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# DEEP SEA PHYSIOLOGY

**Sravani Pragna. K[1], Kalyan Chakravarthi. C[1], Muralinath.E[1], Guruprasad. M[2], V. Sri Devi[3] & Srihari reddy[1]**

[1]College of Veterinary Science, Proddatur

[2]Sterline Bioremedies pvt. Ltd, Andhra Pradesh

[3]Mohan Babu University, Andhra Pradesh

Contrast to higher altitude where the challenges arise from low atmospheric (barometric) pressure, problems in deep sea exploration, underground tunnels and mining activities are related to high barometric pressure. The enhanced pressure beneath the surfaces creates two major problems:

1. Physical compressive forces exerted by air above the surface and the weight of the water itself above the subject, act on the body and internal organs causing pain and tissue damage.
2. Decline in volume of air in the body (According to Boyles law, the volume of air at a given temperature is inversely proportional to atmospheric pressure). As the subject dives deeper and deeper into the water, the volume of air in the body spaces decreases causing asphyxia, which can be averted by supplying life supporting oxygen gas.

**Barometric pressure at different depth**s: At sea level, the barometric pressure is 760 mm Hg. (760 mmHg = 1 atmosphere/ATM). For every 33 feet (about 10 m) drop in the depth of a water body, pressure increases by 1 ATM. Thus, at the depth of 33 feet, the pressure is 2 ATM, which is twice that at the surface (**Table 1**). And this is caused by the weight of the air that is borne by water at the surface as well as the weight of water above the subject. The following table provides the barometric pressures at different levels of water depth, and potential life threatening challenges associated at each depth.

**Table 1**: Effect of different depths on human body

| Depth (in feet) | Atmospheric pressure (mm of Hg.)/(ATM) | Abnormal effects on humans |
|---|---|---|
| 0 (surface) | 1 | |
| 33 | 2 | |
| 66 | 3 | |
| 100 | 4 | Appearance of symptoms of nitrogen narcosis |
| 133 | 5 | Loses concentration and becomes jovial and careless |
| 166 | 6 | Starts feeling drowsy |
| 200 | 7 | Feels fatigued, weak and careless |

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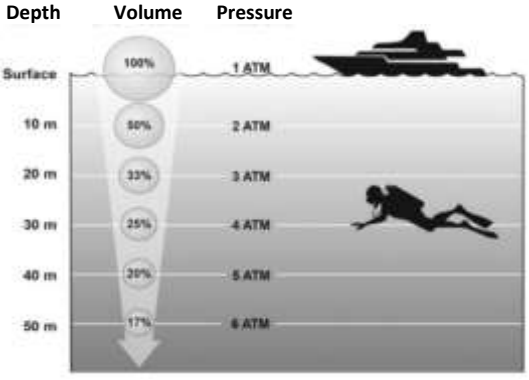
| | | |
|---|---|---|
| 233 | 8 | looses power of judgment and incapable of performing skilled labour |
| 266 | 9 | Becomes Unconscious |

**Effect of high barometric pressure – nitrogen narcosis**

Narcosis is a state of unconsciousness or stupor (lethargy with suppression of sensations and feelings) that is produced by drugs. Nitrogen narcosis relates to the narcotic effect caused by nitrogen at high pressure. Nitrogen narcosis is a common observation in deep sea divers, who breathe compressed air (air under high pressure), a necessity for a deep sea diver or an underwater tunnel worker. It helps equalize the high pressure acting on thoracic wall and abdomen in deep sea. Eighty percent of the atmospheric air is nitrogen. Being an inert gas, it does not produce any known effect on the functions of the body at normal atmospheric pressure (sea level). When a person breathes pressurized air as in deep sea, the narcotic effect of nitrogen appears. It shows an altered mental state like alcoholic intoxication.

**Mechanism:** Nitrogen is a fat soluble gas. During compression by high barometric pressure in deep sea, $N_2$ escapes from blood vessels because of its lipophillicity and enters the fat present in various parts of the body, especially in the myelin sheets of the neuronal membranes. Because of its ability to reduce membrane excitability, dissolved **nitrogen** acts like an anaesthetic agent suppressing the activity nervous system. Nitrogen remains in dissolved form in the fat as long as the person remains in the deep sea (Fig. 1)

**Figure 1:** Effect of depth on atmospheric pressure and air volume in the body.




**Symptoms**

1. Initial symptom appear at a depth of 120 feet. The subject gets very jovial, careless and does not understand the seriousness of the conditions.
2. At a depth of around 150 to 200 feet, the person becomes very drowsy.
3. Between 200 and 250 ft. depth, the person becomes extremely fatigued and weak. Soon, the subject losses concentration and judgment. Ability to perform skilled labour of high cognitive order including coordinated body movements is also lost.
4. Beyond the depth of 250 feet, the person becomes unconscious, comatose and may eventually die.

**Prevention:** Nitrogen narcosis can be prevented by mixing helium with oxygen. Helium may be suitable as substitute for nitrogen to dilute oxygen during deep water diving. Helium also exhibits some effects such as nausea as well as dizziness. What ever it may be, the adverse

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effects of helium are less severe compare to nitrogen necrosis. Nitrogen narcosis may be restricted by limiting the depth of dives. The effect of nitrogen necrosis may be minimized by safe diving, procedures like proper maintenance of equipment and less work effort. In addition, alcohol consumption must be avoided 24 hours particularly before diving.

**Decompression sickness**: Decompression sickness is a disorder that occurs when a person returns rapidly to the surface (atmospheric pressure) from the deep sea area of high atmospheric pressure. It is also known as dysbarism, compressed air sickness, caisson disease, bends or diver's palsy.

**Etiology:** High barometric pressure at deep sea leads to compression of gases in the body. Compression reduces the volume of gases. Nitrogen is present in high concentration (i.e. 80% of total air), which is an inert gas. So, it is neither utilized nor expired. When nitrogen is compressed by high atmospheric pressure in deep sea, it escapes blood vessels and enters the organs. As it is fat soluble, $N_2$ gets dissolved in the tissue fat and fluids, especially in the brain tissues. As long as the person remains in deep sea, nitrogen remains in solution/dissolved in fat and does not cause any problem. But, if the person ascends rapidly and returns to the surface where atmospheric pressure is around 1 ATA, decompression sickness sets in. Due to sudden return to normal atmospheric pressure, dissolved nitrogen is decompressed and escapes from the tissues at a faster rate and forms bubbles in the blood. The bubbles travel through blood vessels and ducts and obstruct the blood flow with potential to produce air embolism leading to decompression sickness.

Underground tunnel workers who use the caissons (pressurized chambers) also develop decompression (caisson disease) sickness. Pressure in the chamber is increased to prevent the entry of water inside. Decompression sickness also occurs in a person who ascends up rapidly from sea level in an airplane without any precaution.

**Symptoms:** Symptoms of decompression sickness are mainly due to the escape of nitrogen from tissues in the form of bubbles.

1. Severe joint pains and temporary paralysis caused by nitrogen bubbles in the myelin sheath of sensory nerve fibers.
2. Numbness, tingling or pricking (paraesthesia) and itching sensations.
3. Muscle cramps causing severe pain.
4. Occlusion of coronary arteries by nitrogen bubbles followed by coronary ischemia.
5. Blood vessel occlusions in brain and spinal cord causing damage to brain and spinal cord tissue.
6. Dizziness, paralysis of muscle, shortness of breath and choking occur.
7. Finally, fatigue, unconsciousness, coma followed by death.

**Prevention:** Decompression sickness is prevented by taking proper precautionary measures. In the case of deep sea divers, while returning to the sea surface, the ascent should be very slow in a

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step wise manner, with interrupted short stays at different depths in regular intervals. Stepwise ascent allows nitrogen to come back to the lungs through the blood without forming bubbles in the blood, therefore avoiding the decompression sickness.

**Treatment:** When a deep sea diver is affected with decompression sickness, recompression should be done, immediately. This can be accomplished by keeping the person in a recompression chamber, where the diver will brought back to normal level of atmospheric pressure by slowly decreasing the pressure. Hyperbaric oxygen therapy may be useful in this case, where the person will be kept in the chamber with his head left outside, and recompression commenced as explained earlier.

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