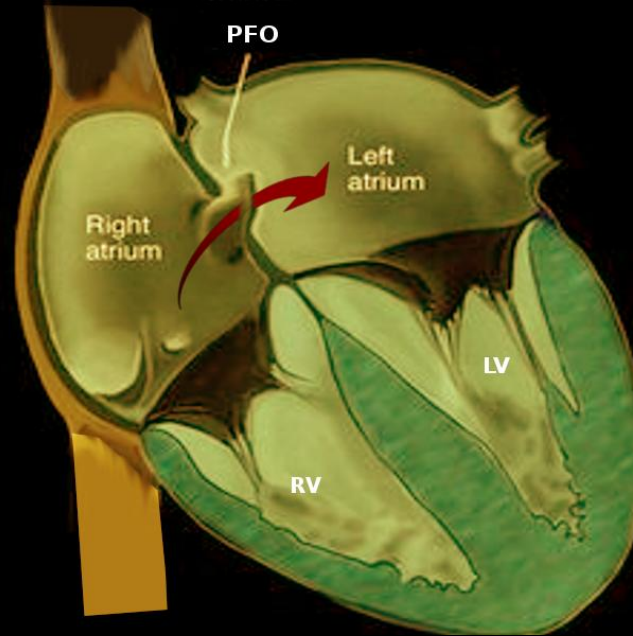
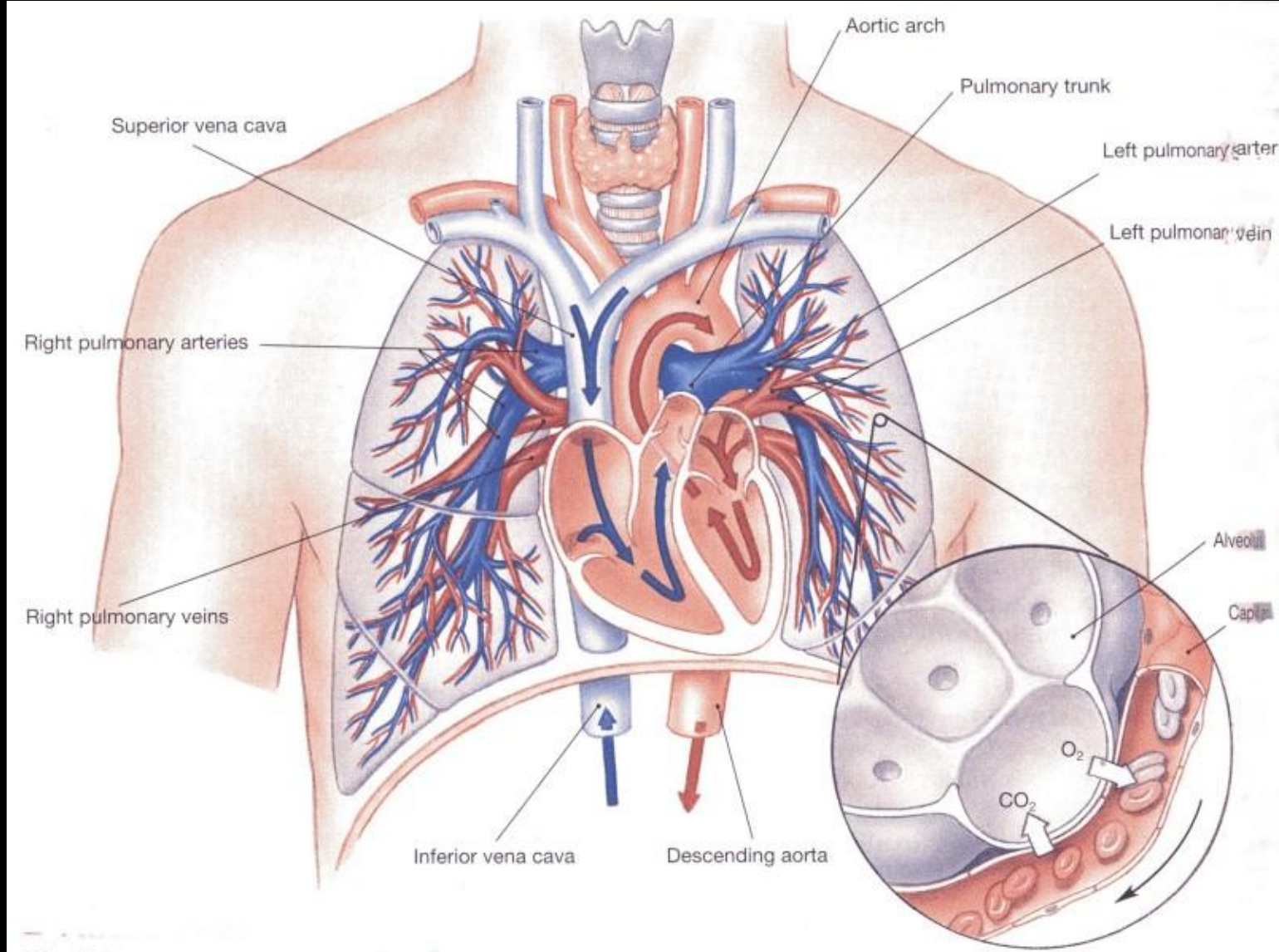


# Patent Foramen Ovale

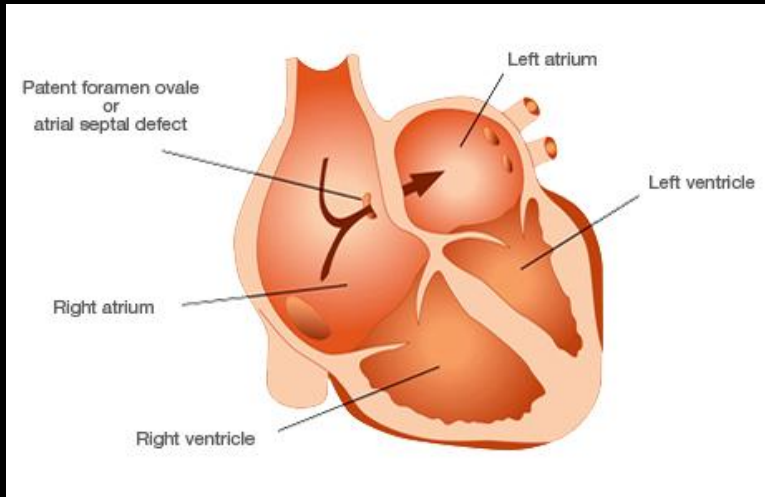


# General Heart-Lung Circulation



# 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**

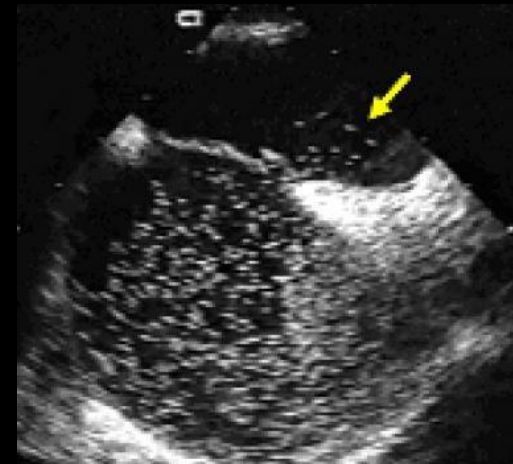
**PFO:**

**Some blood flow bypasses the lungs (bubble filter)**

**Bubbles in circulation: can pass into arterial circulation**

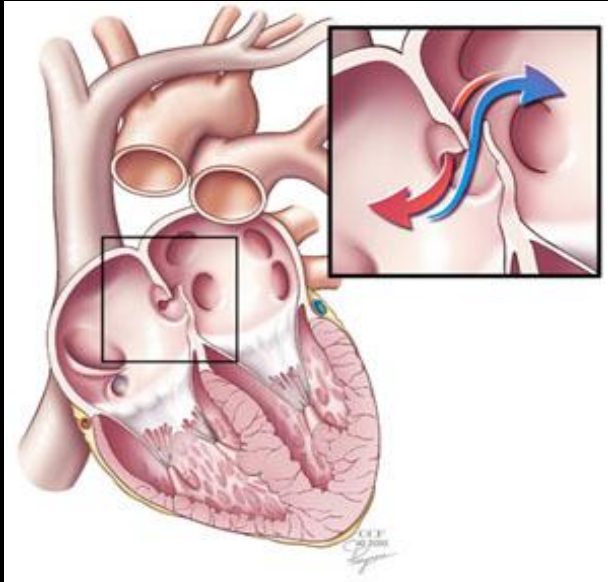
**(Best to assume we bubble on every dive ascent)**

**Possible source of CNS lesions seen in brain and spinal cord**



# PFO: Allows Direct Path to Arterial Circulation

Bubbles can move into arterial circulation



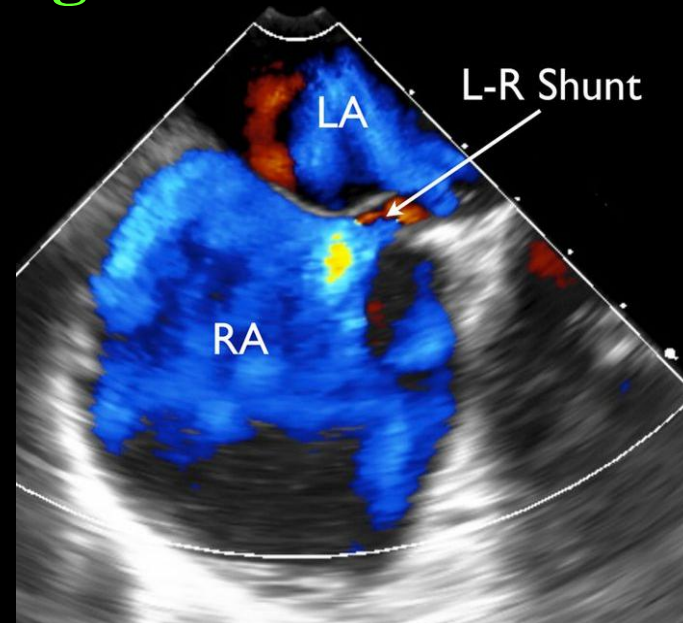
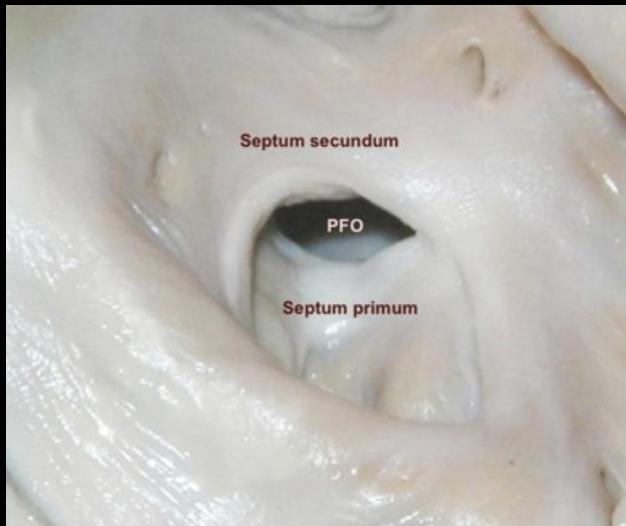
Can lead to:

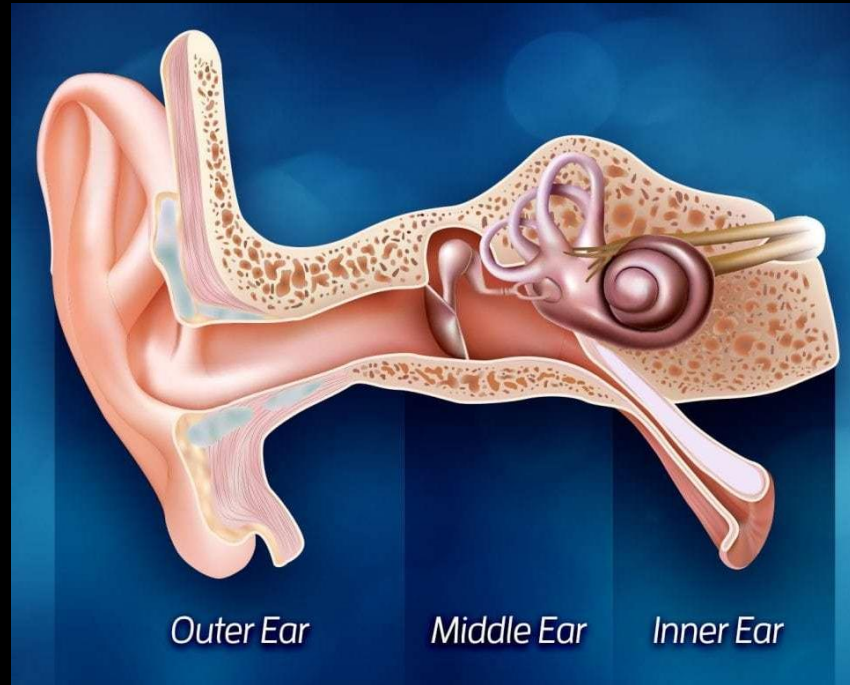
CNS lesions

Severe neurological DCS

Air embolism on descent

Diagnosed with Ultrasound

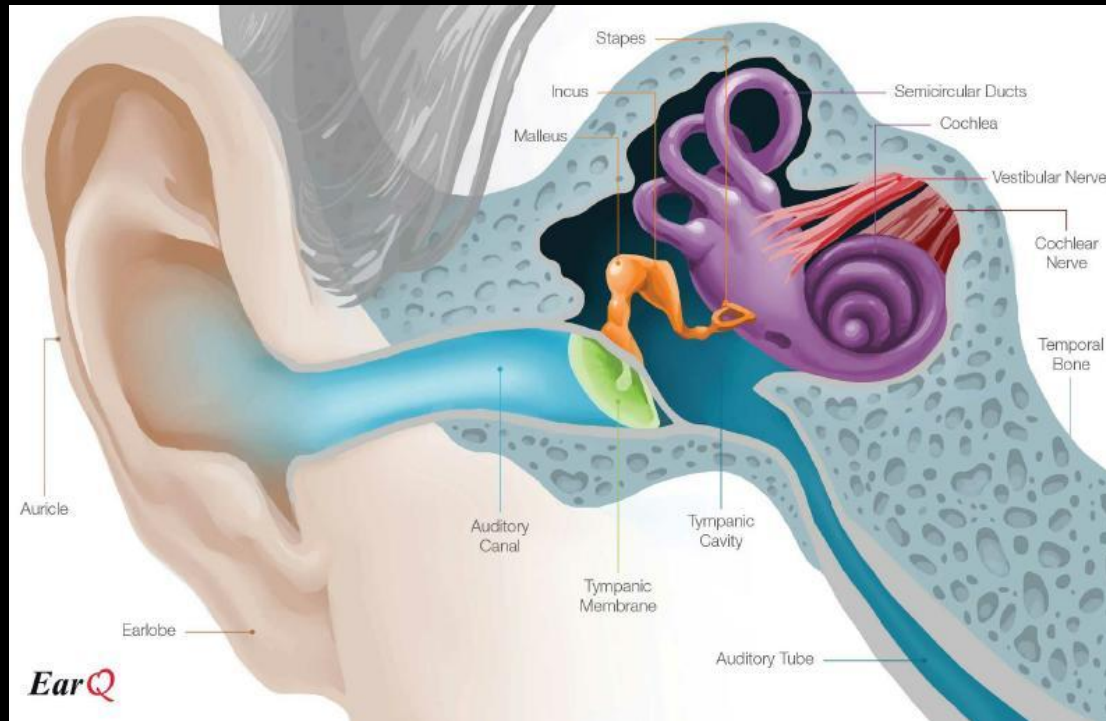




# Ear Issues



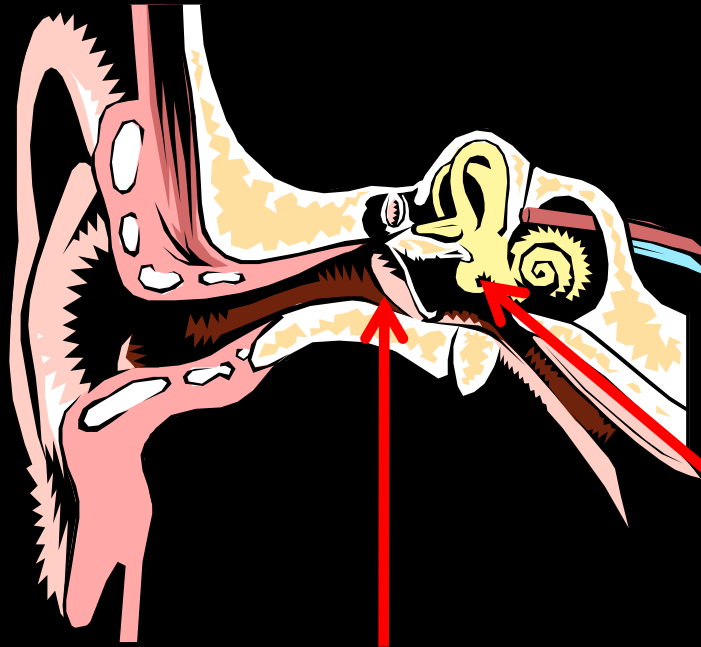
# “Clearing” The Ears



**> 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



**On Descent:**

**Outer Pressure > Middle Ear Pressure**  
**Tympanic Membrane Moves Inward**

**On Ascent:**

**Middle Ear Pressure > Outer Pressure**  
**Tympanic Membrane Moves Outward**

**Round Window**

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

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

# “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**



# 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**

# 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



# 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

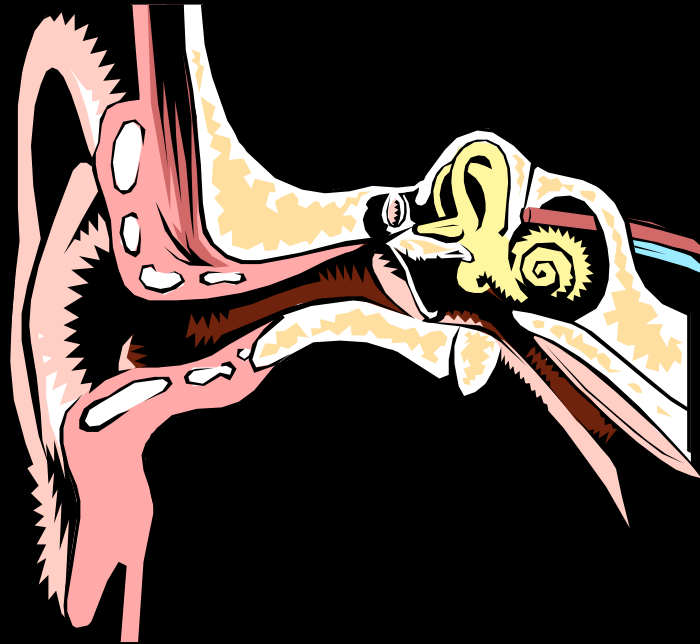
You should hear a “click” in each ear

From wave of air flow hitting the back of the tympanic membrane

**Avoids all the issues with Valsalva**

**Safest method of equalizing ear pressures**

# “Clearing” While Ascending



Valsalva is opposite of need  
Need to decrease middle ear pressure  
If Pressure felt,  
Pinch nostrils and gently suck

# 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

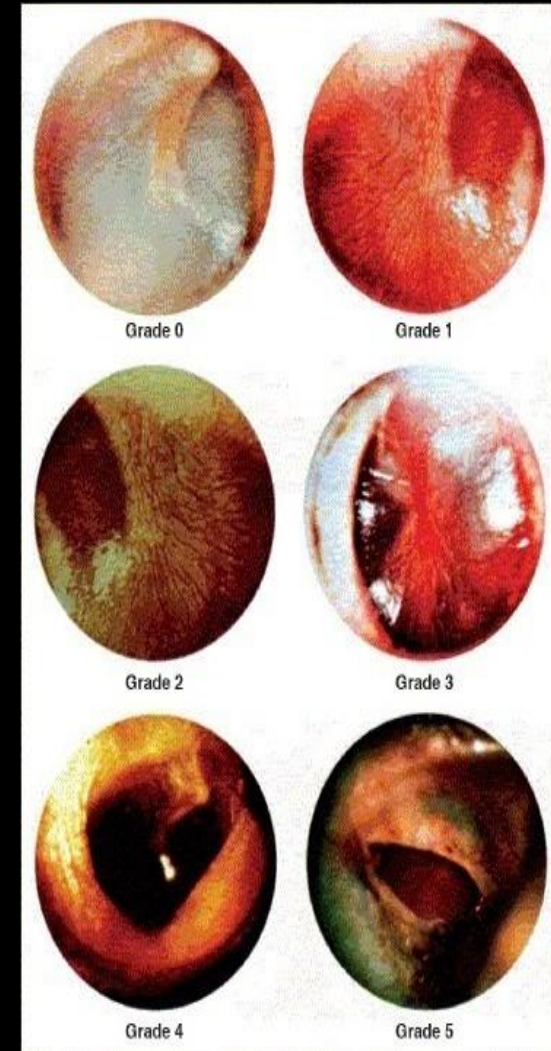
## Symptoms of moderate to severe ear barotrauma:

- 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

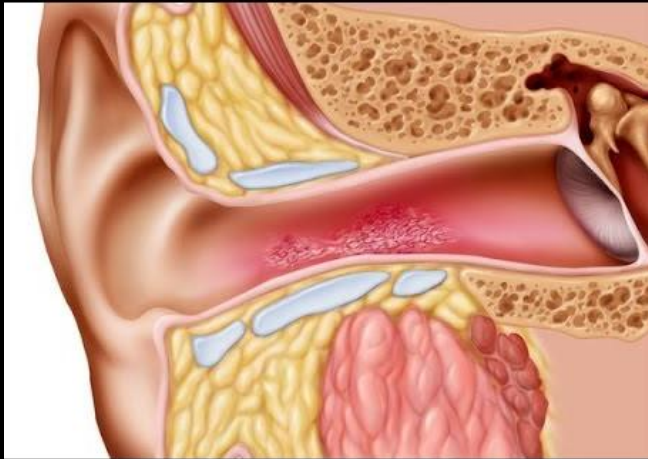
## Unequal response

- pressure different
- sensation of spinning
- termed alternobaric vertigo

## Tympanic Membrane



# 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

