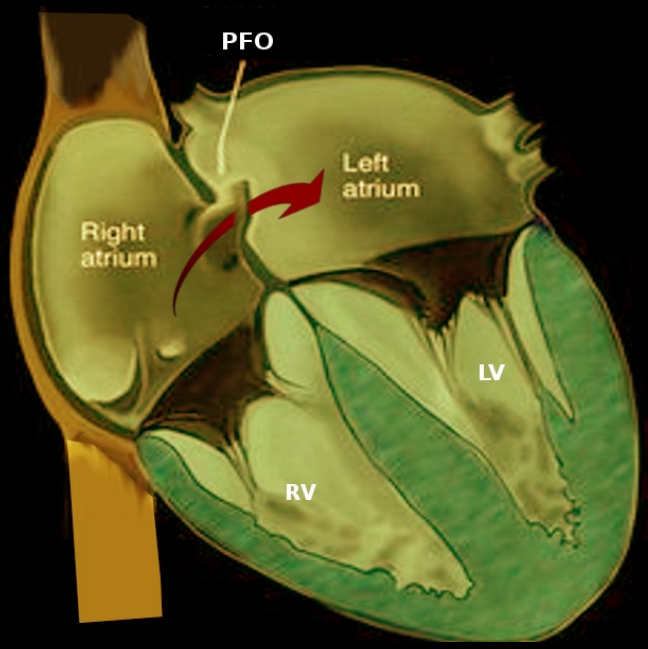
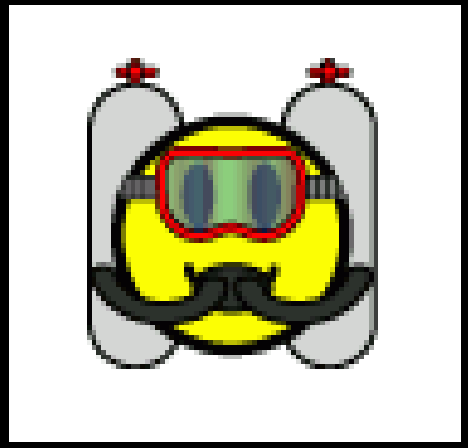
Patent Foramen Ovale





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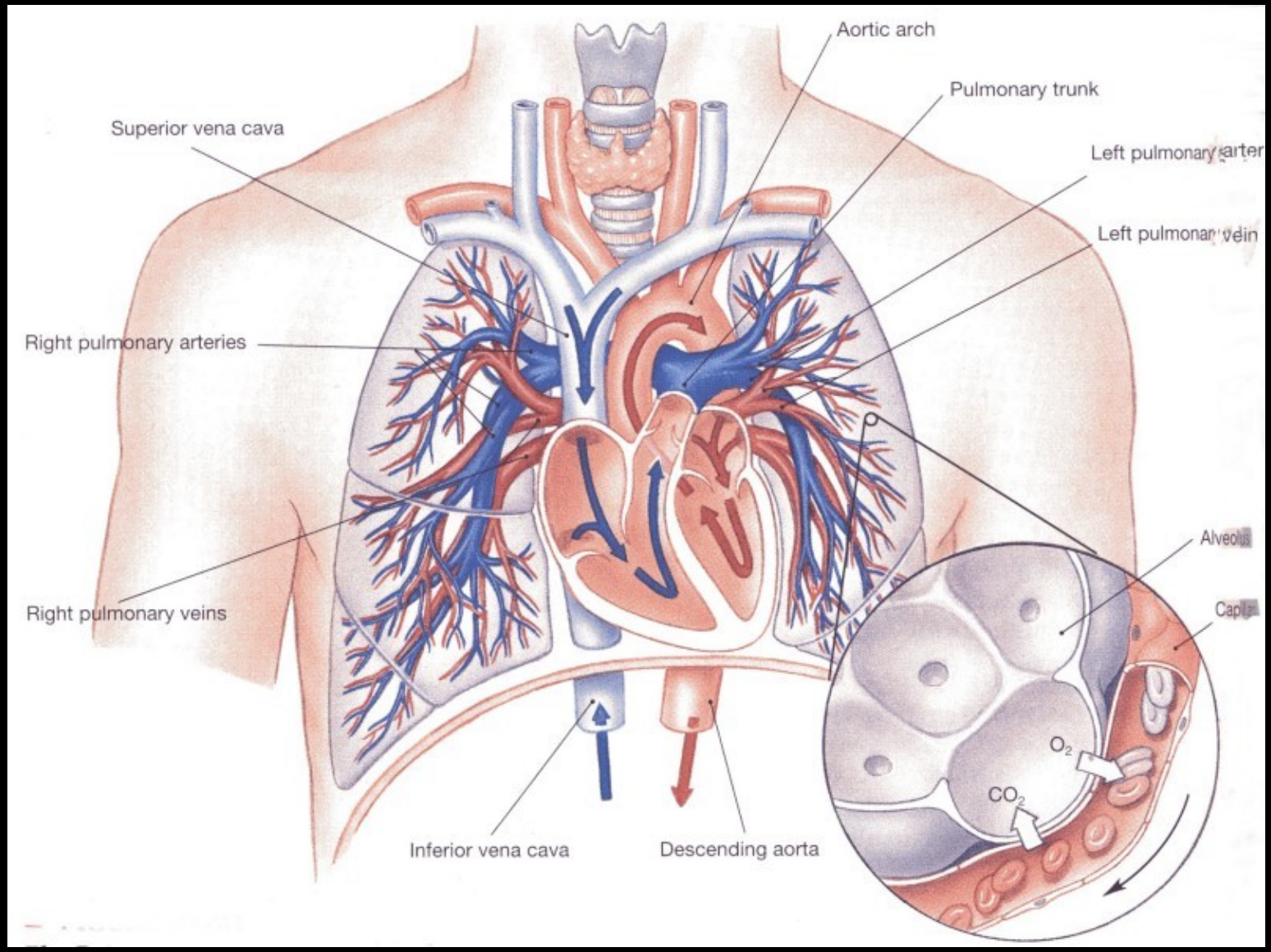
General Heart-Lung Circulation



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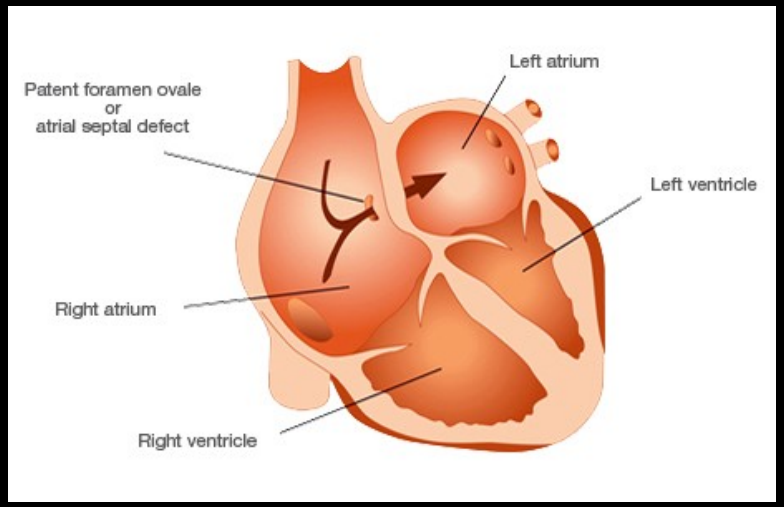
Patent Foramen Ovale

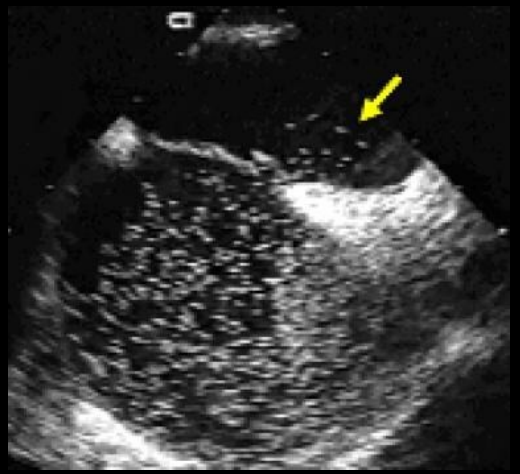
Opening in septum secundum



Patent: open
Foramen: aperture in tissue or bone
Ovale: oval shaped

Present in:
Unborn (mom functions as lungs)
~25 – 30 % of population
~ 6% large opening
~ 5% of serious DCS cases

PFO:
Some blood flow bypasses the lungs (bubble filter)
Bubbles in circulation: can pass into arterial circulation
(Best to assume we bubble on every dive ascent)
Possible source of CNS lesions seen in brain and spinal cord



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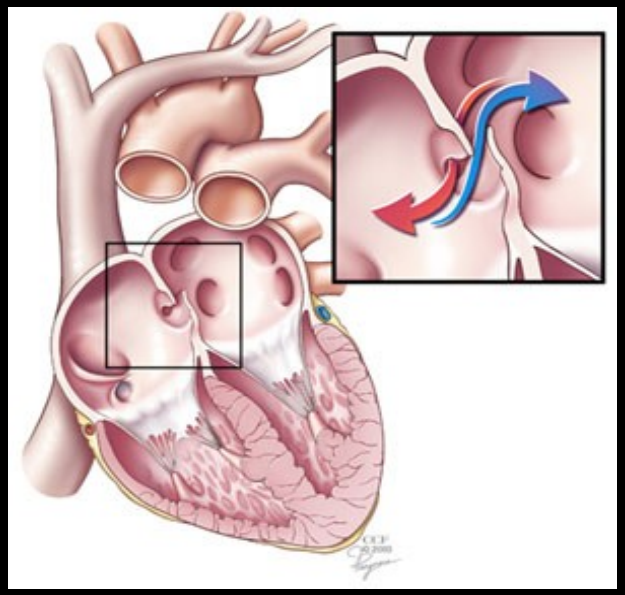
PFO: Allows Direct Path to Arterial Circulation

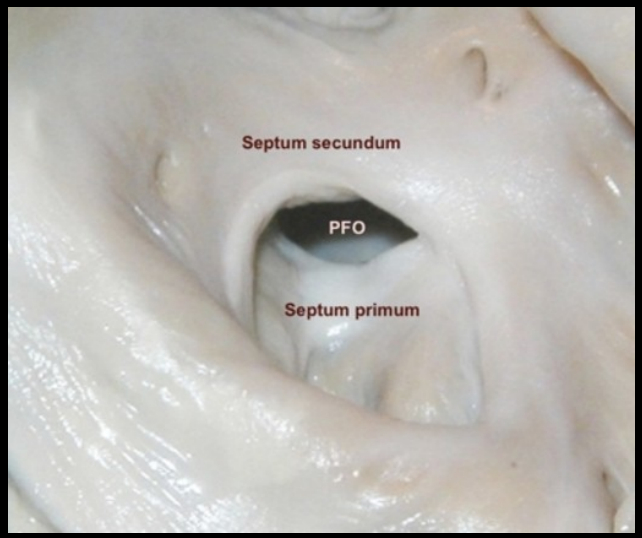
Bubbles can move into arterial circulation

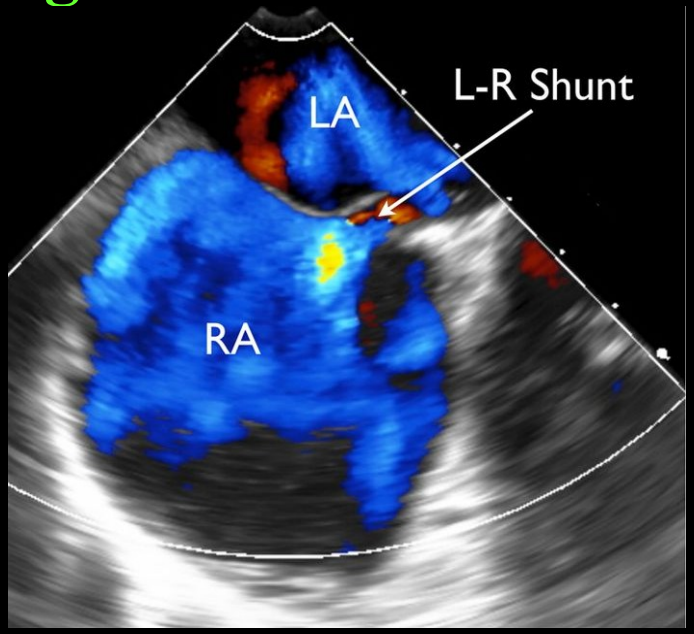


Can lead to:

- CNS lesions
- Severe neurological DCS
- Air embolism on descent

Diagnosed with Ultrasound





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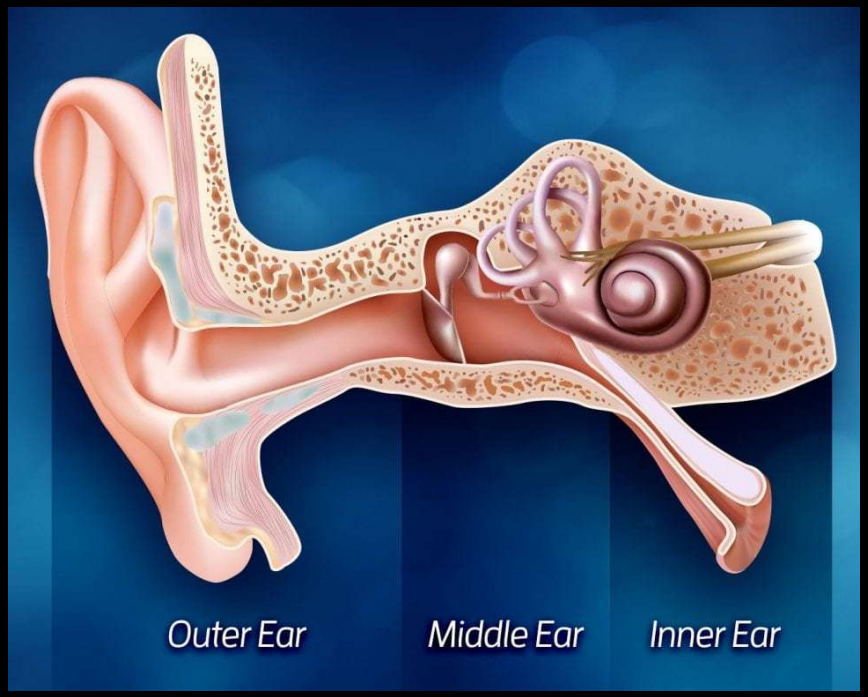
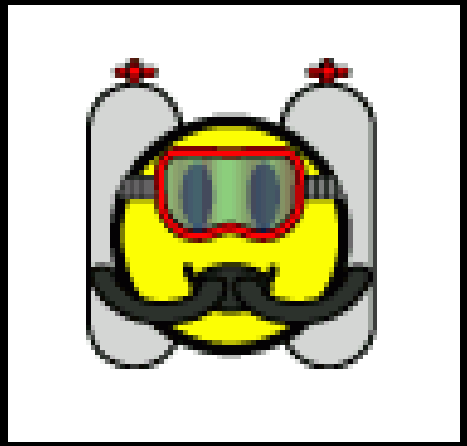


Ear Issues



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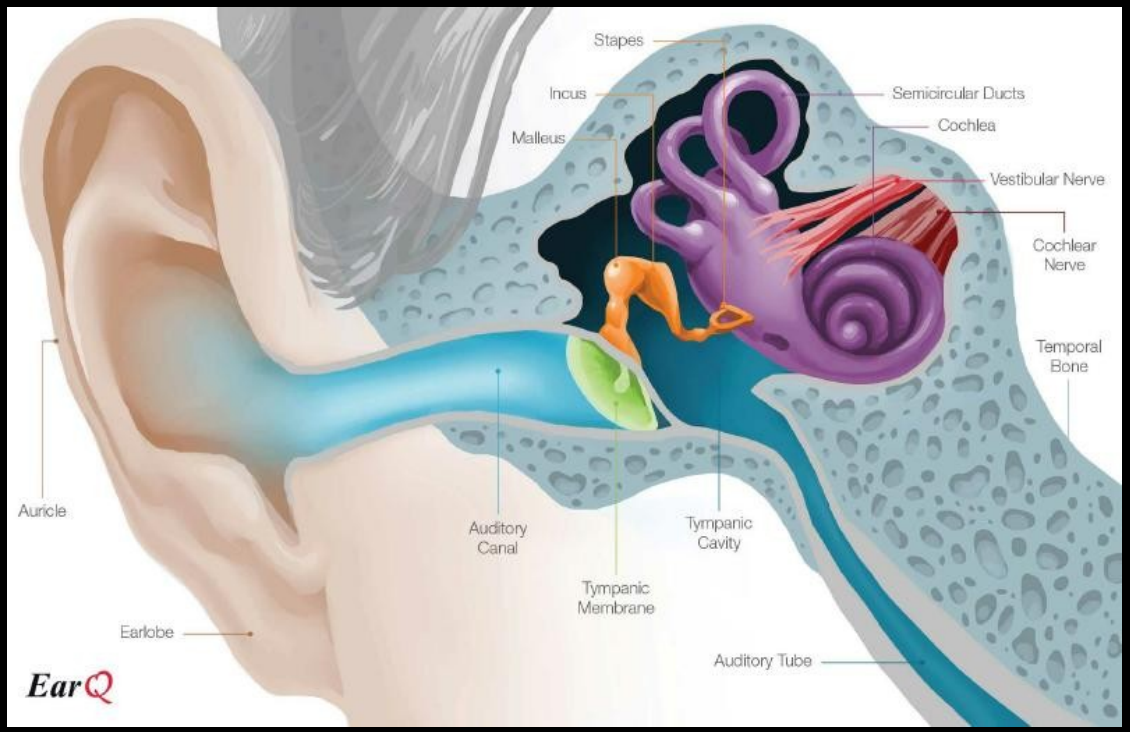
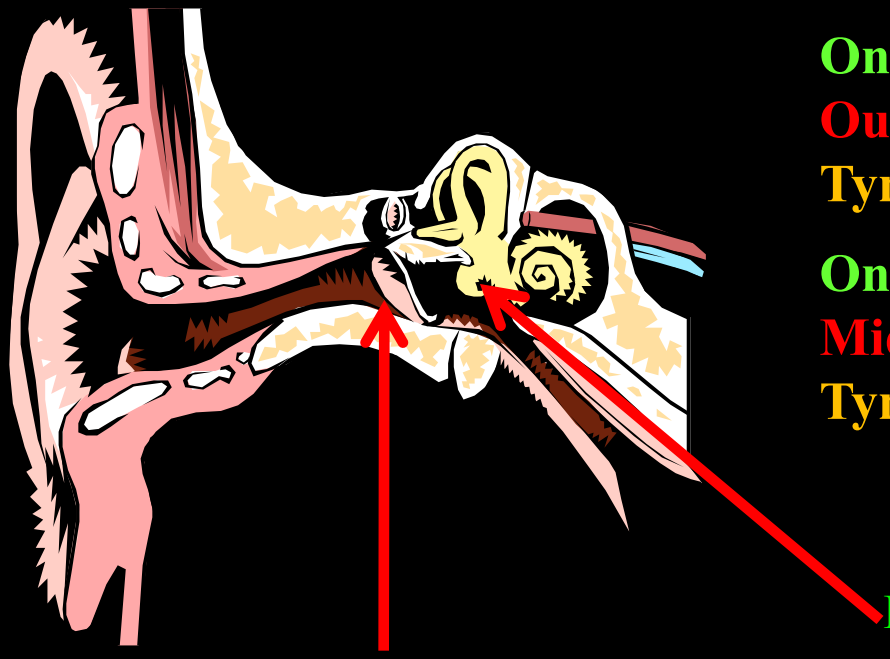
“Clearing” The Ears



> 80 % of basic students suffer ear barotrauma on first open water
George Hapur (Canadian Hyperbaric Physician)

Equalizing ("Clearing") Middle Ear Pressure

"Clearing" equalizes pressure across the tympanic membrane



Round Window

Tympanic Membrane
Separates Outer and Middle Ear
Transmits Vibrations to Middle Ear

On Descent:
Outer Pressure > Middle Ear Pressure
Tympanic Membrane Moves Inward

On Ascent:
Middle Ear Pressure > Outer Pressure
Tympanic Membrane Moves Outward

Too much movement (~ 8 fsw change) can rupture the ear drum
Possible ear infection from water entering the middle ear

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“Clearing” Techniques:
(Most often a problem on descent)

Common Techniques:
Valsalva: Pinch nostrils and blow
Toynbee: Pinch nostrils and swallow

For all descents:
- **Start prior to descent**
- **Clear Often**
- **Slowly move feet first**
- **Look up**

If feeling pressure:
- **Ascend a bit to relieve**
- **Extend jaw forward**

Do NOT swallow
- **Air in stomach can expand on ascent**
- **This can rupture the stomach**

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The Valsalva Maneuver

Pinch Nostrils and Gently Blow
Most Taught Technique

Vigorous Valsalva - Dangerous technique

- Builds Internal Pressure
- Transmitted via CSF to Brain
- Possible Round Window Rupture
  - Loss of hearing if not surgically repaired
- Can drive bubbles thru PFO (if present)
  - Possible air embolism on descent
- Can Constrict Eustachian Tubes

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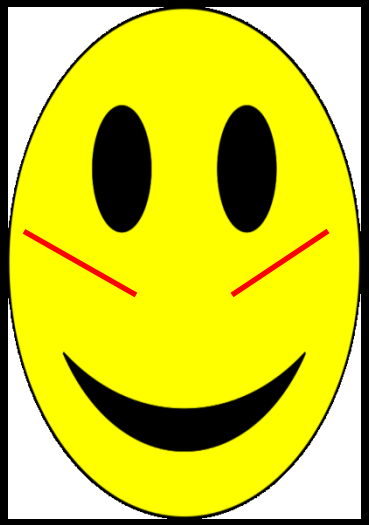
Pressure Equalization Difficult For Youngsters

Young Face Round
Eustachian Tube Flat
Easily Collapses
"Glue Ears"



Adult Face Elongated
Eustachian Tube Angled
Eustachian Tube "Enfolded"
Less resistant to collapse
Not fully formed until late adolescence

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Frenzel Technique

Developed During WWII For German Stuka Pilots

Rapid pressure increase during descent
Pilots needed both hands on control stick
Frenzel developed for hands free clearing

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Frenzel Technique

Hands Free Equalization of Ear Pressures

Place tongue on the roof of the mouth… as far forward as possible
Hold tongue there
Imagine (‘cause you can’t physically do this):
  Driving the tongue through the top of your head
This “ tongue flick” sends a gentle flow of air up the Eustachian tube

You should hear a “click” in each ear
  From wave of air flow hitting the back of the tympanic membrane

Avoids all the issues with Valsalva
Safest method of equalizing ear pressures

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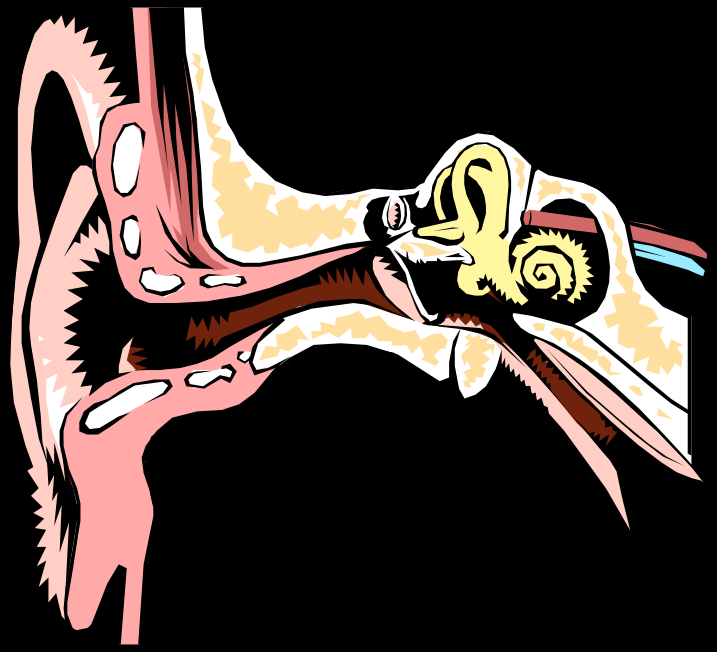
“Clearing” While Ascending



Valsalva is opposite of need

Need to decrease middle ear pressure

If Pressure felt,

Pinch nostrils and gently suck

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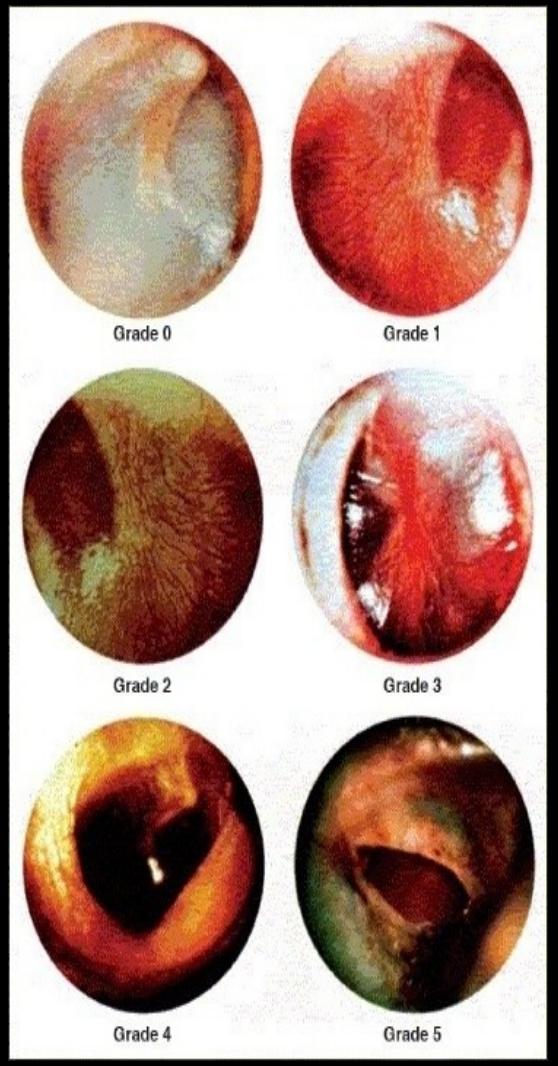
Middle Ear Barotrauma

Symptoms of mild ear barotrauma:
- pain in the ear
- difficulty hearing or mild hearing loss
- dizziness
- feeling of fullness and pressure in the ear

Symptoms of moderate to severe ear barotrauma:
- damage to the eardrum
  - tearing allows water to enter middle ear → infections
- bleeding from the ear
- increased pain in the ear
- constant feeling of pressure and fullness in the ear
- moderate to severe hearing loss

Unequal response
- pressure different
- sensation of spinning
- termed alternobaric vertigo

Tympanic Membrane



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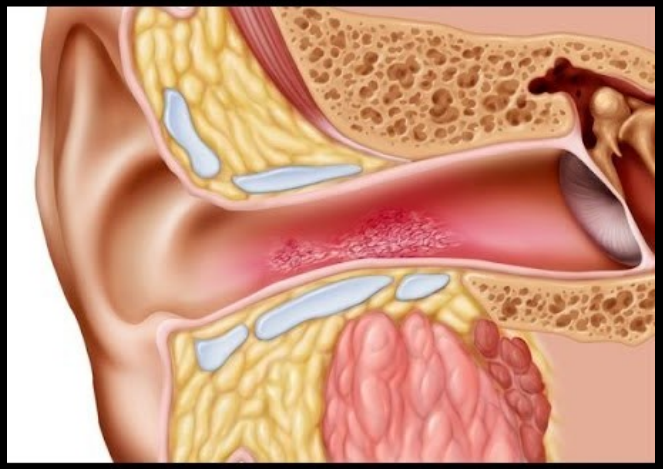
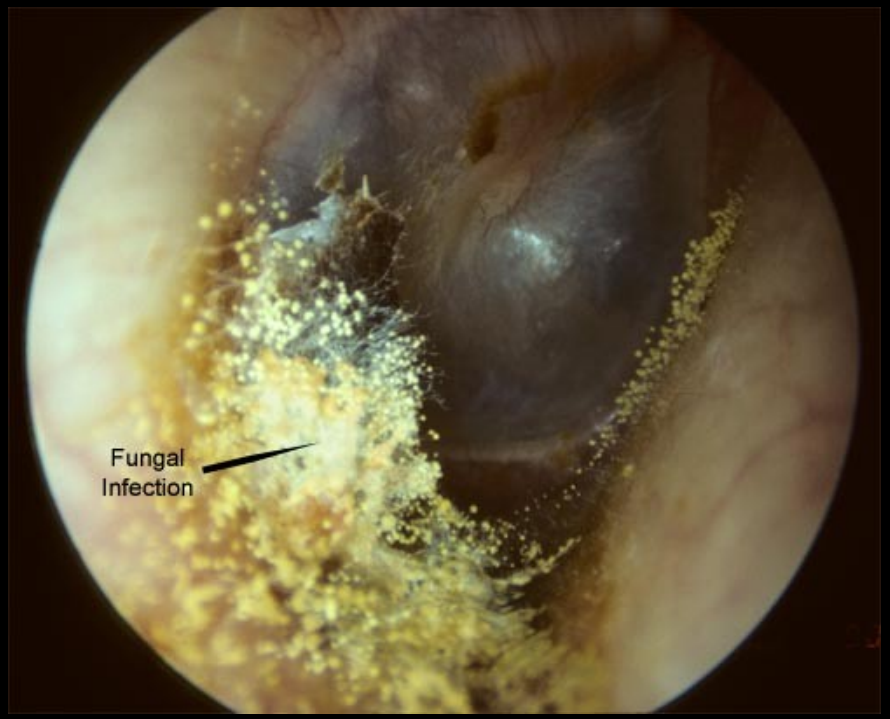
Swimmer's Ear (Otitis Externa)



Most freshwater contains microbes and fungi
They survive well in warm, dark places
They do not survive well in acidic environments

Prevention:
Rinse ears with vinegar after every diving day
Avoid alcohol in ear: dissolves protective ear wax



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