



Koninklijke Marine



Acute (ernstige) duikgeneeskunde

*Ketenavond 'duikongevallen'
Acute Zorgregio Oost*

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Disclosure

• Potentiële belangenverstrengeling	Geen
• Voor bijeenkomst mogelijk relevante relaties met bedrijven	Geen
• Sponsoring of onderzoeksgeld	Geen
• Honorarium of andere (financiële) vergoedingen	Geen
• Aandeelhouder	Geen
• Andere relatie	Geen



Case 1: a 24-year-old Marine

Basic dive training is a 6-week program

- 3 weeks pool training
- 3 weeks open water training

All candidates are fit to dive (EDTC standards)

Assessment includes PFT, exercise tolerance testing and chest X-ray





After surf

- Loss of m
eyesight.

- Dx?

- Recognized as an AGE

- 100% normobaric oxygen was administered

- *Recovery of motor skills and eyesight*

10.5

Duikletsel

klachten ontstaan
> 5 minuten - < 24 uur
na opstijgen

- decompressieziekte
- hevige dyspneu/hoesten
- obstructieve shock
- haemoptoë
- retrosternale pijn
- verlammingen
- sensibiliteitstoornissen/
uitvalsverschijnselen
- spraak-, gehoor-, visusklachten;
duizelingen
- pijn in gewrichten, botten en spieren
- jeuk, rode vlekken

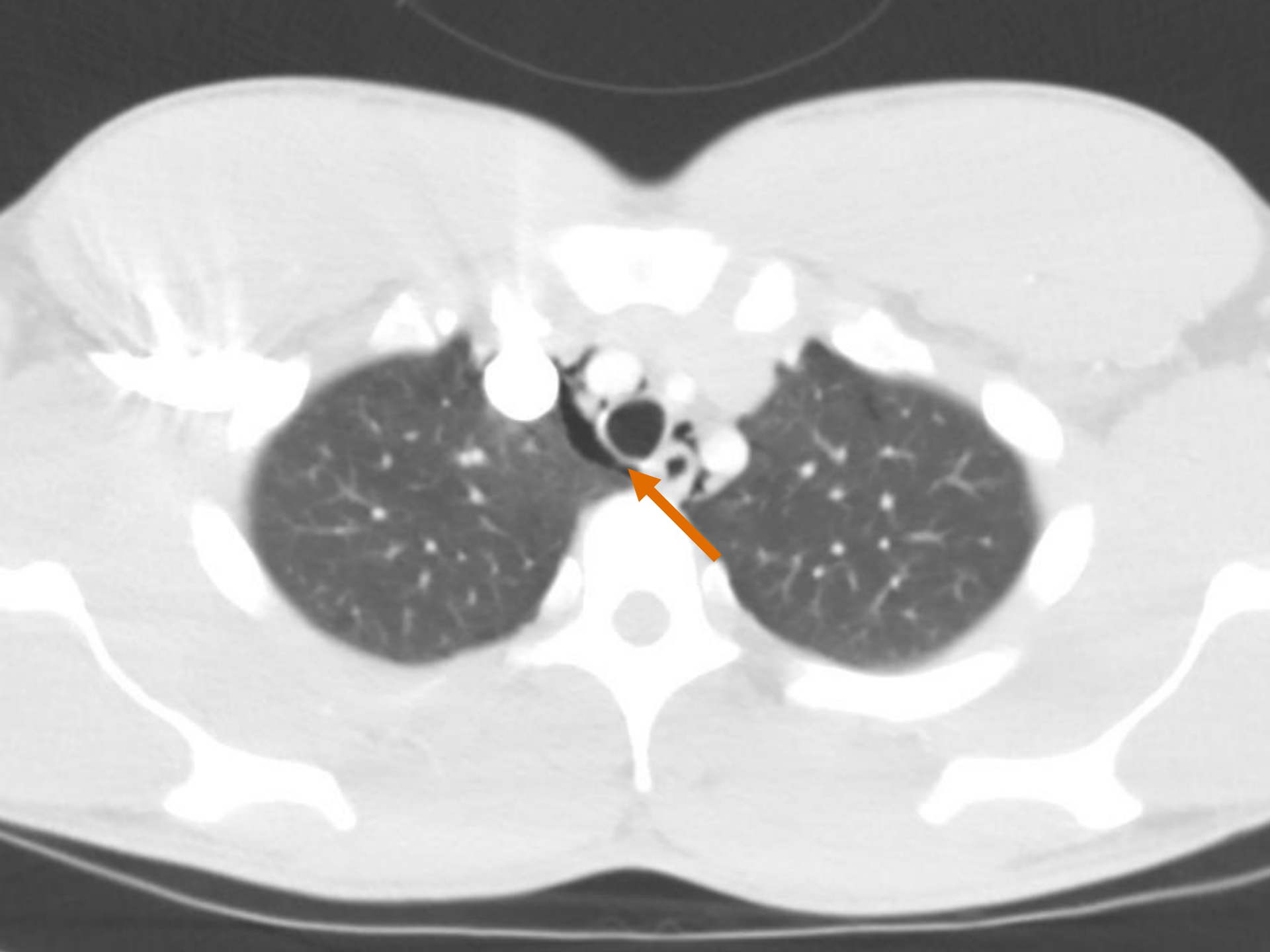
klachten ontstaan
acuut of ≤ 5 minuten

- overdruk barotrauma (longburst)
- luchtembolieën
- (spannings)pneumothorax
- mediastinaal-, halsemfyseem
- hoesten
- massale speeksel- en slijmvloed
- haemoptoë
- ritmestoornissen
- acute cardiale klachten
- retrosternale pijn
- angineuze klachten
- neurologische symptomen



Thirty minutes after ascent

- Assessment at ER in nearest hospital. Patient was ABC-stable, with only muscle weakness of the right leg.
- No clinical signs of pneumothorax. However, a CT-scan of the thorax was made to exclude subclinical lesions.





Two hours after ascent

- Transportation to Royal Netherlands Navy Diving Medical Center, while still administering 100% oxygen.
- No objective muscle weakness, patient reported his leg felt: “like I’ve just been running for 20 km”.
- Started with treatment table 6.



Follow-up

No complaints during or after treatment.

Restriction of exercise for 2 weeks. Continued sports afterwards. Was deemed unfit to dive until further notice.

Assessed by pulmonary specialist after 3 months: full recovery. Was declared fit to dive.



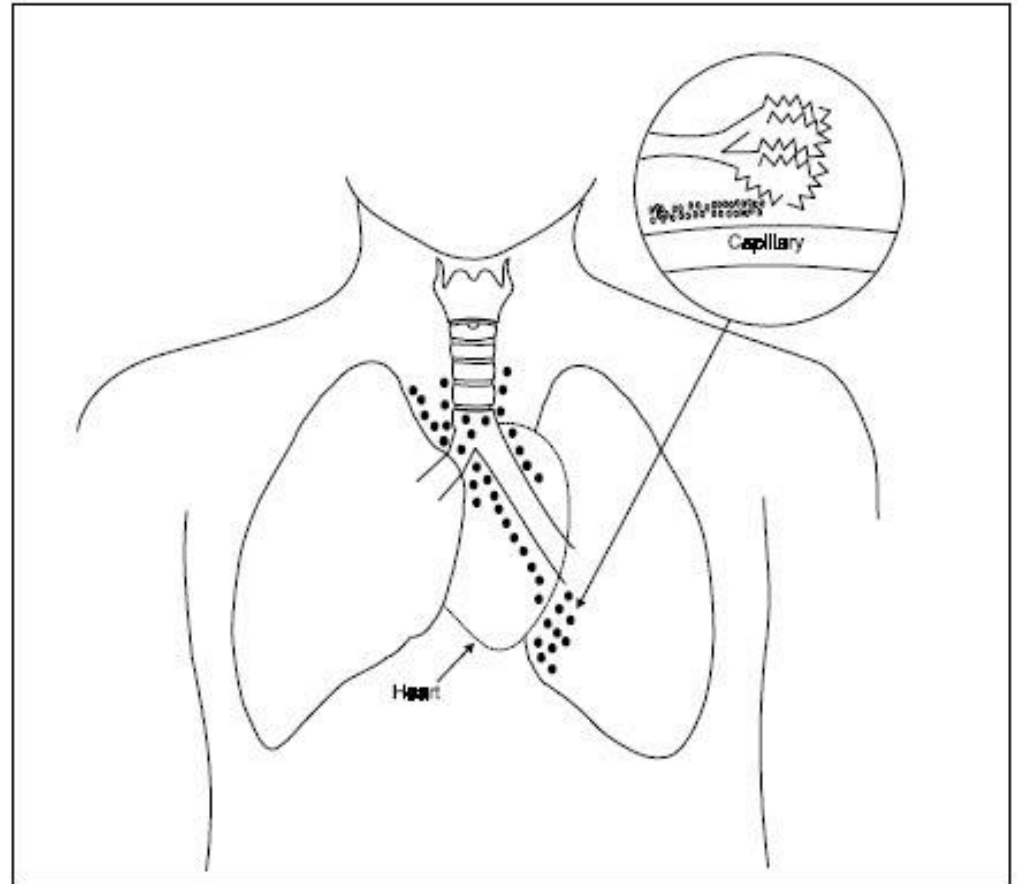
Summarized

A healthy, dive medically fit, marine **held his breath** during free ascent training from 9 to 5 MSW. This caused pulmonary barotrauma and **arterial gas embolism**, which led to hemiplegia and loss of eyesight.

Administration of **100% oxygen** led to quick recovery, although subtle complaints remained. Complete resolution after a **treatment table 6**.



Pathophysiology





Epidemiology

Incidence of AGE is approximately 6-7% of all diving incidents (which is 0.4-1 per 10.000 dives)

'True' incidence of intrapulmonary abnormalities (i.e., bullae or blebs) in the general population is unknown

- 2.3% in a military cohort (Bonnemaïson, Front Physiol, 2022)
- 4.7% in an American general hospital (Weaver, UHMS AMS, 2022)
- 7.2 % in a young and healthy Dutch population (Bresser, Front Physiol, 2024)
- 33.8% in a post-mortem study (de Bakker, 2020, Chest)

Do bullae and blebs contribute to the pathogenesis of AGE?
What about asthma?



Symptoms

An otherwise healthy diver developing severe complaints shortly after surfacing

Related to PBT

- Generally none

Related to (C)AGE

- Neurologic disorders, mostly resembling a stroke

Difficult to distinguish from severe instances of decompression sickness!



Prehospital Management

Oxygen
Oxygen
Oxygen

13.28

Zuurstof (O₂)

Eigenschappen

medicinaal zuurstofgas ter voorkoming of behandeling van acute of chronische hypoxemie en ter behandeling van stikstof gasbellen bij duikongevallen

Transfer for HBOT



Diagnosis

History and signs & symptoms only, no definitive diagnostic measure available.

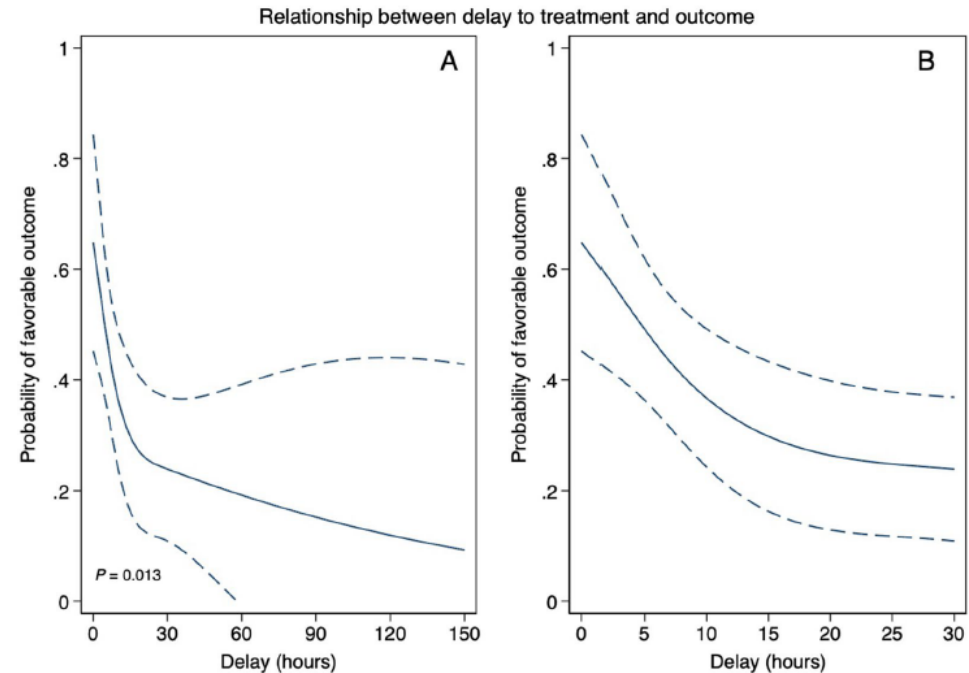
(Be smarter than I was, do not delay for a CT-scan)



Do not delay treatment

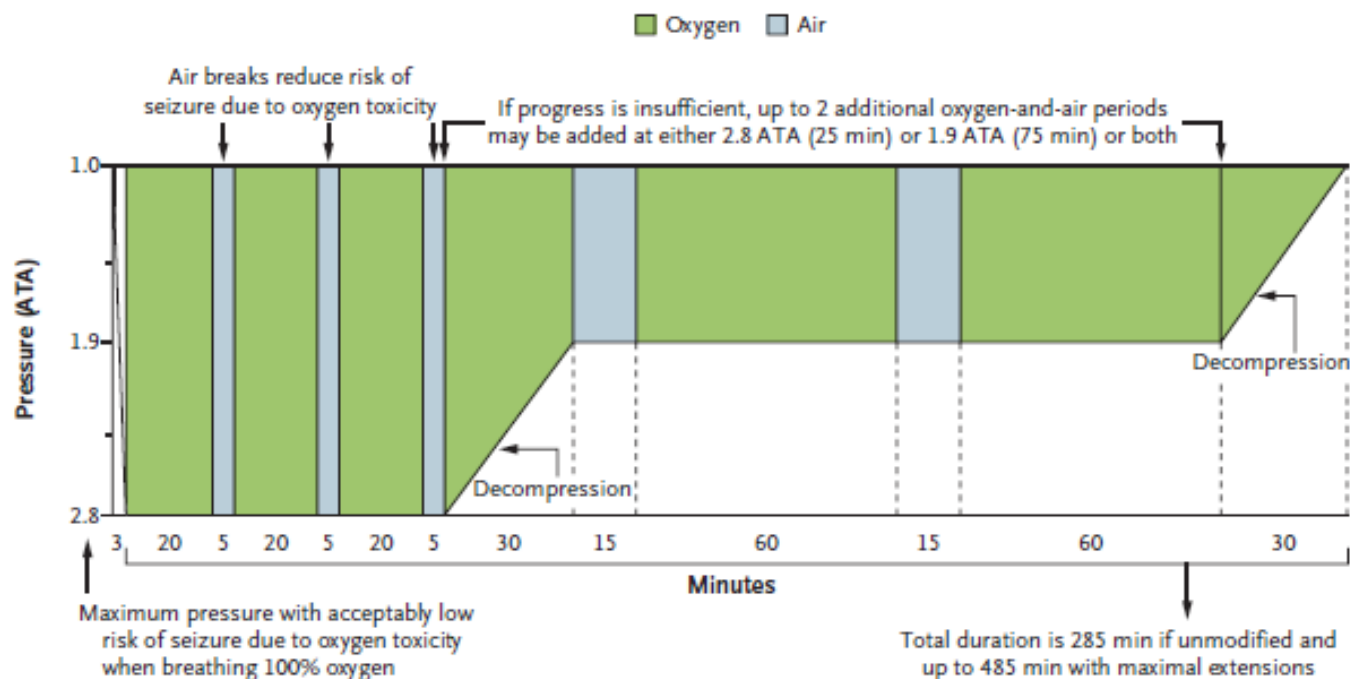
In contrast to earlier literature: “Time is brain”

Fakkert *et al.* Crit Care. 2023;27:282





Treatment





Prevention

- Human factors:
Ascend within the limits of diving procedures, and – more importantly - ALWAYS maintain an open airway during an ascend
- Medical factors:
Prevent individuals from diving when significant pulmonary disease is present
(will this hold up in the future?)



Case 2: Recreational diver

- Male, 56 yrs old, BMI 34, smoking
- “Techdiver”
- Fit to dive?
- “Diving expedition” in the Northern Sea





Chain of events

- Limited visibility, strong currents
- Dyspnea, started to ascend
- LOC during ascend, buddy brings him to to surface
- “Pink foam” in his mouth
- Resuscitation was to little avail
- Dx?



(Swimming) Immersion Pulmonary Edema

- Most commonly described in professional athletes
 - Case series: 42/58 deaths during the swimming part of triathlons. Conclusion: LVH is a risk factor.
- However, also in 'mere mortals'
 - Incidence 0.75% in women and 0.09% in men in amateur open water swimming events



Definition

SIPE is characterized by an acute onset of breathing problems caused by accumulation of fluid in the lung extravascular space, induced by immersion, usually but not always in cold water, and intense physical activity.



Sx/

- Cough
- Dyspnea
- Chest pain
- Hemoptysis
- LOC





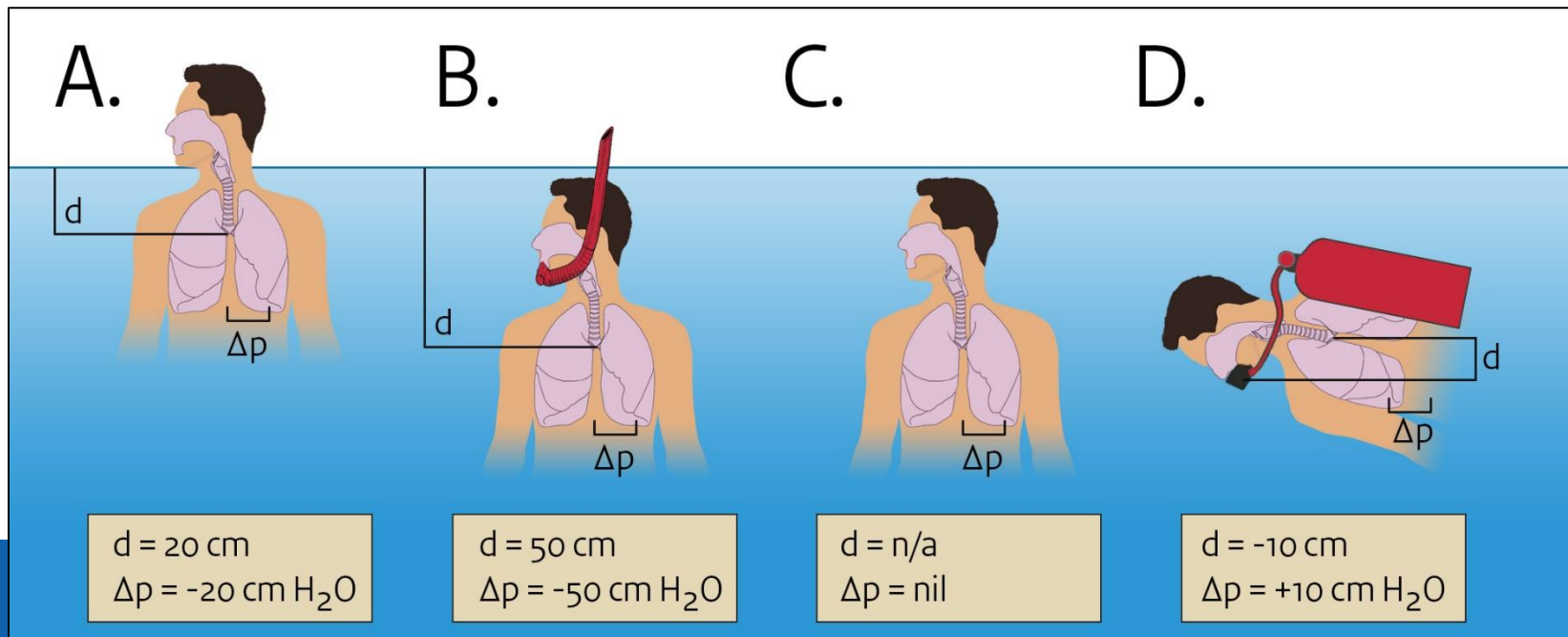
Relevance to diving medicine?





Fluid shift

- Upwards force of the water (buoyancy)
 - Note: no intravascular pressure difference between extremities and heart (closed system).
- Pressure gradient between lungs and body.





Cascade of problems

- Fluid shift (500-700 mL)
- Central pooling
 - Increased afterload left ventricle
- Pulmonary hypertension
- Pulmonary edema
- Diffusion / oxygenation problems



Risk factors

- Cold water (vasoconstriction)
- Preexisting hypertension / LVH / history of IPE
- Medication
- Exercise
- Negative pressure (breathing apparatus vs head-out immersion)
- Prehydration
- Hydrostatic pressure?

* Sildenafil zou kunnen beschermen

Shupak A, et al. Aviat Space Environ Med 2003;74:1201-4.

Moon RE, et al. Circulation 2016;133:988-996.



Prehospital therapy

- Out of the water
- Avoid hypothermia (warming unclear due to afterdrop)
- Oxygen
- “In severe cases tourniquets can be applied to the limbs to reduce preload as a first aid measure.”



Immersed Pulmonary Edema in a single slide

- Pathogenesis
 - Fluid shift and central pooling, pulmonary hypertension, edema in alveoli, impaired oxygenation.
- Sx/ cough, dyspnea, impaired oxygenation
- Exam/ ausc. wheezing, crackling
- Ix/ Decreased SO_2 , overfilling (ultrasound/X-ray)
- Tx/ Oxygen and hospital care.



Summarized

Acute diving injuries can be life threatening

Prehospital recognition (and associated therapy) can save lives.

Don't hesitate to contact us: 088 - 950 1417