= Nitrogen narcosis =

Narcosis while diving (also known as nitrogen narcosis , inert gas narcosis , raptures of the deep , Martini effect) , is a reversible alteration in consciousness that occurs while diving at depth . It is caused by the anesthetic effect of certain gases at high pressure . The Greek word ???????? (narcosis) is derived from narke , " temporary decline or loss of senses and movement , numbness " , a term used by Homer and Hippocrates . Narcosis produces a state similar to drunkenness (alcohol intoxication) , or nitrous oxide inhalation . It can occur during shallow dives , but does not usually become noticeable at depths less than 30 meters (100 ft) .

Except for helium and probably neon , all gases that can be breathed have a narcotic effect , although widely varying in degree . The effect is consistently greater for gases with a higher lipid solubility , and there is good evidence that the two properties are mechanistically related . As depth increases , the mental impairment may become hazardous . Divers can learn to cope with some of the effects of narcosis , but it is impossible to develop a tolerance . Narcosis affects all divers , although susceptibility varies widely from dive to dive , and between individuals .

Narcosis may be completely reversed in a few minutes by ascending to a shallower depth , with no long @-@ term effects . Thus narcosis while diving in open water rarely develops into a serious problem as long as the divers are aware of its symptoms , and are able to ascend to manage it . Diving beyond 40 m (130 ft) is generally considered outside the scope of recreational diving . Below these depths , as narcosis and oxygen toxicity become critical risk factors , specialist training is required in the use of various helium @-@ containing gas mixtures such as trimix or heliox . These mixtures prevent narcosis by replacing some of the breathing gas with non @-@ narcotic helium .

= = Classification = =

Narcosis results from breathing gases under elevated pressure , and may be classified by the principal gas involved . The noble gases , except helium and probably neon , as well as nitrogen , oxygen and hydrogen cause a decrement in mental function , but their effect on psychomotor function (processes affecting the coordination of sensory or cognitive processes and motor activity) varies widely . The effects of carbon dioxide consistently result in a diminution of mental and psychomotor function . The noble gases argon , krypton , and xenon are more narcotic than nitrogen at a given pressure , and xenon has so much anesthetic activity that it is a usable anesthetic at 80 % concentration and normal atmospheric pressure . Xenon has historically been too expensive to be used very much in practice , but it has been successfully used for surgical operations , and xenon anesthesia systems are still being proposed and designed .

= = Signs and symptoms = =

Due to its perception @-@ altering effects , the onset of narcosis may be hard to recognize . At its most benign , narcosis results in relief of anxiety ? a feeling of tranquility and mastery of the environment . These effects are essentially identical to various concentrations of nitrous oxide . They also resemble (though not as closely) the effects of alcohol or marijuana and the familiar benzodiazepine drugs such as diazepam and alprazolam . Such effects are not harmful unless they cause some immediate danger to go unrecognized and unaddressed . Once stabilized , the effects generally remain the same at a given depth , only worsening if the diver ventures deeper .

The most dangerous aspects of narcosis are the impairment of judgement , multi @-@ tasking and coordination , and the loss of decision @-@ making ability and focus . Other effects include vertigo and visual or auditory disturbances . The syndrome may cause exhilaration , giddiness , extreme anxiety , depression , or paranoia , depending on the individual diver and the diver 's medical or personal history . When more serious , the diver may feel overconfident , disregarding normal safe diving practices .

The relation of depth to narcosis is sometimes informally known as " Martini 's law " , the idea that

narcosis results in the feeling of one martini for every 10 m (33 ft) below 20 m (66 ft) depth . Professional divers use such a calculation only as a rough guide to give new divers a metaphor , comparing a situation they may be more familiar with .

Reported signs and symptoms are summarized against typical depths in meters and feet of sea water in the following table :

= = Causes = =

The cause of narcosis is related to the increased solubility of gases in body tissues , as a result of the elevated pressures at depth (Henry 's law) . Modern theories have suggested that inert gases dissolving in the lipid bilayer of cell membranes cause narcosis . More recently , researchers have been looking at neurotransmitter receptor protein mechanisms as a possible cause of narcosis . The breathing gas mix entering the diver 's lungs will have the same pressure as the surrounding water , known as the ambient pressure . After any change of depth , the pressure of gases in the blood passing through the brain catches up with ambient pressure within a minute or two , which results in a delayed narcotic effect after descending to a new depth . Rapid compression potentiates narcosis owing to carbon dioxide retention .

A divers ' cognition may be affected on dives as shallow as 10 m (33 ft) , but the changes are not usually noticeable . There is no reliable method to predict the depth at which narcosis becomes noticeable , or the severity of the effect on an individual diver , as it may vary from dive to dive even on the same day .

Significant impairment due to narcosis is an increasing risk below depths of about 30 m (100 ft) , corresponding to an ambient pressure of about 4 bar (400 kPa) . Most sport scuba training organizations recommend depths of no more than 40 m (130 ft) because of the risk of narcosis . When breathing air at depths of 90 m (300 ft) ? an ambient pressure of about 10 bar (1 @,@ 000 kPa) ? narcosis in most divers leads to hallucinations , loss of memory , and unconsciousness . A number of divers have died in attempts to set air depth records below 120 m (400 ft) . Because of these incidents , Guinness World Records no longer reports on this figure .

Narcosis has been compared with altitude sickness insofar as its variability (though not its symptoms) ; its effects depend on many factors , with variations between individuals . Thermal cold , stress , heavy work , fatigue , and carbon dioxide retention all increase the risk and severity of narcosis . Carbon dioxide has a high narcotic potential and also causes increased blood flow to the brain , increasing the effects of other gases . Increased risk of narcosis results from increasing the amount of carbon dioxide retained through heavy exercise , shallow or skip breathing , or because of poor gas exchange in the lungs .

Narcosis is known to be additive to even minimal alcohol intoxication , and also to the effects of other drugs such as marijuana (which is more likely than alcohol to have effects that last into a day of abstinence from use) . Other sedative and analgesic drugs , such as opiate narcotics and benzodiazepines , add to narcosis .

= = Mechanism = =

The precise mechanism is not well understood , but it appears to be the direct effect of gas dissolving into nerve membranes and causing temporary disruption in nerve transmissions . While the effect was first observed with air , other gases including argon , krypton and hydrogen cause very similar effects at higher than atmospheric pressure . Some of these effects may be due to antagonism at NMDA receptors and potentiation of GABAA receptors , similar to the mechanism of nonpolar anesthetics such diethyl ether or ethylene . However , their reproduction by the very chemically inactive gas argon makes them unlikely to be a strictly chemical bonding to receptors in the usual sense of a chemical bond . An indirect physical effect ? such as a change in membrane volume ? would therefore be needed to affect the ligand @-@ gated ion channels of nerve cells . Trudell et al. have suggested non @-@ chemical binding due to the attractive van der Waals force between proteins and inert gases .

Similar to the mechanism of ethanol 's effect , the increase of gas dissolved in nerve cell membranes may cause altered ion permeability properties of the neural cells ' lipid bilayers . The partial pressure of a gas required to cause a measured degree of impairment correlates well with the lipid solubility of the gas : the greater the solubility , the less partial pressure is needed .

An early theory , the Meyer @-@ Overton hypothesis , suggested that narcosis happens when the gas penetrates the lipids of the brain 's nerve cells , causing direct mechanical interference with the transmission of signals from one nerve cell to another . More recently , specific types of chemically gated receptors in nerve cells have been identified as being involved with anesthesia and narcosis . However , the basic and most general underlying idea , that nerve transmission is altered in many diffuse areas of the brain as a result of gas molecules dissolved in the nerve cells ' fatty membranes , remains largely unchallenged .

= = Management and diagnosis = =

The management of narcosis is simply to ascend to shallower depths ; the effects then disappear within minutes . In the event of complications or other conditions being present , ascending is always the correct initial response . Should problems remain , then it is necessary to abort the dive . The decompression schedule can still be followed unless other conditions require emergency assistance .

The symptoms of narcosis may be caused by other factors during a dive : ear problems causing disorientation or nausea ; early signs of oxygen toxicity causing visual disturbances ; or hypothermia causing rapid breathing and shivering . Nevertheless , the presence of any of these symptoms should imply narcosis . Alleviation of the effects upon ascending to a shallower depth will confirm the diagnosis . Given the setting , other likely conditions do not produce reversible effects . In the rare event of misdiagnosis when another condition is causing the symptoms , the initial management ? ascending closer to the surface ? is still essential .

= = Prevention = =

The most straightforward way to avoid nitrogen narcosis is for a diver to limit the depth of dives . Since narcosis becomes more severe as depth increases , a diver keeping to shallower depths can avoid serious narcosis . Most recreational dive schools will only certify basic divers to depths of 18 m (60 ft) , and at these depths narcosis does not present a significant risk . Further training is normally required for certification up to 30 m (100 ft) on air , and this training should include a discussion of narcosis , its effects , and cure . Some diver training agencies offer specialized training to prepare recreational divers to go to depths of 40 m (130 ft) , often consisting of further theory and some practice in deep dives under close supervision . Scuba organizations that train for diving beyond recreational depths , may forbid diving with gases that cause too much narcosis at depth in the average diver , and strongly encourage the use of other breathing gas mixes containing helium in place of some or all of the nitrogen in air ? such as trimix and heliox ? because helium has no narcotic potential . The use of these gases forms part of technical diving and requires further training and certification .

While the individual diver cannot predict exactly at what depth the onset of narcosis will occur on a given day , the first symptoms of narcosis for any given diver are often more predictable and personal . For example , one diver may have trouble with eye focus (close accommodation for middle @-@ aged divers) , another may experience feelings of euphoria , and another feelings of claustrophobia . Some divers report that they have hearing changes , and that the sound their exhaled bubbles make becomes different . Specialist training may help divers to identify these personal onset signs , which may then be used as a signal to ascend to avoid the narcosis , although severe narcosis may interfere with the judgement necessary to take preventive action .

Deep dives should be made only after a gradual training to test the individual diver 's sensitivity to increasing depths , with careful supervision and logging of reactions . Diving organizations such as Global Underwater Explorers (GUE) emphasize that such sessions are for the purpose of gaining

experience in recognizing the onset symptoms of narcosis for an individual , which are somewhat more repeatable than for the average group of divers . Scientific evidence does not show that a diver can train to overcome any measure of narcosis at a given depth or become tolerant of it .

Equivalent narcotic depth (END) is a commonly used way of expressing the narcotic effect of different breathing gases . The National Oceanic and Atmospheric Administration (NOAA) Diving Manual now states that oxygen and nitrogen should be considered equally narcotic . Standard tables , based on relative lipid solubilities , list conversion factors for narcotic effect of other gases . For example , hydrogen at a given pressure has a narcotic effect equivalent to nitrogen at 0 @.@ 55 times that pressure , so in principle it should be usable at more than twice the depth . Argon , however , has 2 @.@ 33 times the narcotic effect of nitrogen , and is a poor choice as a breathing gas for diving (it is used as a drysuit inflation gas , owing to its low thermal conductivity) . Some gases have other dangerous effects when breathed at pressure ; for example , high @-@ pressure oxygen can lead to oxygen toxicity . Although helium is the least intoxicating of the breathing gases , at greater depths it can cause high pressure nervous syndrome , a still mysterious but apparently unrelated phenomenon . Inert gas narcosis is only one factor influencing the choice of gas mixture ; the risks of decompression sickness and oxygen toxicity , cost , and other factors are also important .

Because of similar and additive effects , divers should avoid sedating medications and drugs , such as marijuana and alcohol before any dive . A hangover , combined with the reduced physical capacity that goes with it , makes nitrogen narcosis more likely . Experts recommend total abstinence from alcohol for at least 12 hours before diving , and longer for other drugs . Abstinence time needed for marijuana is unknown , but owing to the much longer half @-@ life of the active agent of this drug in the body , it is likely to be longer than for alcohol .

= = Prognosis and epidemiology = =

Narcosis is potentially one of the most dangerous conditions to affect the scuba diver below about 30 m (100 ft) . Except for occasional amnesia of events at depth , the effects of narcosis are entirely removed on ascent and therefore pose no problem in themselves , even for repeated , chronic or acute exposure . Nevertheless , the severity of narcosis is unpredictable and it can be fatal while diving , as the result of illogical behavior in a dangerous environment .

Tests have shown that all divers are affected by nitrogen narcosis , though some experience lesser effects than others . Even though it is possible that some divers can manage better than others because of learning to cope with the subjective impairment , the underlying behavioral effects remain . These effects are particularly dangerous because a diver may feel they are not experiencing narcosis , yet still be affected by it .

= = History = =

French researcher Victor T. Junod was the first to describe symptoms of narcosis in 1834 , noting " the functions of the brain are activated , imagination is lively , thoughts have a peculiar charm and , in some persons , symptoms of intoxication are present . " Junod suggested that narcosis resulted from pressure causing increased blood flow and hence stimulating nerve centers . Walter Moxon (1836 ? 1886) , a prominent Victorian physician , hypothesized in 1881 that pressure forced blood to inaccessible parts of the body and the stagnant blood then resulted in emotional changes . The first report of anesthetic potency being related to lipid solubility was published by Hans H. Meyer in 1899 , entitled Zur Theorie der Alkoholnarkose . Two years later a similar theory was published independently by Charles Ernest Overton . What became known as the Meyer @-@ Overton Hypothesis may be illustrated by a graph comparing narcotic potency with solubility in oil .

In 1939 , Albert R. Behnke and O. D. Yarborough demonstrated that gases other than nitrogen also could cause narcosis . For an inert gas the narcotic potency was found to be proportional to its lipid solubility . As hydrogen has only 0 @.@ 55 the solubility of nitrogen , deep diving experiments using hydrox were conducted by Arne Zetterström between 1943 and 1945 . Jacques @-@ Yves

Cousteau in 1953 famously described it as " l ? ivresse des grandes profondeurs " or the " rapture of the deep " .

Further research into the possible mechanisms of narcosis by anesthetic action led to the " minimum alveolar concentration " concept in 1965 . This measures the relative concentration of different gases required to prevent motor response in 50 % of subjects in response to stimulus , and shows similar results for anesthetic potency as the measurements of lipid solubility . The (NOAA) Diving Manual was revised to recommend treating oxygen as if it were as narcotic as nitrogen , following research by Christian J. Lambertsen et al. in 1977 and 1978 .