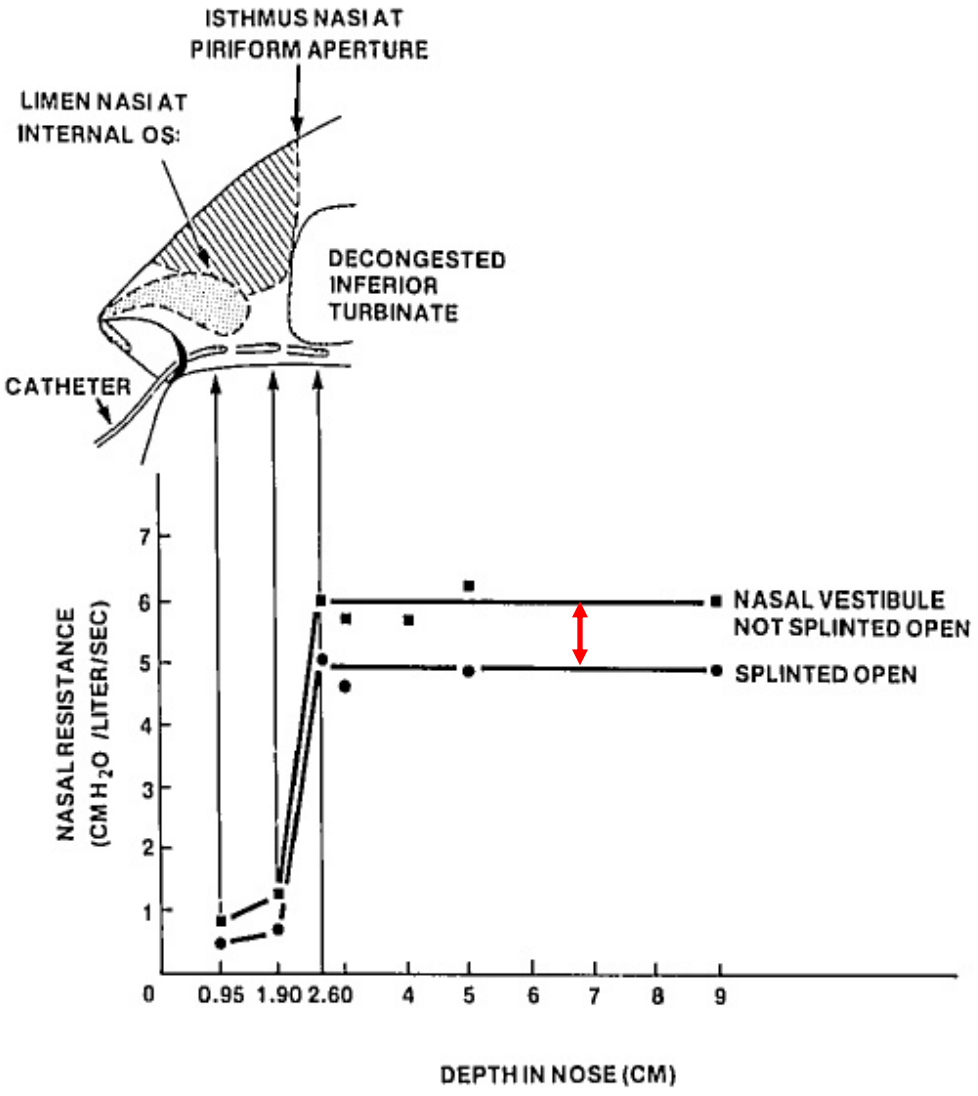
Septal Deviation

Therapy (if symptomatic) – surgical correction





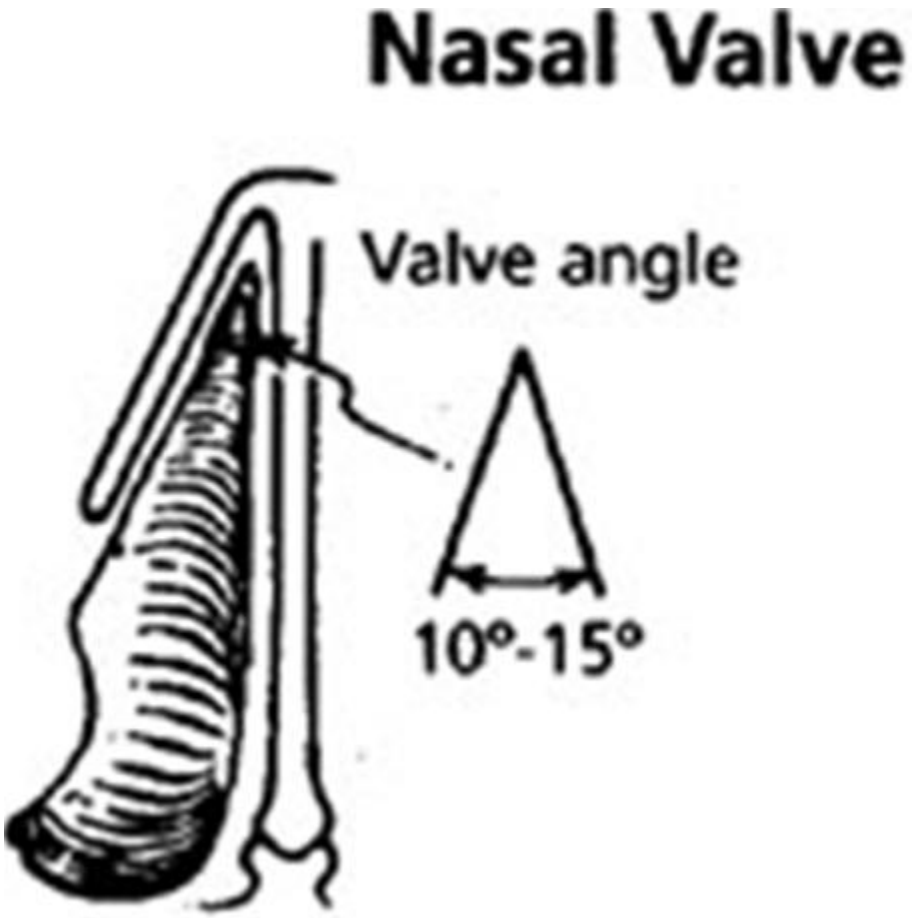
Nasal Valve

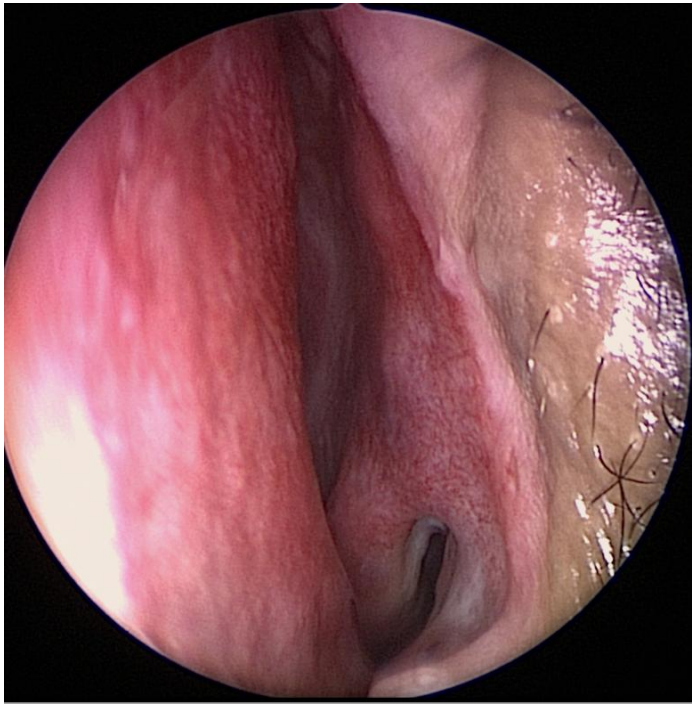


Nasal splint

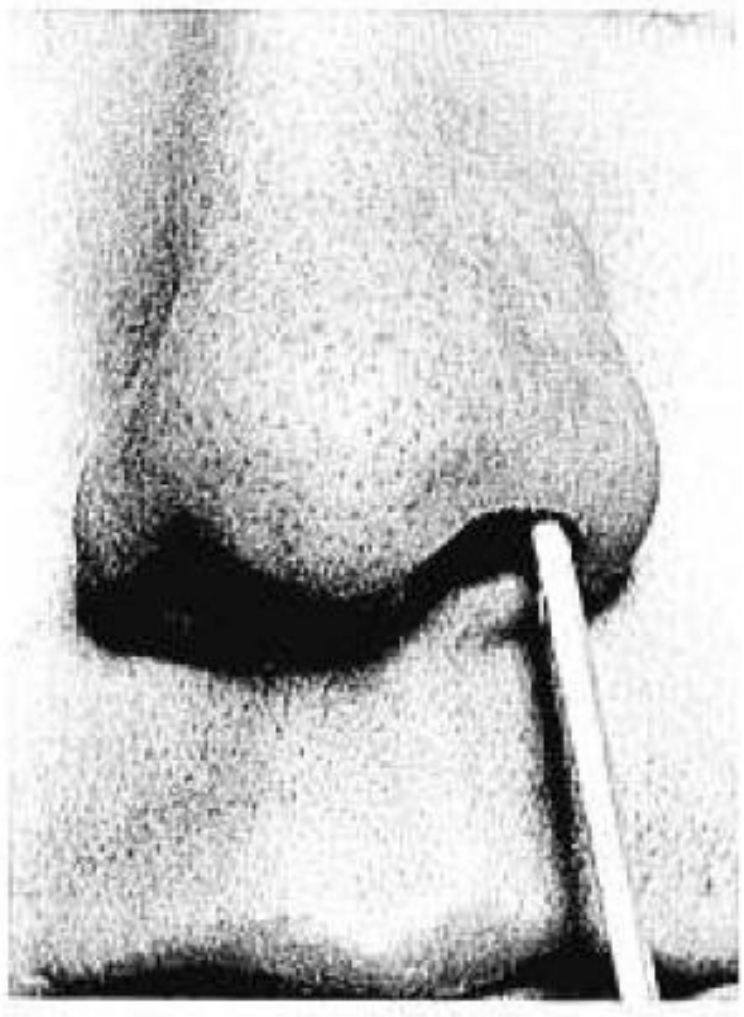
Haight and Cole, Laryngoscope 1983

Nasal Valve

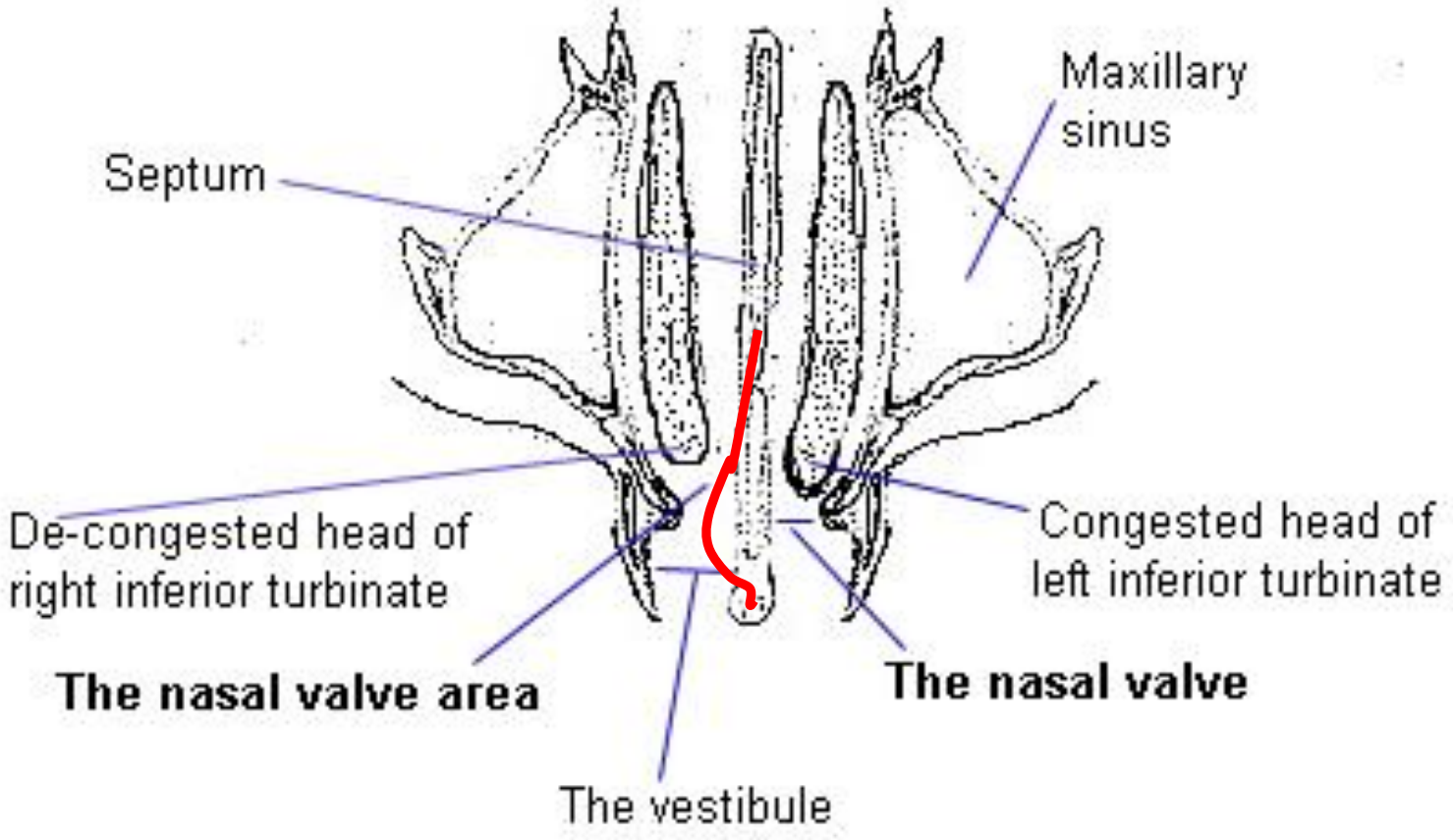




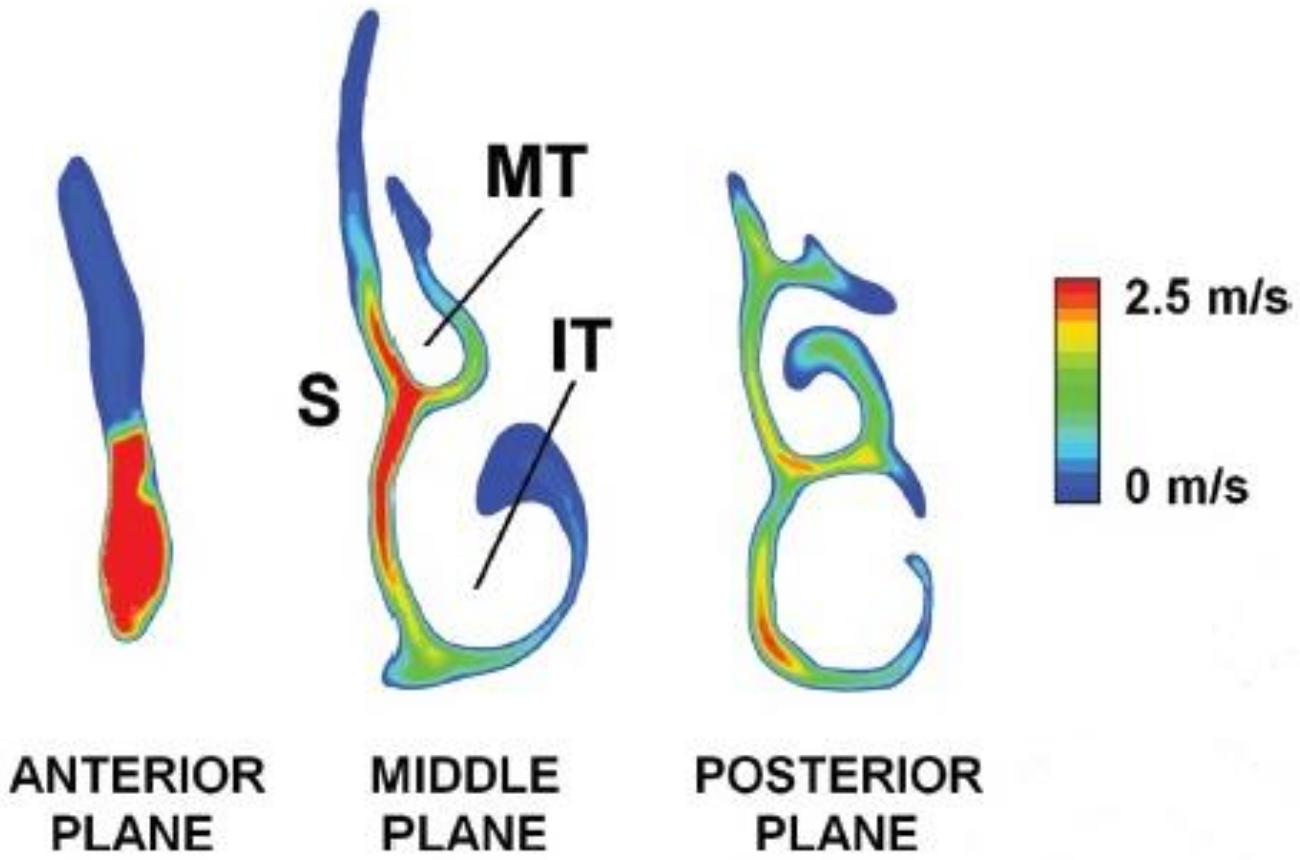
Cottle Sign



Nasal Valve


Septum
Maxillary sinus
De-congested head of right inferior turbinate
Congested head of left inferior turbinate
The nasal valve area
The nasal valve
The vestibule

Septal deviation and airflow



Color maps of airflow velocity in resting breath

Garcia, Am J Rhinol Allerg 2010

Airflow

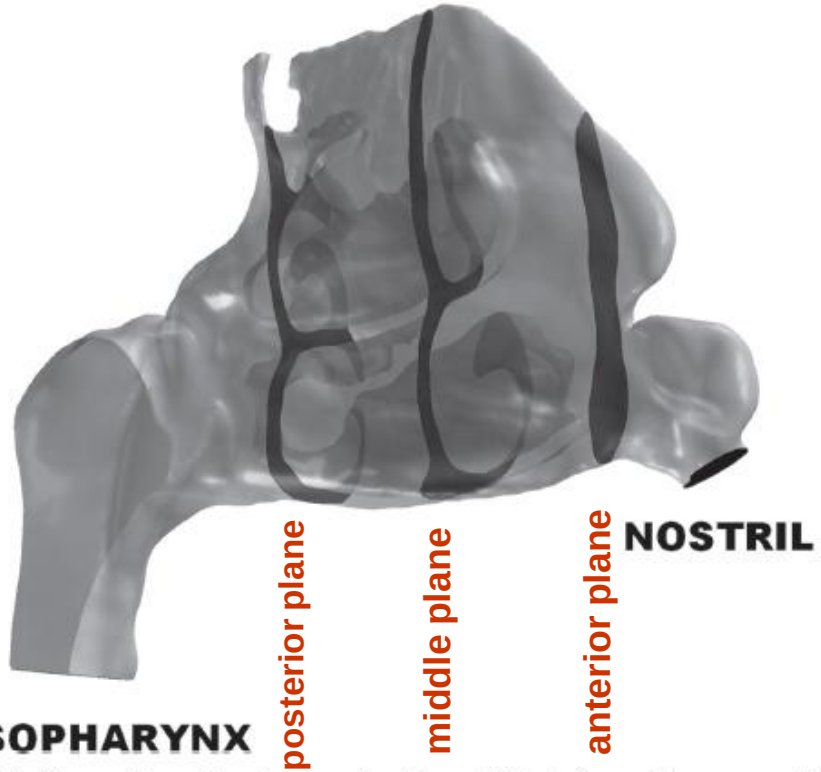


Figure 1. Three-dimensional reconstruction of the left nasal passage of a healthy subject. This geometry was the cornerstone to create models with simulated septal deviations. The three highlighted coronal planes (anterior, middle, and posterior planes) show where septal deviations were created (see Fig. 4).

Garcia, Am J Rhinol Allerg 2010

Septal deviation surgery– Influence on the airflow

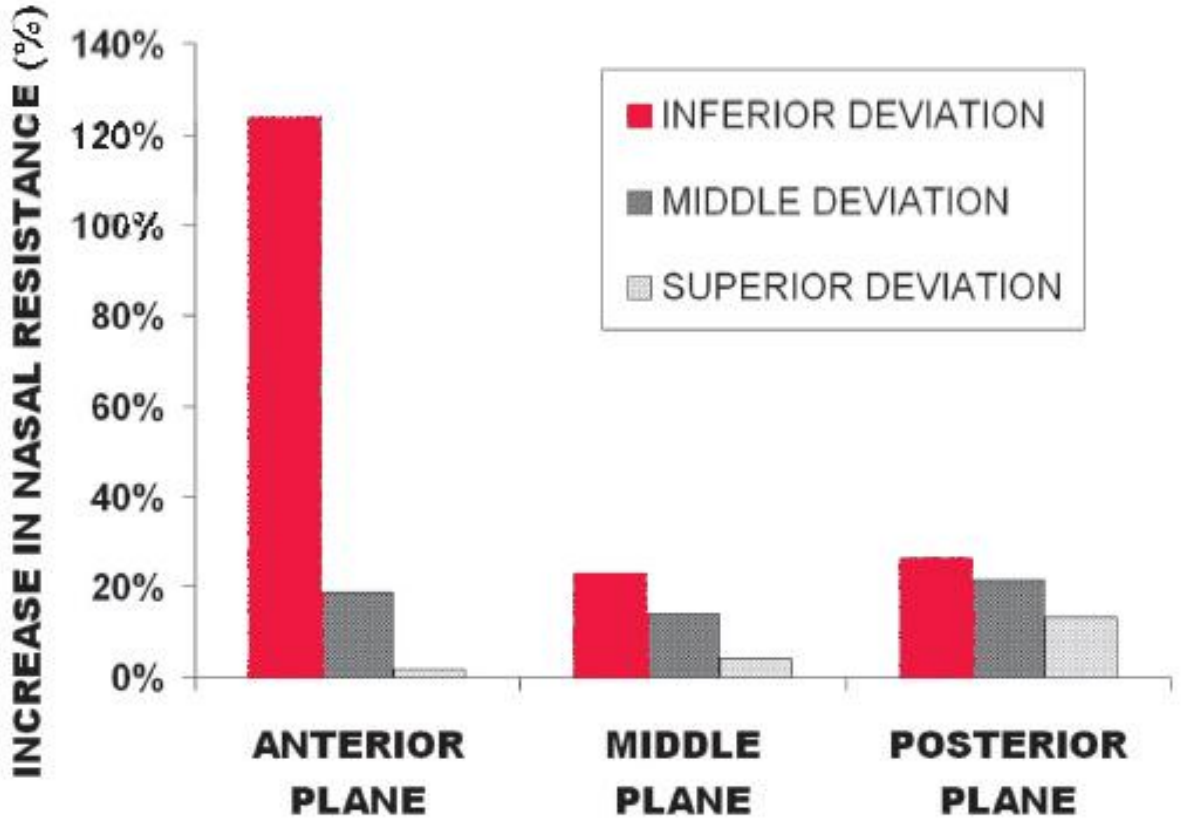
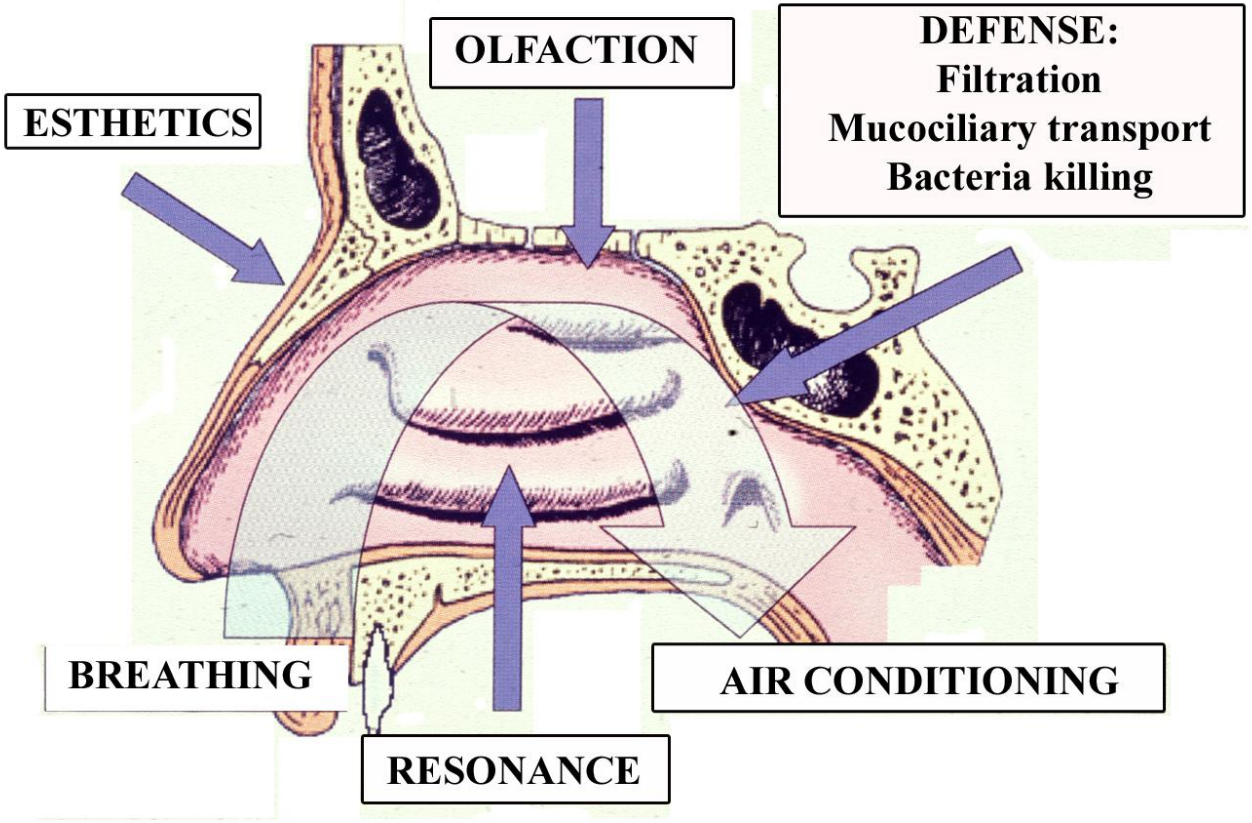


Figure 5. Percentage increase in nasal resistance in the nine models with septal deviation in relation to the original nasal geometry.

Garcia, Am J Rhinol Allerg 2010

Physiology

Nasal Functions



The Nose is an ORGAN!!!!

Breathing

Nasal Functions

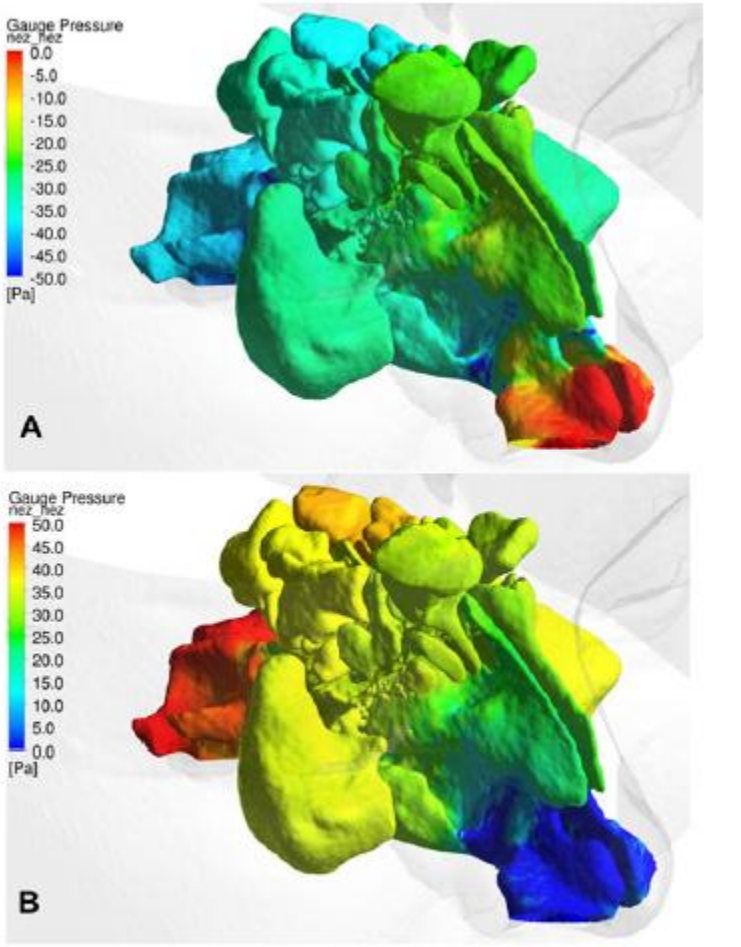
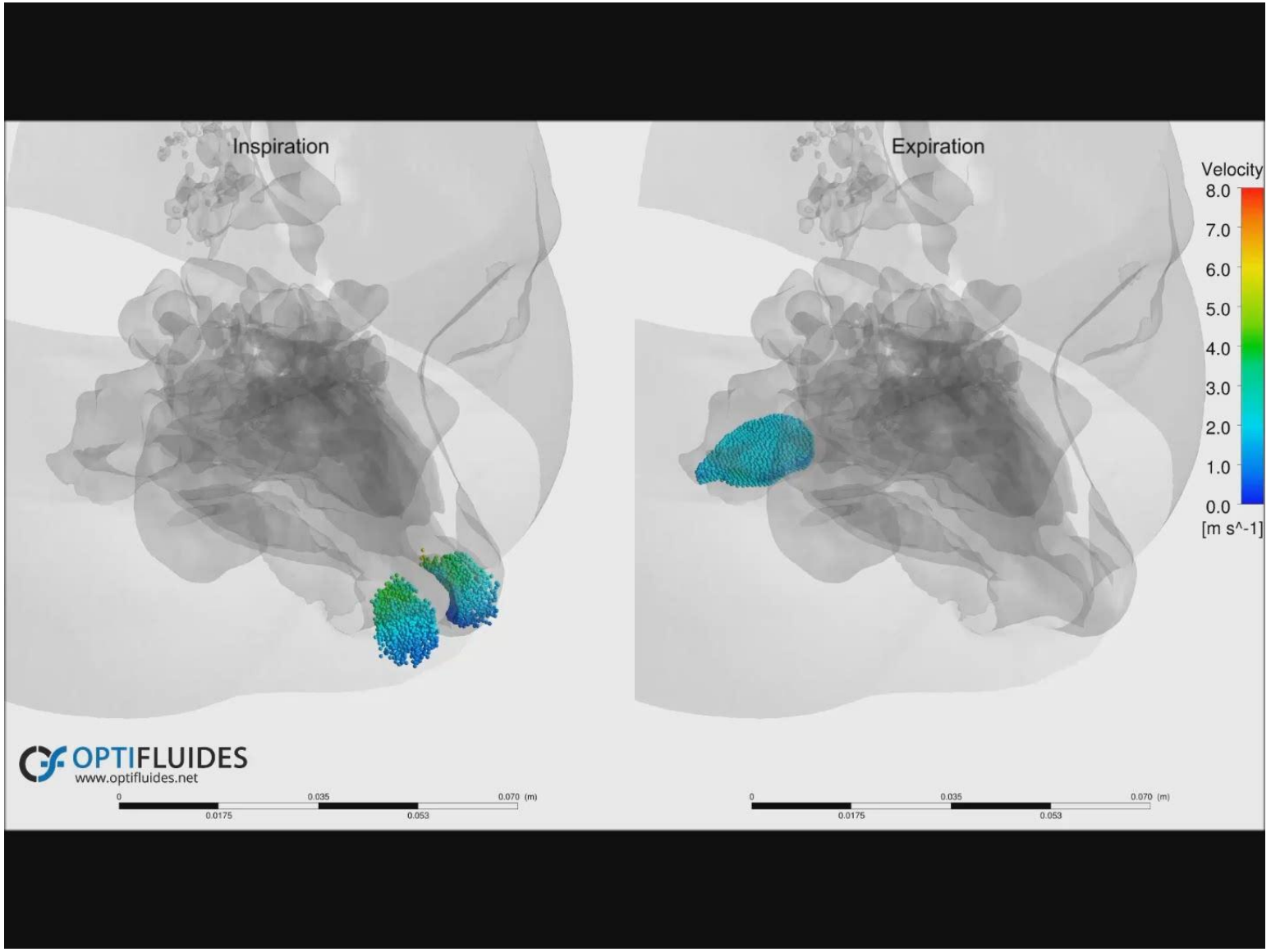


FIGURE 1. Pressure cartography at maximum flow rate during inspiration (A) and expiration (B).

De Gabory, Int Forum Rhinol Allergy 2018

Breathing



De Gabory, Int Forum Rhinol Allergy 2018

Breathing

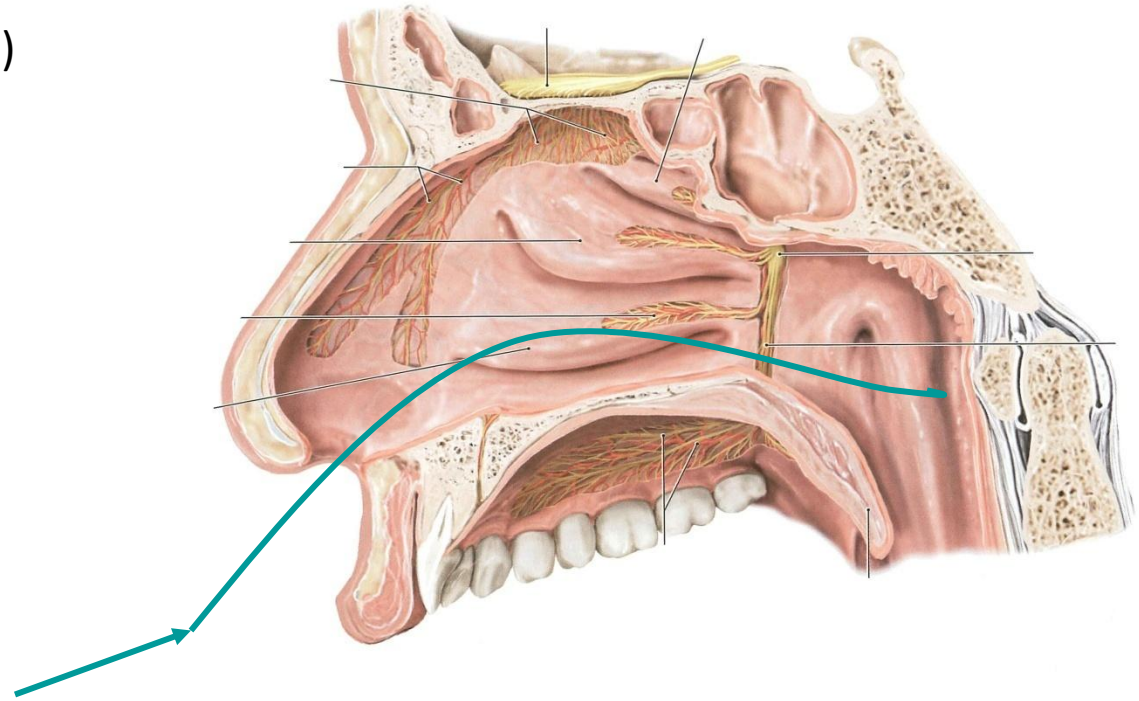
De Gabory, Int Forum Rhinol Allergy 2018

Conditioning

Nasal Functions

Humidification (Mucus)

Warming (Blood)



Example :

Temp. ext = 23 °C HR 40% Pharynx T = 30 °C, HR 98 %

Temp. ext = -4 °C HR 0% Pharynx T = 31 °C, HR 98 %

Prometheus, Springer Verlag

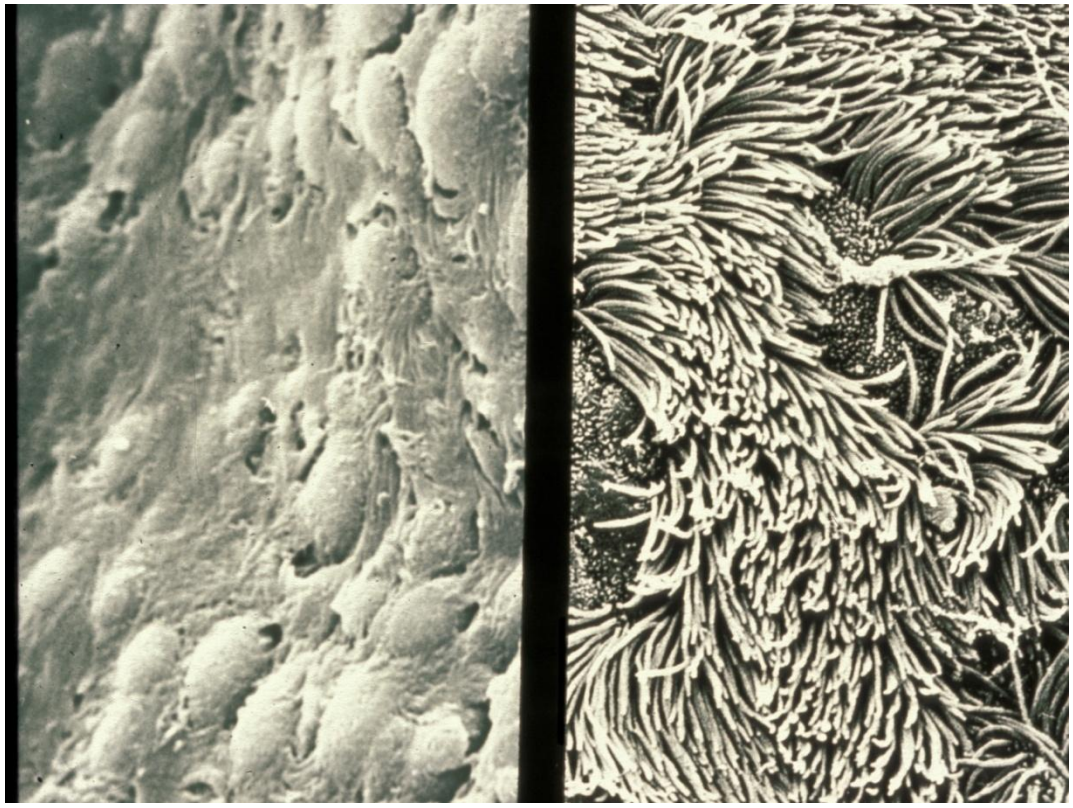
Cleaning

Nasal Functions

Self cleaning

Mucus layer

Mucociliary transport



Metaplasia, disappearance of the cilia (ex. smoker)

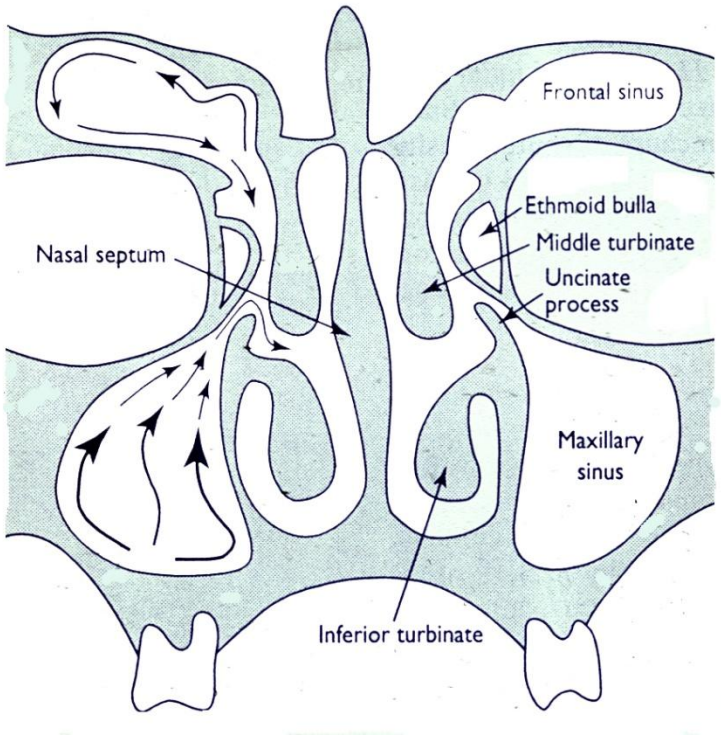
Healthy respiratory epithelium

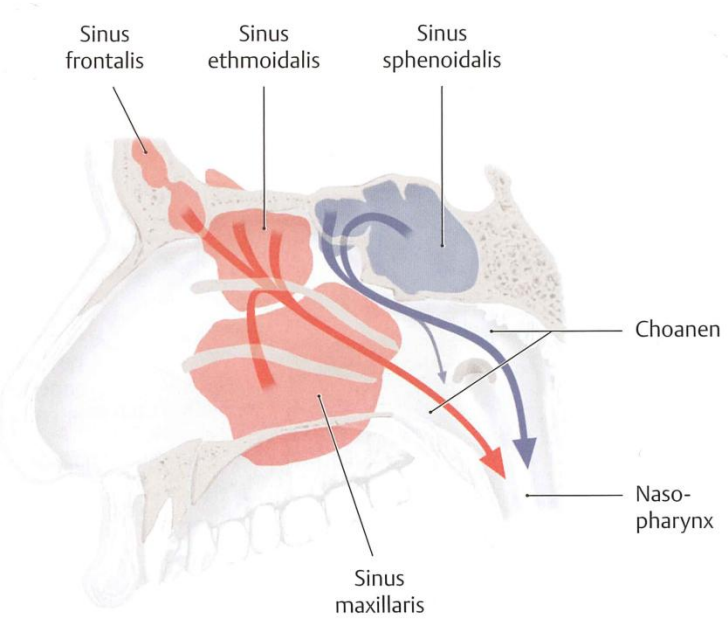
Cleaning

Nasal Functions

Mucociliary Transport

Nettoyage



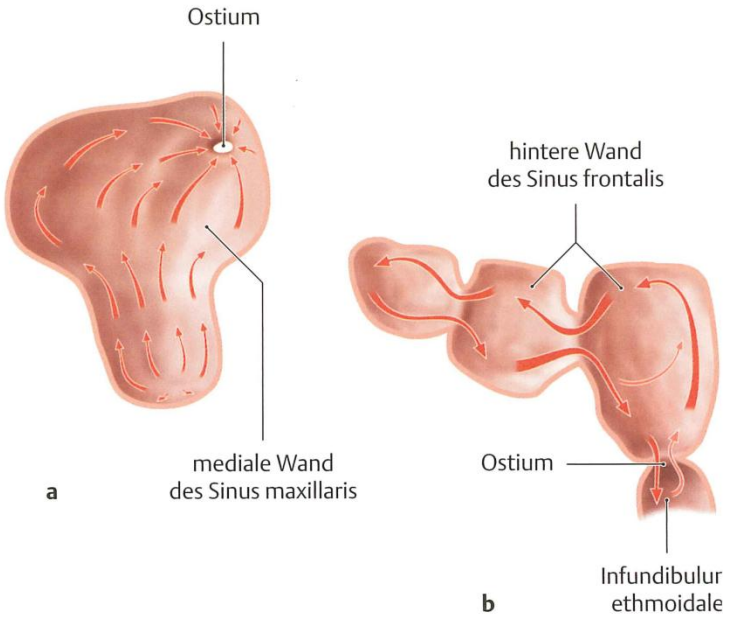


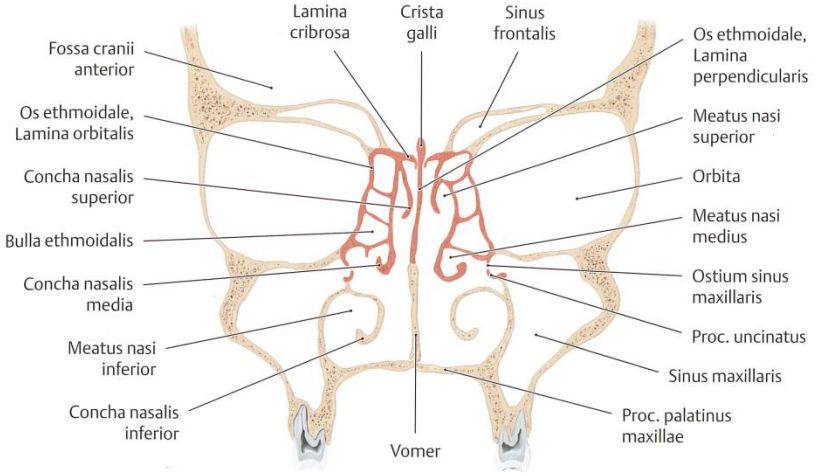
The mucociliary transport is **directed** towards determined structures

Cleaning

Nasal Functions

Mucociliary Transport





Mean velocity:

3mm/min à 25 mm/ min

The mucociliary transport is **directed** towards determined structures

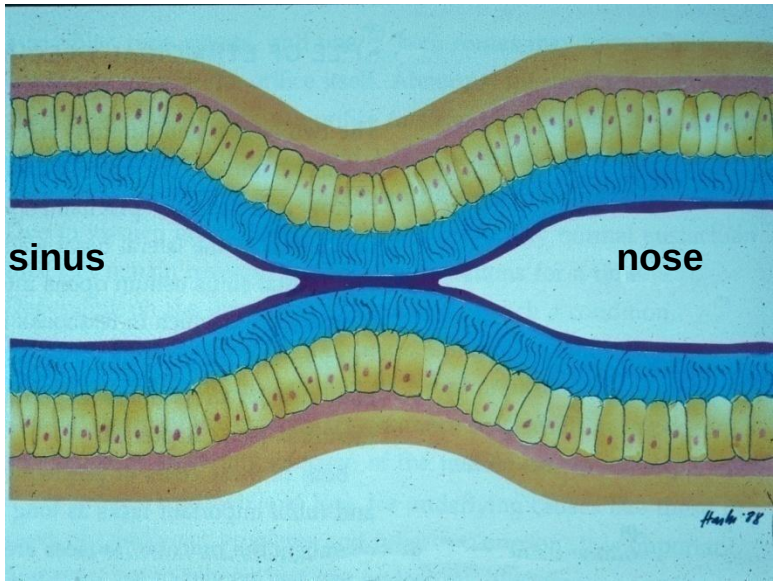
Prometheus, Springer Verlag

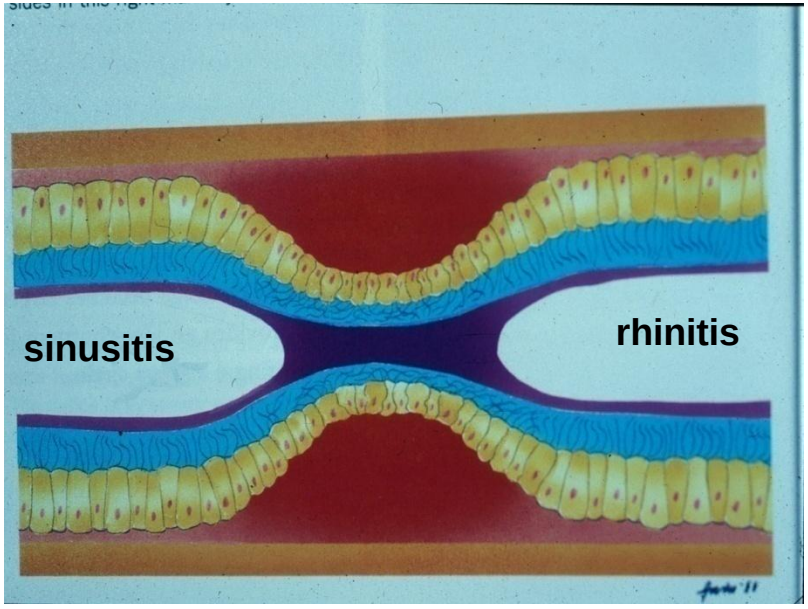
Mucociliary Dysfuntion

- Defect Cilia (immotile, merely inefficient or unsynchronized beatment)
  - Primary Ciliary Dyskinesia, Kartagener Syndrome
- Mucus viscosity
  - Cystic Fibrosis (Mucoviscidose)
- Destroyed Cilia (mostly secondary)
  - Enviromental Exposure, Radiotherapy, Smoking, etc.

Sinus Ostia

Osteomeatal Complexe





Physiological :

- Ostium open for mucociliary transport
- Not necessarily more open

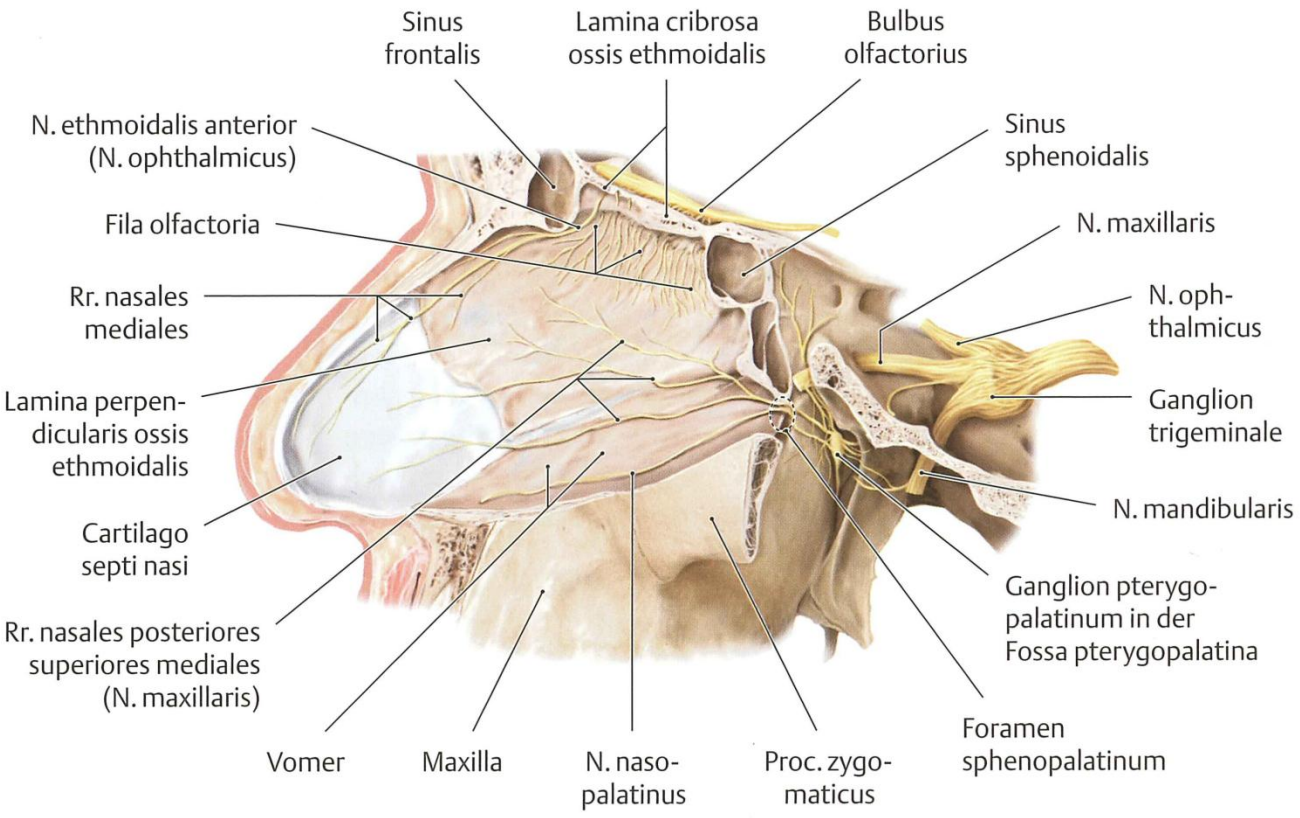
Pathological :

- Inflammation blocs the permeabiliy of the ostium
- Mucociliary transport impossible

Sensory Organ

Nasal Functions

Olfaction and Trigeminal (Touch/Somatosensory)



Prometheus, Springer Verlag

Sensory Organ

Nasal Functions

<u>Trigeminal Nerve</u>

- **Airflow Perception**
- **Reflexes (<u>defense</u>)**
  - Sneezing (ex: pepper)
  - Cough (ex: dust)
  - Inspiratory stop (ex: ammonia)

Angell James, Proc R Soc Med 1969

Axillary – Nasal Reflex

More cross area = more space

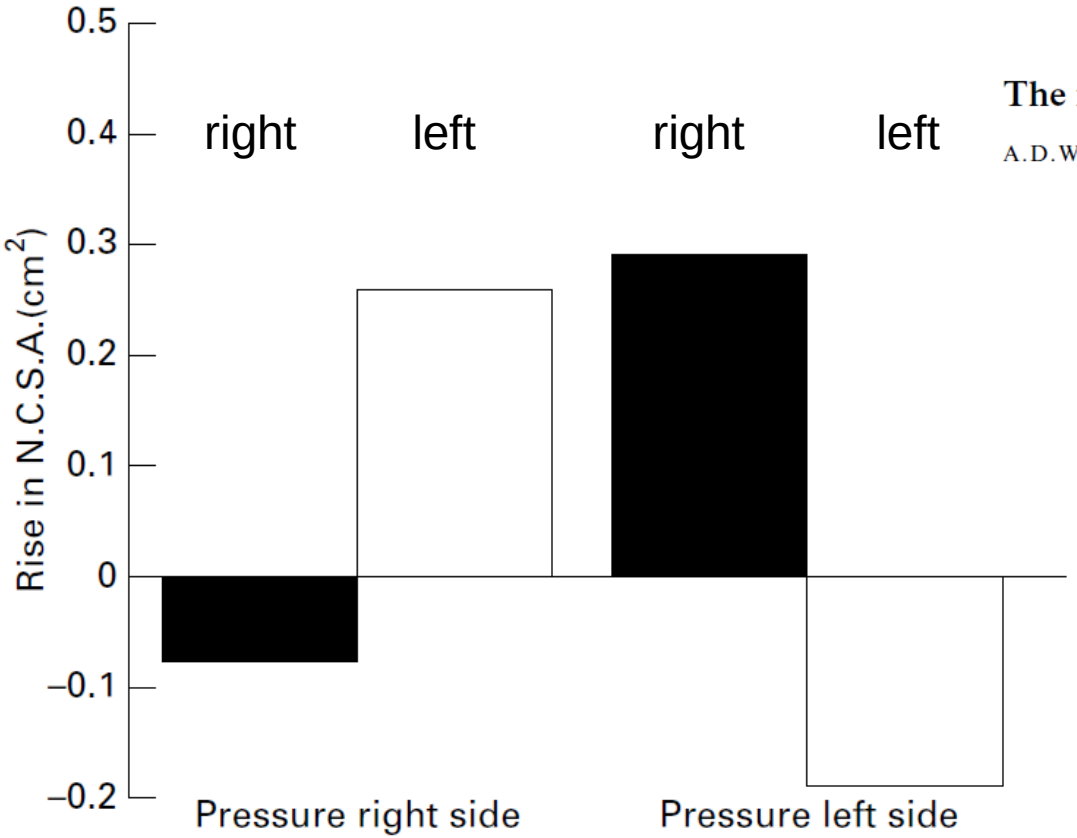


Figure 1.

Clin. Otolaryngol. 1996, **21**, 442–444

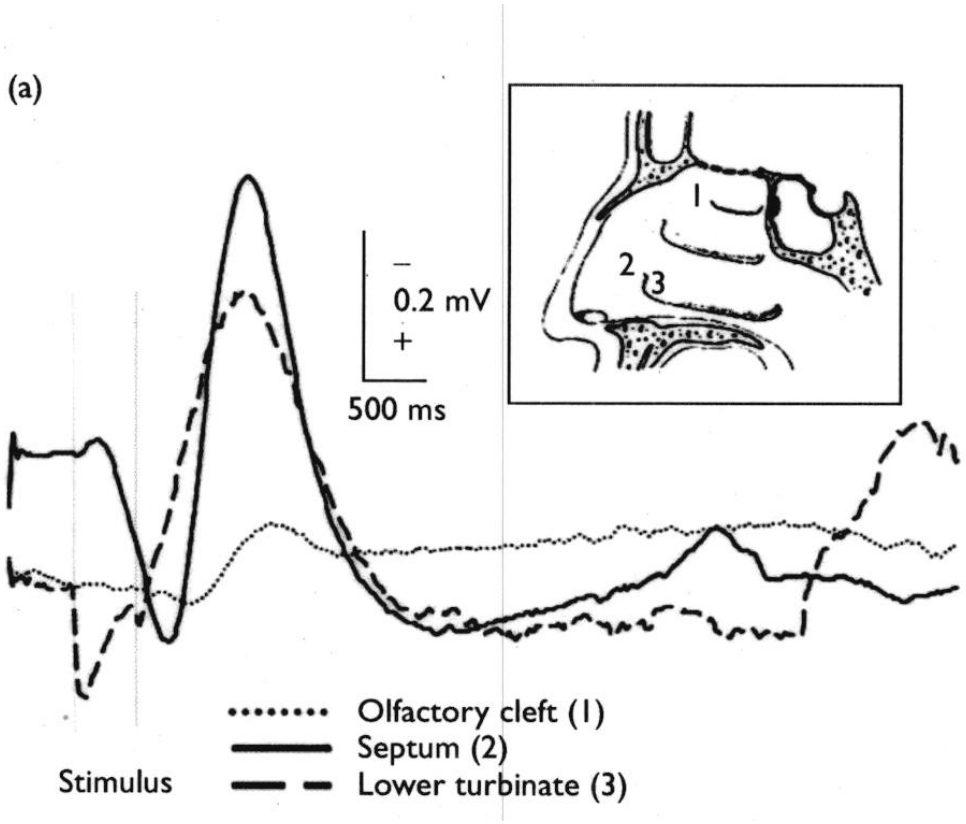
The nasal response to axillary pressure

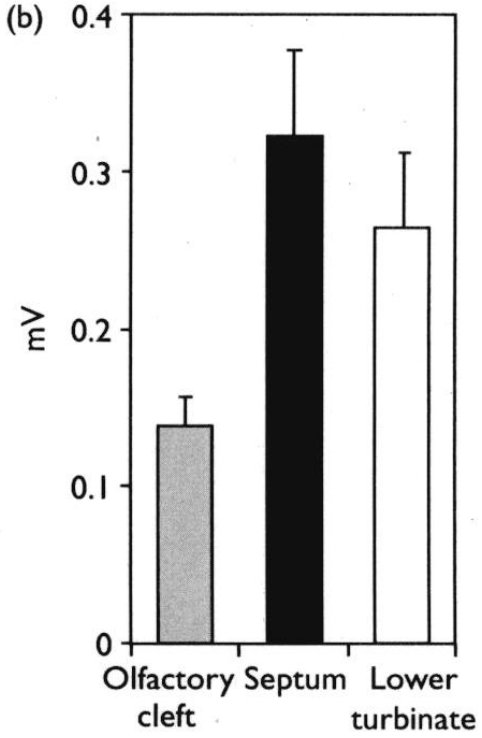
A.D.WILDE & A.S.JONES

The nasal mucosa exhibits laterality in its vascular erectile response to axillary pressure with congestion on the side of the stimulus and clearing on the opposite side. The rise in

Nasal Mucosa – Sensory Organ

Negative Mucosa Potential (NMP):

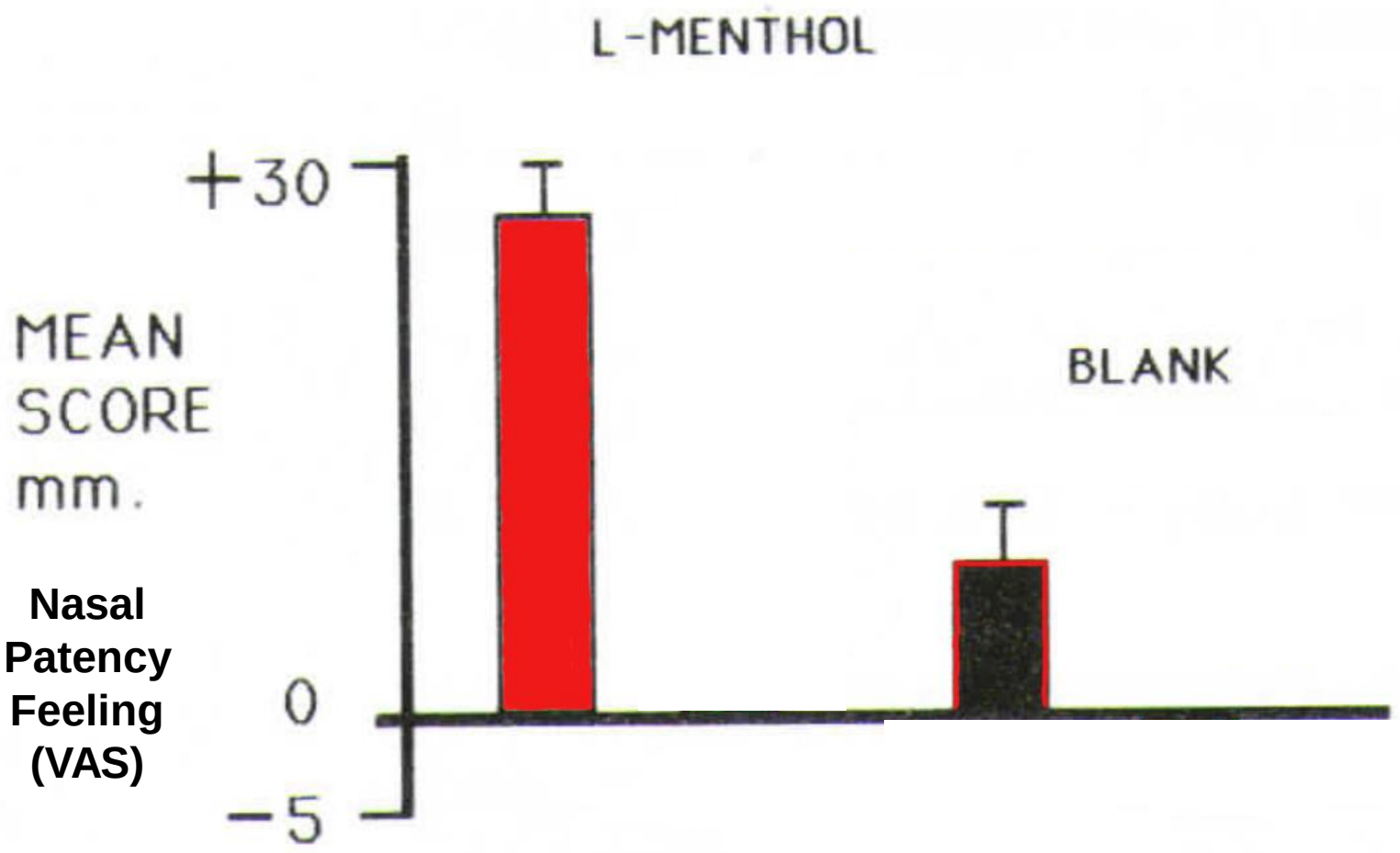




Nasal mucosa is functionally not homogeneous !

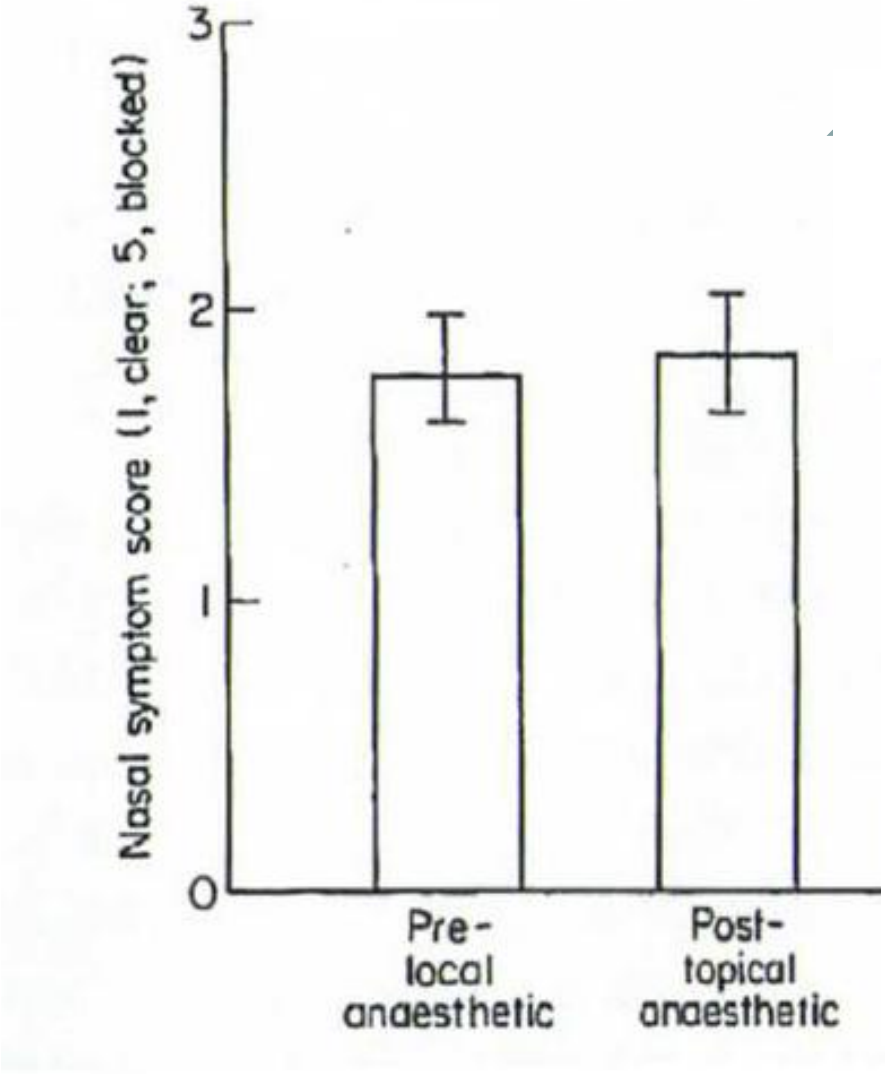
Scheibe, Neuroreport 2006

Clinical Relevance: Airflow Perception



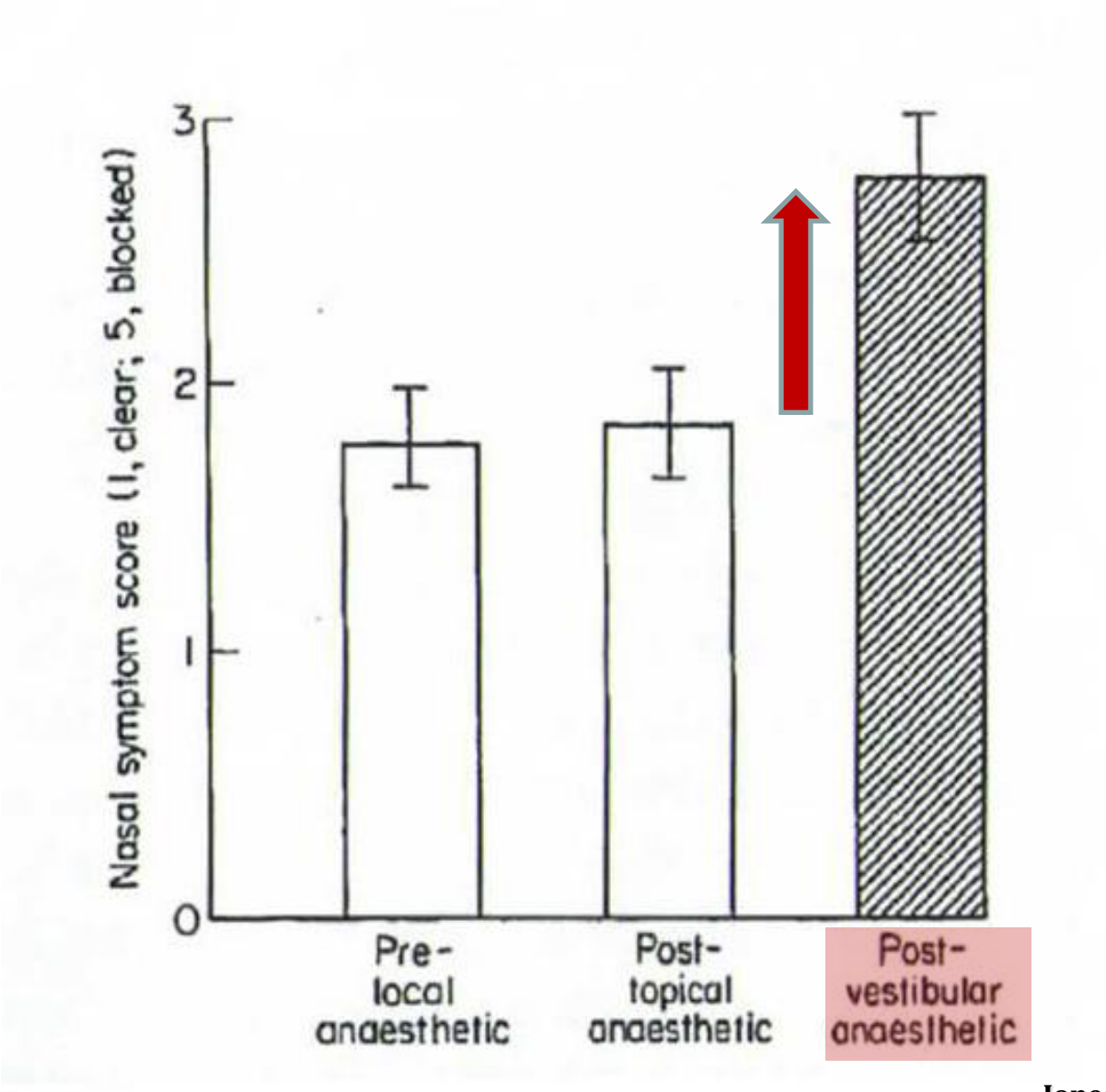
Eccles, Acta Otolaryngol 1988

Clinical Relevance: Airflow Perception



Jones, Clin Otolaryngol 1989

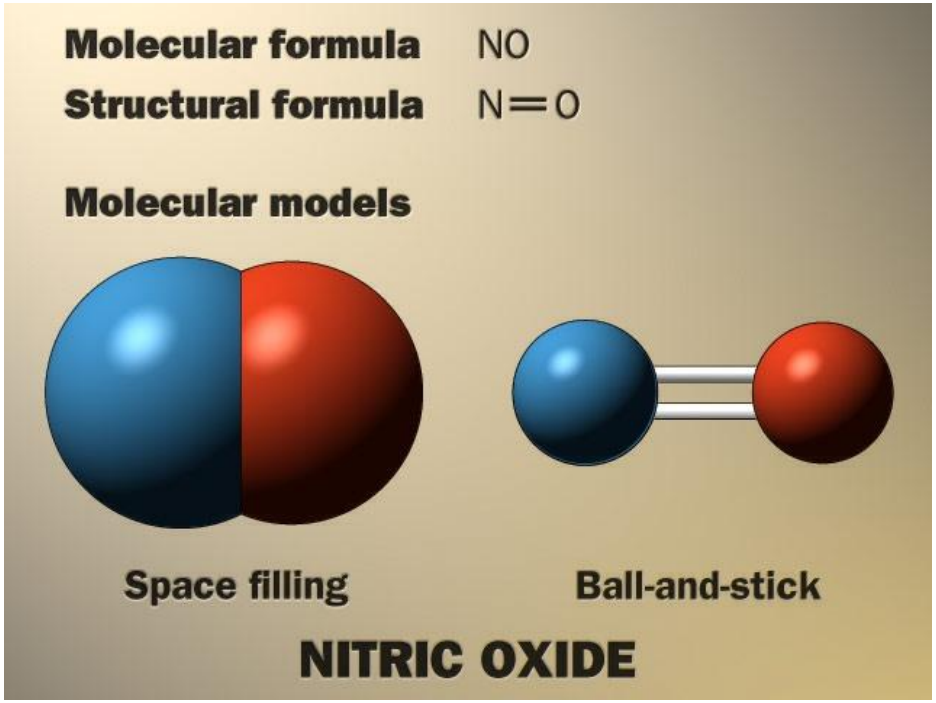
Nasal Valve Anaestesia: Airflow Perception

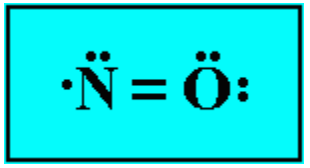


Jones, Clin Otolaryngol 1989

Physiology

Nasal nitric oxide





→ free radical !

NO – Nitric oxide

- Nasal nitric oxide
  - Discovered accidentally (Gustafsson et al. *Biochem Biophys Res Commun, 1991)*
  - Free radical produced at high concentrations by the sinonasal mucosa
    - sinus > nasal cavity
    - concentrations above allowed industrial emission values !

Physiology

- Function of the nasal NO:
  - Improve the gas exchanges at the alveolar level (lung) – improves mismatch ventilation-perfusion
  - Essential for mucociliary function
  - Airborne protection against pathogens

Lundberg, Thorax, 1999

Physiology

Nasal Nitric Oxide

- Antibacterial et Virocide

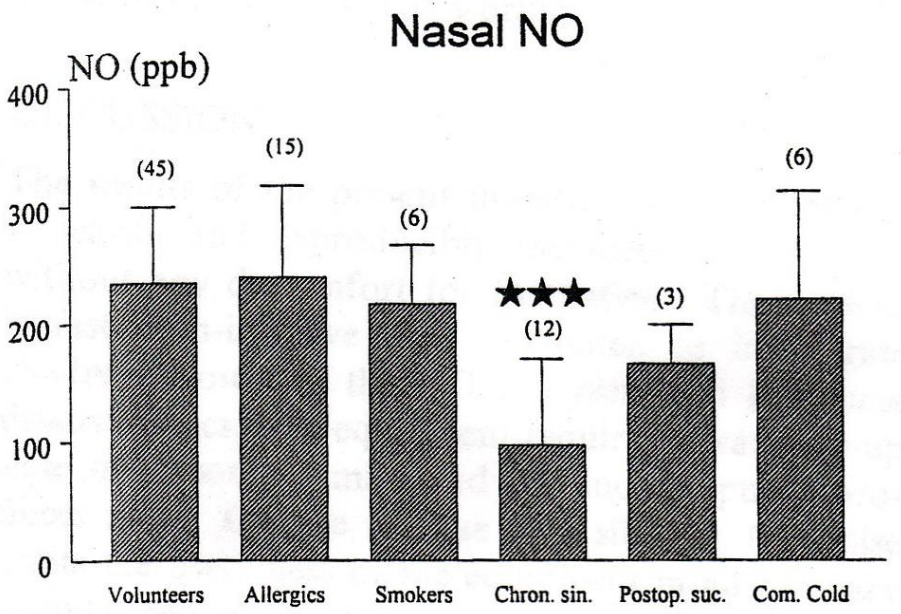


Fig. 2. Bar diagram of steady state nasal NO concentration in the various subgroups investigated. Data are presented as means and SD. *** $= p < 0.001$ vs. healthy subjects (Mann-Whitney U test).

Lindberg, Acta Otolaryngol 1997

Physiology

Nasal Nitric Oxide

- Mucociliary beat frequency

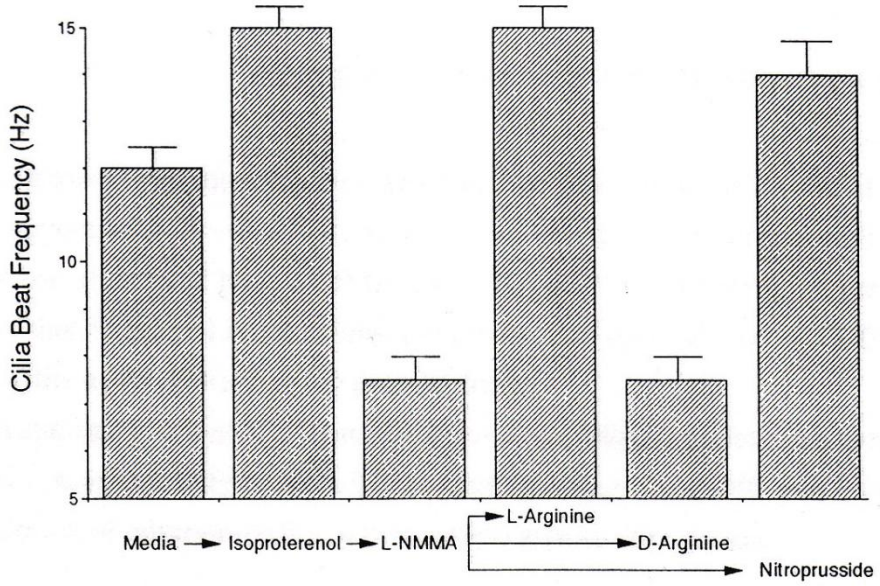
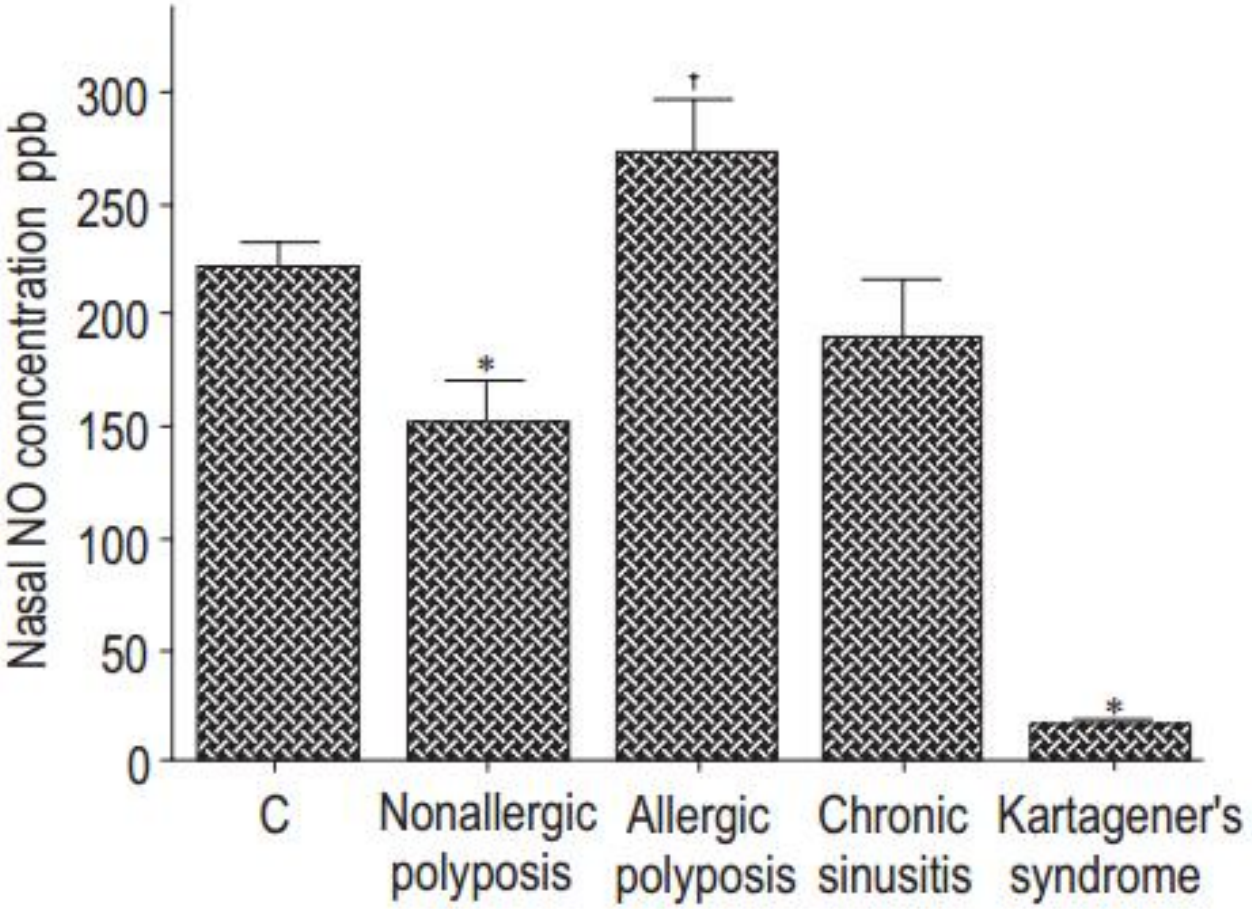


Figure 4. *Reversal of the effects of NOS inhibitors on CBF by L-arginine and NO donors.* Ciliary beat frequency (CBF) was measured at baseline (t = 0 min) and after the sequential addition of isoproterenol (1 mM; t = 30 min) and N^G-monomethyl-L-arginine (L-NMMA; 0.1 mM; t = 40 min). L-arginine (10 mM), sodium nitroprusside (0.1 mM) or D-arginine (10 mM) was then added (t=40 min) and CBF again determined (t = 50 min). CBF represents the mean ± SEM of at least 5 different cells on each of three plates.

Jain, Biochem Biophys Res Comm 1993

Nasal NO in different pathologies



Arnal, Eur Resp J 1999

Physiology

Nasal Nitric Oxide

- Lung: improving ventilation-perfusion

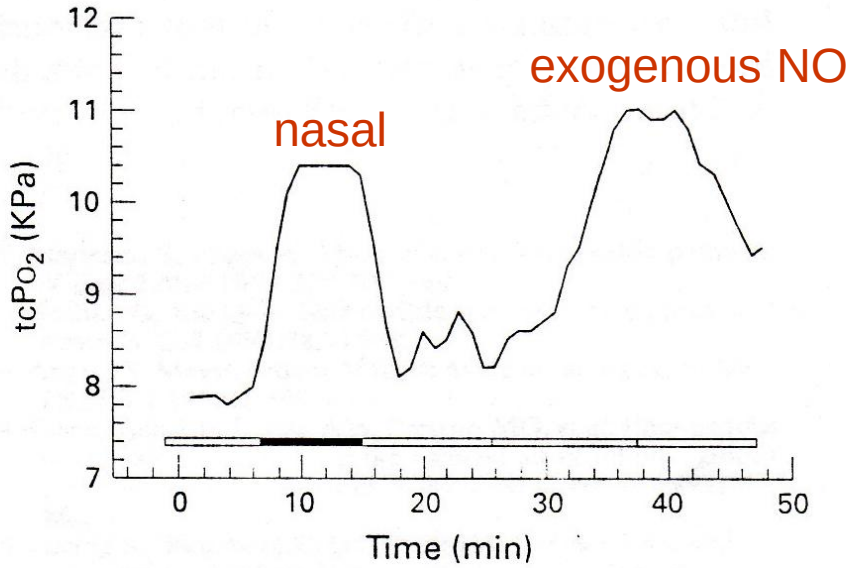


Figure 2 Representative tracing showing transcutaneous oxygen tension in a healthy subject during periods of oral breathing (empty bars), nasal breathing (filled bar), or oral breathing of air containing exogenous NO at a concentration of 100 ppb (hatched bar). Reprinted from Lundberg et al[63] with permission.

Lundberg, Thorax, 1999

Merci de votre attention!

Giacometti, Le nez