Immersion pulmonary oedema: is it confused with drowning?

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Drowning and pulmonary oedema

- Drowning - lungs and airways contain fluid as a result of inhalation.
- Pulmonary oedema - lungs and airways contain fluid that has leaked into alveoli from capillaries.
- In both – the fluid impairs gas exchange.
- So both cause breathlessness, cough, frothy sputum (may be blood stained), cyanosis & arterial blood desaturation, unconsciousness, cardiac arrhythmias and death.
- In both lungs are heavy and “waterlogged”.
drowning

normal lung
drowning

pulmonary oedema
How do you distinguish between death from pulmonary oedema and death from drowning?
Causes of pulmonary oedema on land

- High blood pressure (hydrostatic pressure) in alveolar capillaries that pushes fluid into alveoli (the commonest cause is heart failure).
- Low plasma albumin concentration - the osmotic pressure of albumin should be high enough to keep the plasma in the capillaries.
- Damage to the alveolar walls so that they leak (e.g. inhalation of smoke and chlorine gas)
Hydrostatic effects of immersion

On head out immersion in **warm** water:

- Compression of peripheral (leg) veins increases venous return and central blood volume by 700ml
- Heart size increased and lung volumes reduced
- Increases RA and PA pressures by 15-20mm Hg
- 30% increase in stroke volume and cardiac output
- BNP release > renal excretion of salt and water
- The effects are increased in cold water because of the additional cold-induced vasoconstriction
First recognised case of immersion pulmonary oedema

- Plymouth Sound
- Female instructor, age 49, had dived 10 years
- Suraced and gave distress signal
- Breathlessness which started at depth
- No water inhalation
- Cyanosed
- Coughing up blood-stained froth on surface
- Reported 6 previous episodes
- On examination signs of pulmonary oedema
Chest x-ray of drowning casualty
Progress

- Symptoms rapidly improved on leaving the water
- Therefore she declined medication
- Chest x-ray cleared rapidly
- Cardiac tests showed function and blood supply of heart were normal
Cold-induced pulmonary oedema in scuba divers and swimmers and subsequent development of hypertension: Lancet 1989

- 11 divers (3 female)
- All had pulmonary oedema when scuba diving
- 2 also had it when surface swimming
- 2 had syncope & some needed ICU admission
- Appeared to be related to cold water only
- All were asymptomatic out of water
- 4 known to have mild hypertension
- Tests for coronary heard disease were negative
Compared with 9 normal divers

- Showed pathological vasoconstriction to cold and a raised partial pressure of oxygen

- During the tests 9 of 11 developed signs of cardiac decompensation (3\textsuperscript{rd} heart sounds), 2 developed functional mitral regurgitation and one had frank pulmonary oedema requiring IV vasodilator

- During follow up (mean 8 years) 3 more became hypertensive (7 in total)
Other reports

- Since the Lancet paper many others have confirmed that this condition exists and that it is relatively common
- Some cases require ICU treatment and mechanical ventilation
- Increasingly recognised in diving fatalities
- Risk factors are hypertension and occult heart disease, but can occur without heart disease
Weiler-Ravell et al. BMJ 1995

- 8 out of 30 military swimmers in Israeli Defence Force (age 18 – 19) had haemoptysis /pulmonary oedema during surface swim in Mediterranean (temperate)

- Drank at least 5 litres in 2 hours before strenuous swim

- 2 had recurrence on another occasion
IPO in other military personnel

- US Navy Seals on surface swims
- French navy divers
- UK Special Boat Service on a research dive in a cold indoor pool
Immersion pulmonary oedema

- 1.1% of scuba divers have history consistent with IPO
- 1.4% of US triathletes had a history consistent with IPO (in events with swimming component)
- Some similarities to pulmonary oedema in endurance athletes and at high altitude
Overall observations suggest IPO

- Precipitated by immersion – swimming and scuba
- Most frequent in people with hypertension or undiagnosed cardiac disease
- Can occur in normal & super-fit individuals
- More frequent in cold water than thermo-neutral
- Pre-hydration increases risk
- Exertion and stress increase risk
- Rarely affected people get pulmonary oedema in other situations
Clinical summary of IPO

- It causes cough, breathlessness, frothy or blood stained sputum, blackouts and death.

- It is difficult to distinguish in a casualty or at post mortem from drowning.