


# DIVING MEDICINE

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PULMONARY & CRITICAL CARE MEDICINE
2021

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- Physical qualifications for diving
- Pulmonary overinflation syndrome / Pulmonary barotrauma
- Decompression sickness
- Nitrogen narcosis
- Shallow water blackout

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## NON-DIVING MEDICAL APPLICATIONS

- Barotrauma in hospitalized patients
- Pneumothoraces in Bullous lung disease or blebs
- Altitude changes
- Recreational – swimming, hiking, etc

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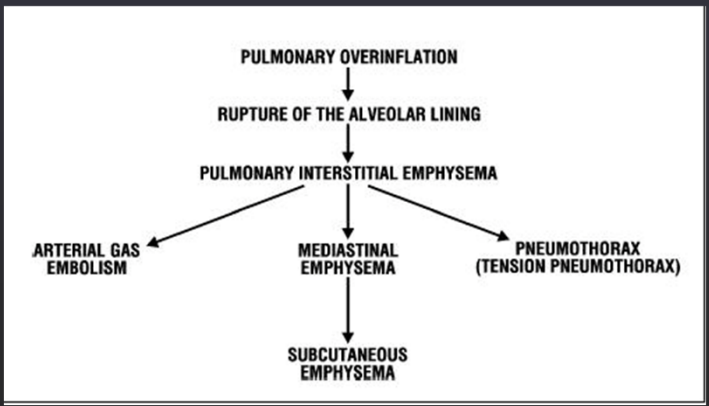
## PULMONARY OVERINFLATION SYNDROME / PULMONARY BAROTRAUMA




- Pneumothorax
- Subcutaneous Emphysema
- Mediastinal Emphysema
- Arterial Gas Embolism (AGE)

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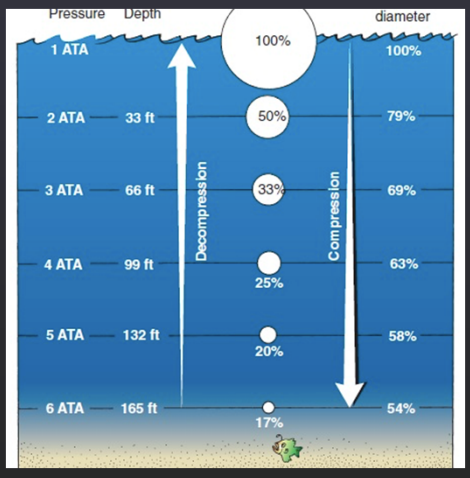
# PATHOPHYSIOLOGY




Boyle's Law

$P1 \times V1 = P2 \times V2$

Bouyancy effects

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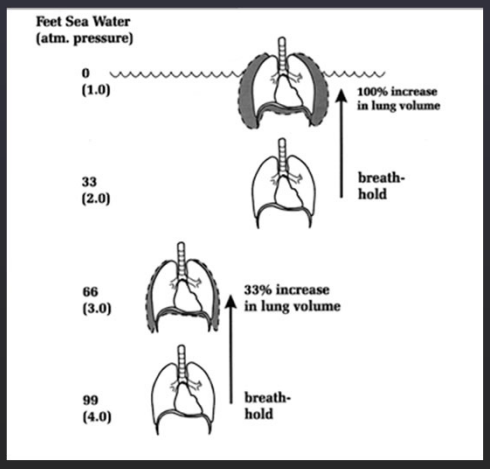
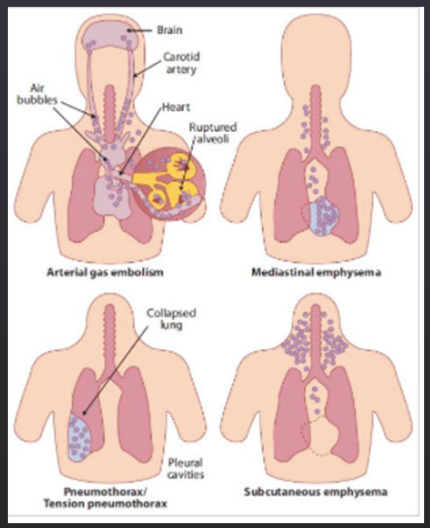
# PULMONARY BAROTRAUMA OF ASCENT

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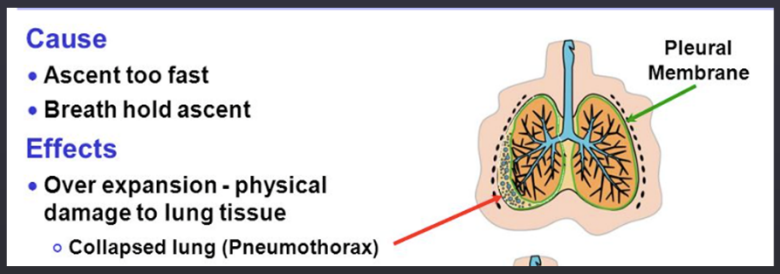
# PNEUMOTHORAX




- When visceral pleura ruptures and air enters the pleural cavity and expands during ascent.
- Less common than other POIS
- Considerations: PTX at altitude; recompression chamber

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# NON-DIVING RELATED PNEUMOTHORAX

- Ventilator associated due to high peak / plateau pressures, high tidal volumes in non-compliant lungs, underlying fibrotic or emphysematous lung disease, air trapping in COPD/asthma
- Aggressive Bag-Valve Mask ventilation
- Traumatic secondary to blunt or penetrating trauma (MVAs, stabbing, rib fractures, needle punctures from procedures, etc)

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- If incurred any type of barotrauma, risk for worsening if ascent to altitude (ie: traveling from Phoenix to Flagstaff, climbing up Mount Humphreys, going on airline flight or medical flight)
- Risks also present for patients with history of spontaneous pneumothorax or at-risk pulmonary disorders

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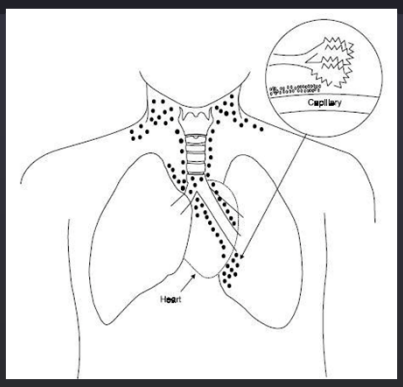
## SUBCUTANEOUS/MEDIASTINAL EMPHYSEMA




Hx: Breathing against high regulator resistance from low-on-air tank or rapid ascent

Tends to be delayed as tracking of gas occurs

S/Sx: voice changes, crepitus, dysphagia, etc

Tx: Observe –> shallow therapeutic recompression

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## NON-DIVING ETIOLOGIES FOR MEDIASTINAL & SUBCUTANEOUS EMPHYSEMA

- Ventilator associated and Traumatic(same as for PTX)
- CPR resuscitation
- Aggressive BVM especially with tracheostomies

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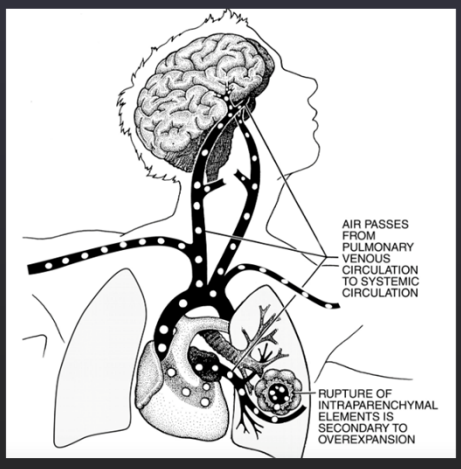
## ARTERIAL GAS EMBOLISM




- Gas passes from ruptured lung into pulmonary veins and into systemic circulation
- Occurs almost always within 5 minutes of ascent
- Can occur in ascent from as shallow at 3 FSW
- TX: 100% O2, recompression chamber

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# NON-DIVING MEDICAL APPLICATIONS FOR AIR GAS EMBOLISM

- Underlying PFO
- During surgeries involving clamping of arteries / major vessels (ie: cardiac and vascular surgeries)
- Clinically will appear as those patient had a stroke

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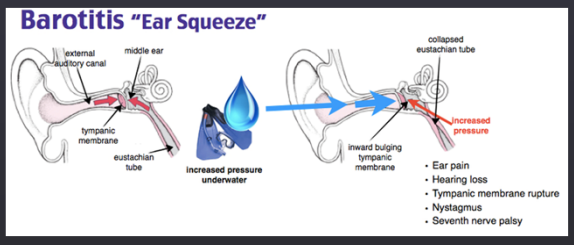
# Middle Ear Barotrauma





- Tissue damage occurs by expansion or contraction of enclosed gas spaces due to pressure changes
- Occurs on descent or ascent
- Avoid by equalizing, don't dive with ETD, caution with URI, allergies / consider decongestants
- Diving marine mammals have arteriovenous plexus in middle ear that responds to pressure changes

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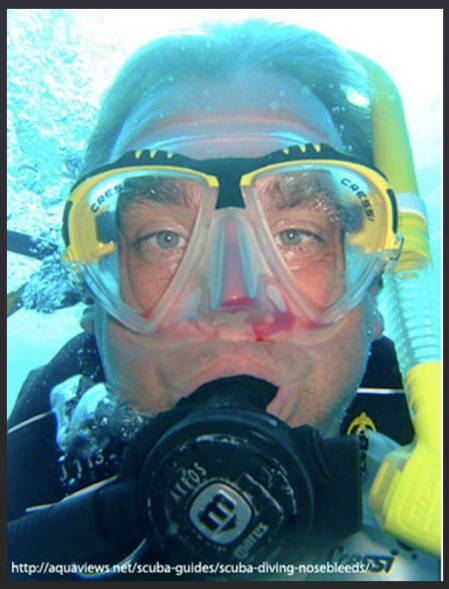
## Sinus Barotrauma




- Occur on descent when sinus ostium is blocked with mucosal congestion and hemorrhage to compensate for contraction of air within cavity
- On ascent, expansion of enclosed air expels blood and mucous from ostium. Occasionally may cause fracture of walls of lamina papyracea resulting in emphysema

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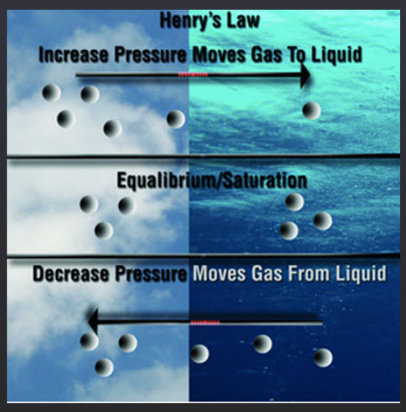
## DECOMPRESSION SICKNESS PATHOPHYSIOLOGY

HENRY'S LAW = When the pressure of a gas in contact with a liquid is decreased, the amount of gas dissolved in the liquid will also decrease proportionally

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- During the ascent or decompression phase of a dive, inert gas, which has been dissolved under depth pressure into tissues, comes out of solution under lower pressure.

- If we come up too quickly, then we may exceed the capacity for dissolved inert gas in our tissues, and the excess gas has no where else to go except to form…

**BUBBLES!**

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## DECOMPRESSION SICKNESS

### DCS TYPE 1

"PAIN ONLY"
Limb or joint pain
Pruritic rash
localized swelling

### DCS TYPE 2

"SERIOUS"
Neurological
Inner Ear
Cardiac
Pulmonary

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## DCS TYPE I

- Musculoskeletal - joint pain / most often in shoulders
- Cutaneous - pruritus, localized erythema, mottling thought to be result of small bubbles in skin.
- Lymphatic obstruction - localized swelling

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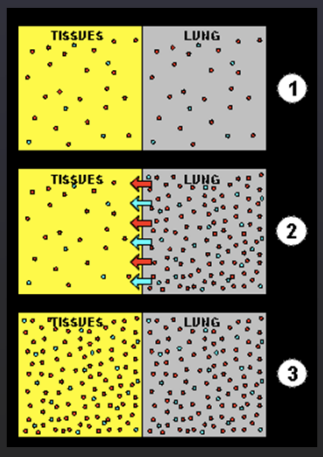
## DCS TYPE II




- NEUROLOGICAL
- CEREBRAL
- CEREBELLAR
- SPINAL
- INNER EAR
- CARDIAC
- RESPIRATORY
- SHOCK/DIC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## DCS TYPE II

- NEUROLOGICAL: spinal cord, paralysis, stroke-like sxs, paresthesias, cerebral
- CARDIOVASCULAR: Ischemia, thrombosis
- PULMONARY: The "Chokes"
- INNER EAR

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## DECOMPRESSION SICKNESS

- DCS Sxs usually within 6 hrs. Delay 24hrs rare
- Deep dives >30m present early = potentially more severe
- Sxs may be initiated or aggravated by exposure to altitude – DELAY travel at least 24 hrs after last dive!

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- Climbing to altitude is like ascending to the surface and can bring on DCS
- If air transport is necessary, the cabin should be pressurized to 1 ATA: C-9, C-40 (and other commercial airliners), Citation jet, Learjet

## FLYING AFTER DIVING....

- For a single no-decompression dive:
  - Wait at least 12 hours before flying
- For multiple dives/day or multiple days of diving:
  - Wait at least 18 hours before flying
- For any decompression dives:
  - "substantially longer than 18 hours appears prudent."

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## DCS - TREATMENT

- Mainstay of treatment = recompression followed by slow decompression
- Oxygen increase washout of inert gas and to promote bubble resolution
- Recompression therapy increases diffusion gradient of gas out of bubble, can relieve ischemia and hypoxia, and can restore normal tissue function

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# RECOMPRESSION CHAMBER


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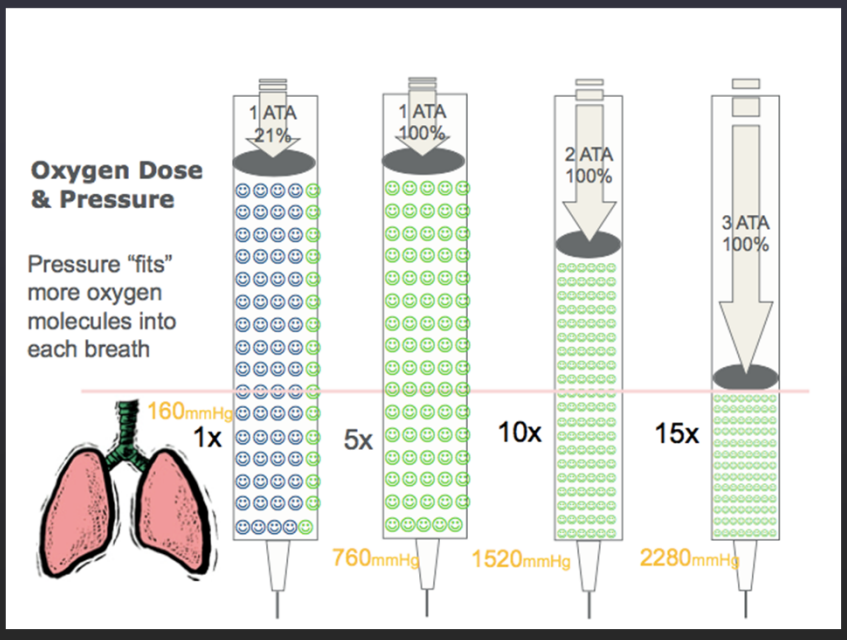


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# NITROGEN NARCOSIS "THE RAPTURE OF THE DEEP"

## NITROGEN NARCOSIS

- Air is 79% nitrogen
- At high partial pressures (>1 kPa), nitrogen has depressant effect on CNS
- Usually occurs at depths > 30 m
- Effects mimics alcohol
- Symptoms: light-headedness, tendency to laugh, poor concentration, short attention span, impaired judgement,
- impaired motor coordination, impaired cognitive function

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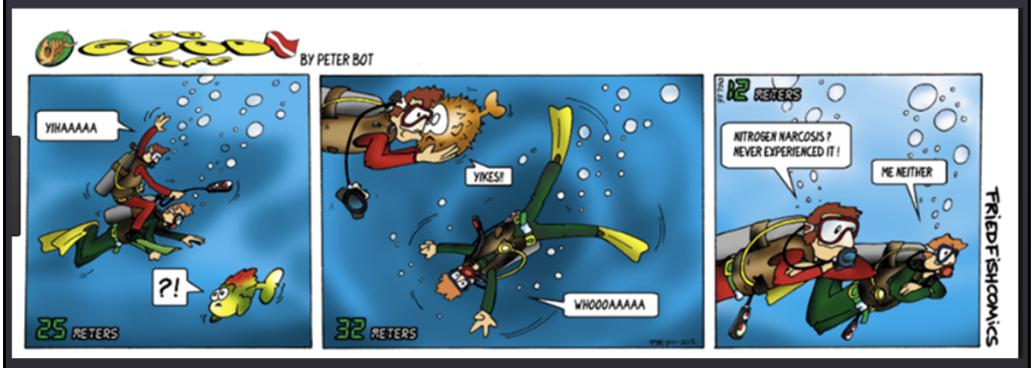


## NITROGEN NARCOSIS

Prevention: Always dive with buddy and know your limits!

Tx: Ascend - sxs resolve with decrease ATA

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# PHYSICAL QUALIFICATIONS FOR DIVING

## Questions to Consider to Assess Fitness to Dive

1. Does the condition or disease affect in-water safety of diver?
2. Does the disease or condition affect the safety or other divers?
3. Will diving exacerbate the condition or disease?
4. Will diving result in any long-term sequelae in the presence of the condition or disease?

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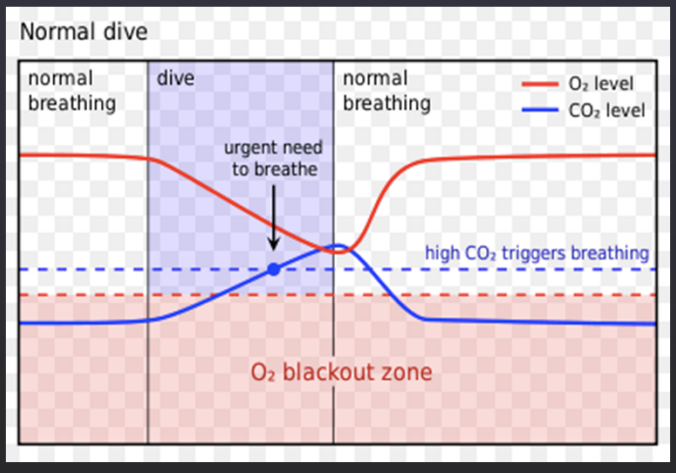
# HYPOXIA and BREATH-HOLD DIVING




A simple breath-hold has a Breaking point initiated by rise in CO2

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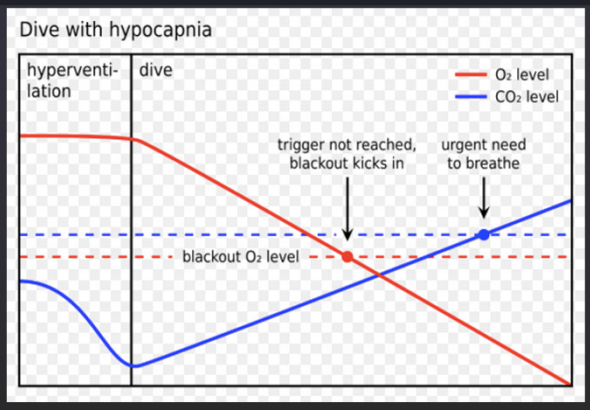
# HYPERVENTILATION and HYPOXIA




- Hyperventilation extends breath-holding time by decrease breaking point
- paO2 drops to inadequate level to sustain consciousness
- Exercise enhances O2 consumption (ie: competitive swimmers or spear fishing)

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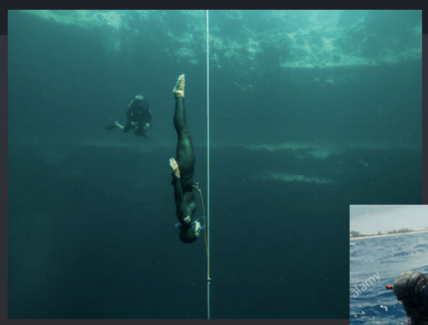
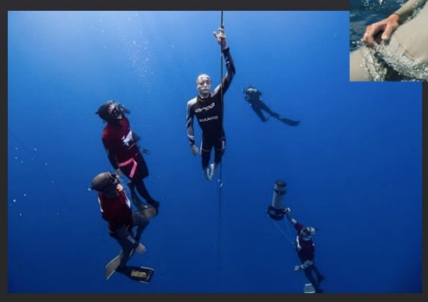
# HYPOXIA OF ASCENT





- In breath-hold divers, with descent, the pressure rises proportionally in the alveoli gases, increasing O2, CO2 and N2
- O2 utilized until back to "normal values," but during ascent volume in lungs expands and partial pressure of gases drops

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# QUESTIONS
?

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# REFERENCES


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# NO DISCLOSURES