

Physiology

Pressure increases by 1 atm (760mmHg, 1 bar or 100 kPa) for every 10m below sea level. So gas in body cavities compresses on descent and expands on ascent. As gas partial pressure of gases increases proportionally with ambient pressure, inert gases e.g. N₂ can dissolve in tissues at depth and come out of solution when the diver ascends. The density of inhaled gas increases with pressure too, and this can restrict breathing. Lung volume is also reduced because of displacement of blood from the periphery to the thorax.

Different forms of diving

- SCUBA diving: Air is suitable for depths of up to 40m for advanced, experienced divers.
- Snorkel diving: effectively increases the anatomical dead space by its own volume. Risk of aspiration. Reduced if snorkel has ball-cage valve.
- Deep sea diving: high risk occupation and depths down to 60-70m. Need proper diving suit and air is pumped through a line and the diver does not swim freely but is raised and lowered from above. For greater depths, special high pressure suits are necessary and for very great depths a bathysphere is required.

General safety precautions

- Physically fit
- Good swimmer
- Suitable training
- Dive with a 'buddy'
- Carry a knife to disentangle
- Equipment checks
- Avoid any EtOH

Fitness to dive

Exclusion criteria:

- Lung bullae or cysts, COPD, sarcoid, active TB, CF, fibrotic lung disease,
- Asthma & Hx of pneumothorax may be CI
- Epilepsy, ruptured eardrums, ear surgery, poorly controlled DM, addiction to alcohol or drugs, mental instability, obesity

Assessment of respiratory fitness to dive

- Routine chest X-ray is not required but spirometry should be undertaken.

Problems of Descent

Respiratory drive - shallow water blackout

- Hyperventilating before diving with a snorkel, drops pCO₂ markedly but it does little to the pO₂. Hence pO₂ may fall to dangerous levels before pCO₂ rises enough to stimulate urge to breathe → hypoxia & swift unconsciousness. More likely on ascent as pO₂ falls.

Nitrogen narcosis

- Obvious mental deterioration occurs at depths below 50m. This is caused by N₂ dissolving in nerve membranes, thickening them. Develops within minutes, reversed by ascent.
- Replacing N₂ with He allows divers to go to 700m without narcosis.
- At greater depths, compression & partial thinning of the neurone → fits. Adding back some N₂ to the O₂-He mix thickens the tissues and can prevent this.

Hypothermia

- Hypothermia is a significant problem when at deeper depths and it limits the dive time.

Oxygen toxicity

- Idiosyncratic response from breathing oxygen at a higher partial pressure. Nausea is the most common feature, followed by muscle twitching.

Pressure squeeze

Ear:

- Ear plugs/wax → pain/tympanic trauma as pressure pushes plug inwards.
- If Eustachian tube blocked then unable to equalize pressure across eardrum and on descent forced inwards and will rupture after 2-6m depth. Valsalva may prevent.
- However valsalva may cause problems:
 - Round or oval window rupture
 - Alternobaric vertigo - one ear clears before the other, causing disorientation due to uneven stimulation. May occur on ascent too.
- Caloric vertigo - If external auditory canals are unequally blocked before diving, cold water entering one canal can lead to vertigo.

Sinus problems: squeeze or expansion on ascent may be painful and cause trauma/bleeding.

Dental: air trapped in tooth causes pain.

Problems of ascent

Ascent is more dangerous than descent.

Pulmonary barotrauma:

Compressed air in lung expands on ascent and can → interstitial emphysema, pneumothorax or arterial gas embolism. Divers should exhale continuously and ascend at a rate no faster than the exhaled bubbles. Immed. needle thoracocentesis for tension pneumothorax + chest drain.

Arterial gas embolism

Following lung barotrauma and alveolar rupture gas emboli form which expand as the ascent continues. If physiological or anatomical (RFO) R→L shunt these can reach arterial circulation and the cerebral arteries. Stroke/TIA like features, ↓LOC, even death. Also can affect coronaries. Usually sudden onset <20min after surfacing. Mx: ABCs, hyperbaric oxygen, no further diving.

Decompression sickness ("The bends")

N₂ or He absorbed in tissues or blood comes out of solution on ascent → ↑bubbles → may block blood vessels and distort/rupture cells if ascent is not slow enough to allow removal by lungs.

Symptoms:

- Larger joint (shoulder, elbows, pelvic girdle) dull pain, relieved by pressure
- Neurological: LOC, denial, mood, behaviour, CN involvement, cerebellar, patchy motor/sensory changes. May be vague and subtle.
- Audiovestibular: N&V, vertigo, nystagmus, hearing loss
- Pulmonary ("the chokes"): cough, dyspnoea, chest pain, haemoptysis, cyanosis, shock
- Other: lymphoedema, lymphadenopathy, pruritic rash, headache, malaise, lethargy

Risk factors: obesity, smokers, EtOH, exercise, cold, dehydration, multiple dives, previous joint injury, ascent to altitude (flying) soon after diving.

Mx: Lie flat, 100% O₂, IVF fluids, **aspirin**, IDC, transport to HBO chamber in pressurised aircraft or at <1000ft altitude.