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PSYCHOLOGICAL MECHANISMS AND PHYSIOLOGICAL

CONSEQUENCES OF PANIC ATTACK IN

RECREATIONAL SCUBA DIVING

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PSYCHOLOGICAL MECHANISMS AND PHYSIOLOGICAL CONSEQUENCES OF PANIC ATTACK IN RECREATIONAL SCUBA DIVING

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Background

The ocean has always been a source of wonder for mankind creating an insatiable desire to discover what lies beneath the surface. It covers approximately 2/3 of the planet to an average depth of 10,000 feet (Lee). One of the ways which allows scientists, adventurers, and others infatuated with the investigation of the sea to gain first hand knowledge of its contents is through the use of scuba equipment. The history of diving can be traced back at least as far as Homer as he referred to early divers when he wrote the Iliad around 750 B.C. The first diving bell is traced back to Alexander the Great when he used this device in 323 A.D. Leonardo da Vinci had among his drawings the first known sketches of mask, fins and snorkel. While these items alone are more often associated with what today we refer to as snorkeling, they are staples of modern day scuba diving. The revolution of underwater work came about with the perfection of the classical hard hat and flexible dress diving suit by Augustus Siebe in 1819. The conception of modern day diving is associated with Captain Jacques-Yves Cousteau and Emil Gagnan when they co-invented the Self-Contained Underwater Breathing Apparatus or SCUBA. This allowed the modern diver the freedom to move and work underwater with more independence than was ever before possible.

A scuba diver must make certain allowances for visiting an alien and unfamiliar environment such as the sea in order to facilitate a rewarding underwater experience. There are a number of physical consequences worth mentioning. Water is 800 times heavier than air and consequently more dense. This forces the diver to slow movement or else elevate air consumption (from a limited supply) and expend exorbitant energy to perform the work associated with moving in such an environment. While diving in water where the temperature is less than body temperature, heat is removed directly from the body by conduction. A wetsuit is in order for any prolonged exposure to all but the most temperate waters. It is a wise diver who will wear a wetsuit on any dive in order to protect against brushes with marine life such as the Portuguese Man-O-War or Fire Coral. Both can leave a painful reminder of what would otherwise have been a very pleasant experience. Vision is distorted while submerged as the water conforms to the curvature of the eye causing blurred vision much like that in extreme cases of astigmatism. The face mask, a flat optical plane, restores approximately normal vision. With the facemask in place, objects appear a third larger and closer due to the refraction of light passing through the faceplate. At depths greater than 100 feet, a diver will see most objects in blues and greens. This is due to the filtering of the color spectrum by water. The colors of the longest wavelengths are filtered first (first red then orange, yellow, and finally the greens and blues). Filtering progresses with depth until approximately 2000 feet where there is no daylight visible to the human eye. The only light present at depths greater than 2000 feet is from luminescent organisms. Therefore when diving at the approved maximal depths of recreational diving, up to 160 feet, it is wise to bring along a dive light in order to fully appreciate the vast array of colors of marine life.

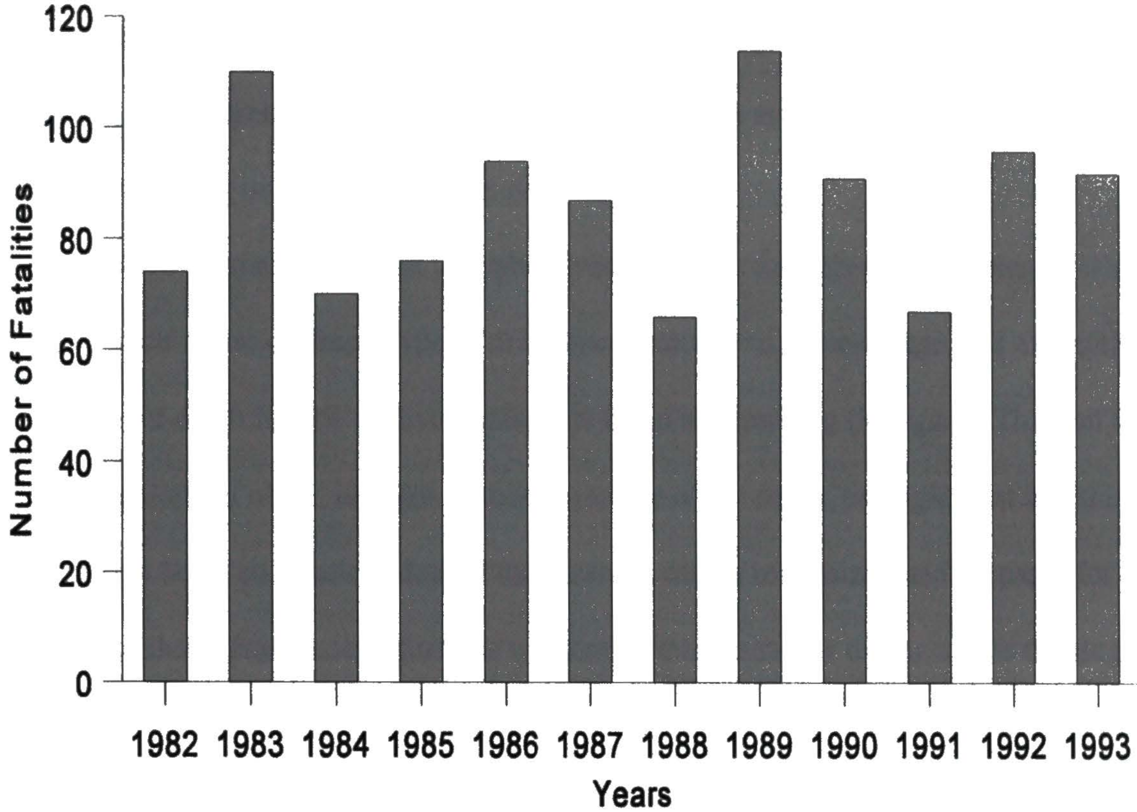
Risk Assessment of Recreational Scuba Diving

There are an estimated 2.7 to 3.1 million recreational scuba divers in the United States (Morgan). To be classified as a scuba diver one must be in possession of certification (a "C" card). This designates that individual as having completed a diver training course from a certified dive instructor affiliated with an organization such as PADI, the Professional Association of Dive Instructors, or NAUI, the National Association of Underwater Instructors. These are only two of a number of organizations capable of certifying a person as a recreational diver. However, not all registered divers are active. That is, to be considered an active diver, the certified individual should perform at least one open water dive annually. If the number of divers in the United States is simply a count of the number of registered divers this creates a problem with estimating the number of active divers for evaluating the risk of recreational diving. Furthermore, by counting simply the number of certifications, the estimate may be inflated. Monaghan, for example, reported that about 20% of PADI certifications are issued for advanced or leadership level classes (Monaghan). A single diver may hold over 20 certifications in an organization such as PADI when accounting for the leadership level PADI rating system. This individual would then represent over 20 divers in a statistical analysis. The number of active divers in America thus constitutes a simple estimate and cannot represent a truly valid number in the traditional sense.

The estimated risk to scuba divers contains several additional problems. First, in counting only certified divers, there is not an accurate portrayal of those divers who chose to dive without first completing an open water certification course. The number of divers who are able to obtain the equipment which allows them to dive without the proper certification would be very difficult to obtain. Second, the exposure rate of each individual diver is extremely varied. Comparing the risk to a diver performing 1 or 2 dives annually with a diver performing 200 or more dives annually does not follow conventional epidemiological principles. Third, the incidence of morbidity and mortality in recreational scuba diving must be viewed as a conservative estimate of the true number. The injured diver may simply choose not to or may not be able to seek medical treatment and the condition may resolve without aid, this is possible in mild cases of decompression sickness. Some diving fatalities go unreported while others may occur far removed from the dive site where an autopsy, if performed at all, would not be geared toward investigation of dive related injuries.

Despite these problems in gathering accurate statistics on the true risk of recreational scuba diving, there is a tendency among the dive organizations to assert that diving is safer today than it was 20 years ago (Morgan). Traditionally, this view has been based on the idea that there are fewer diving fatalities in conjunction with a larger dive population. The problems with these assumptions have been outlined previously (e.g. number of active divers, number of dive exposures, etc.). Furthermore, there is evidence that the number of treated dive injuries has actually increased over previous years (Morgan). Morgan suggests that there appears to be a trend of increasing fatalities from 1982 to 1993 shown graphically in **Figure 1**. There is another trend in these data showing that following each year with a higher fatality rate, the following year shows a

FIGURE 1: adapted from Morgan



reduction in fatalities. Another way of interpreting this is to say that the year following a lower number of fatalities shows an increase in fatalities. The first view would suggest that divers are using more precaution due to the high incidence of fatalities of the previous year. The second view might suggest that leaders of the dive community tend to de-emphasize the fact that diving is a high risk activity and there is a relaxation of safety concerns. For example, there was a great deal of attention given in popular diving journals to the small number of fatalities in 1988. However, 1989 showed an increase of 73% in the number of fatalities to 114 (DAN). Furthermore, the Diver's Alert Network (DAN), reported that over half of the 1991 cases of decompression sickness and arterial gas embolism were experienced by divers who had followed the established dive tables. It is possible that the number of dive injuries has in fact not increased but that there have been improvements in the recognition and reporting by physicians. The best way to approach the apparent risk of recreational scuba diving in any event is to view the statistics as erring on the conservative side.

When estimating the risk to scuba divers there are a number of variables on which to focus such as use of drugs, type of dive (open water, wreck, cave), age, and experience. The cause of death in 60% of dive fatalities is listed as drowning (Morgan). This can be due to running out of air, nitrogen narcosis (rapture of the deep), entanglement in fishing nets or kelp beds, and panic. Most of these causes can be recognized and prepared for during simulated emergency situations by a competent instructor during a dive training class. However, there is seldom adequate attention paid to the problem of panic. Panic behavior may be brought about by instances such as failure to escape entanglement, running out of air, or seeing apparently dangerous marine life. A panic ascent may then be performed which may in turn cause a gas embolism, a common cause of diving fatalities. Moreover, in cases of entanglement causing death, the body of a diver may be found later with plenty of air left in the tank. An example is given my McAniff, "a 58-year-old male diver, cause of death, entanglement in kelp, with over 6895 kPa of air left in his tank when found 24 hours later in kelp at a depth of 4.6 meters."(McAniff). In this case, the diver may have experienced a panic episode and in the ensuing moments removed his regulator either intentionally or accidentally. Furthermore, this diver was wearing a sharp diving knife with which he could have disentangled himself from the kelp, moreover suggesting loss of cognitive ability. When a diving fatality occurs due to lack of air, this too may well be due to a case of panic. There are often other sources of air available to the diver such as a pony bottle or buddy breathing that would preclude drowning due to lack of air.

Panic Disorder

Panic disorder is characterized by debilitating anxiety attacks which are repeatedly manifest in the absence of frightening stimuli. It is a common disorder occurring in approximately 2-5% of the general population (Reiman). Smoller described a panic attack as 'intense, acute anxiety, associated with certain physical symptoms (e.g. dyspnea, palpitations, chest pain) and cognitive fears (e.g., of dying or going crazy)' (Smoller). **Table 1** lists 10 symptoms specified by the Diagnostic and Statistical Manual of Mental

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TABLE 1

DSM-IV Criteria for a Panic Attack

1. Palpitations, pounding heart, or elevated heart rate
2. Sweating
3. Trembling or shaking
4. Sensations of dyspnea or smothering
5. Feeling of choking
6. Chest pain or discomfort
7. Nausea or abdominal distress
8. Feeling dizzy, unsteady, lightheaded, or faint
9. Derealization (feelings of unreality) or depersonalization (being detached from oneself)
10. Fear of losing control or going crazy

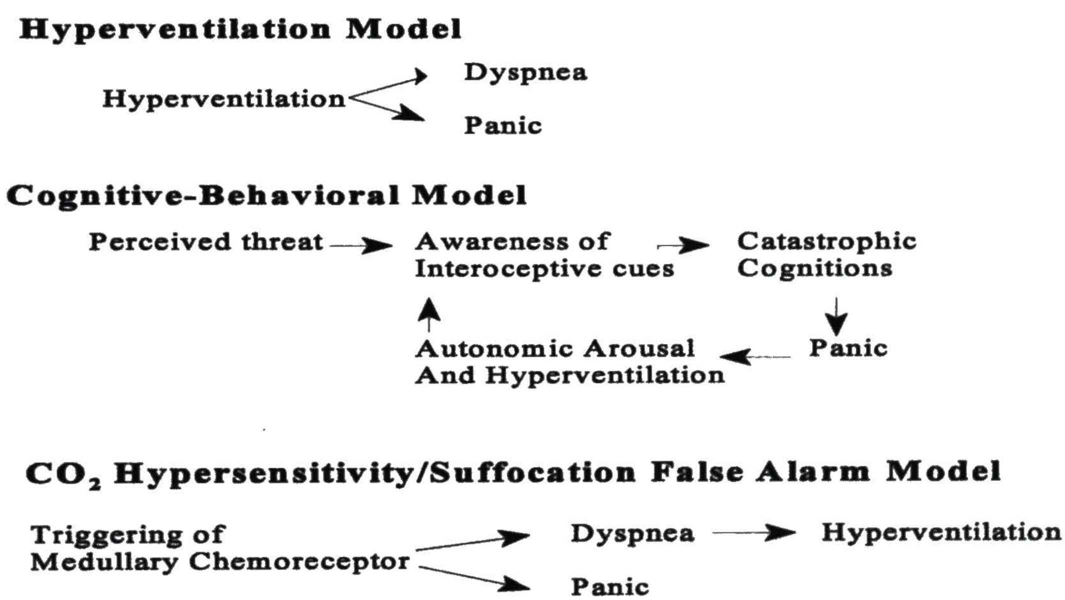
adapted from Smoller

Disorders (DSM-IV). Smoller has presented three models which represent why a panic attack may occur. The first model (**figure 2**) is based on hyperventilation and was initially described by Kerr and colleagues in 1937 (Kerr). Patients with panic disorder often are very susceptible to the hypocapnic alkalosis resulting from hyperventilation. The cerebral vasoconstriction resulting from the hypocapnia can lead to feelings of dizziness, lightheadedness, derealization and a sense of impeding doom. Coronary vasoconstriction may result in feelings of chest discomfort and palpitations. Treatment for the physiological and psychological symptoms of hyperventilation are paper bag rebreathing (common in emergency rooms) and breathing retraining techniques. The retraining techniques teach patients slow, abdominal breathing patterns that can be used in stressful situations which antagonize hyperventilation. Obviously, the paper bag rebreathing technique would not work for a diver while underwater. However, during stressful situations while diving (e.g. seeing a shark) the breathing techniques may be employed to alleviate the consequences of hyperventilation and thereby keep a panic attack from occurring.

A second model given by Smoller is the Cognitive-Behavioral Model (**figure 2**). In this, it is the individual's misinterpretation and fear of the physical sensations associated with dyspnea, hyperventilation or other symptoms which are crucial for producing panic attacks. Zoellner reports that among 37 females and 19 males with panic disorder, a substantial subset of patients (40%) exhibit overvalued ideation (Zoellner). In other words, this means that the individual does not recognize that the obsessions or compulsions are excessive or unreasonable. Individuals with panic disorder often catastrophize anxiety related physical sensations such as dyspnea or tachycardia. These sensations will be interpreted as being more dangerous than they actually are. A positive feedback cycle is then started with escalating anxiety as the autonomic nervous system causes arousal and hyperventilation with the other symptoms about which the patient can catastrophize further. This viscous cycle self perpetuates until the patient experiences a panic attack with the resulting loss of cognitive abilities. The cognitive-behavioral model suggests that it is the fear and catastrophic interpretation of unpleasant bodily sensations that provokes panic. This model might explain why both hypercapnia as well as hypocapnia can provoke panic. Both of these conditions cause unpleasant bodily sensations about which the patient is able to catastrophize. However, this model does not account for the panic attacks which may occur during sleep when cognitive misinterpretation is presumably inoperative. Regardless of the inability to explain this aspect of panic disorder, cognitive-behavioral therapy, used as first-line treatment, has reported panic-free rates of 70-85% (Smoller).

The third model Smoller describes (**figure 2**) is based on carbon-dioxide hypersensitivity and a suffocation false alarm. Patients with panic disorder have been shown to be hypersensitive to carbon dioxide when compared with normal controls and other psychiatric patients (Smoller). The most common symptoms reported during a carbon dioxide-induced panic attack are respiratory including dyspnea and smothering sensations. The mechanism by which carbon dioxide induces panic is unclear but patients susceptible to this type of challenge show distinct ventilatory responses. A specific neurological basis for panic is suspect as it is proposed that patients with panic disorder have an abnormally sensitive brainstem respiratory control mechanism. The medullary respiratory chemoreceptor area quite possibly detects increasing P_{CO_2} as signs of impending suffocation. This stimulates hyperventilation and autonomic arousal. Central chemoreceptors detect hypercapnia which increases the firing rate of the locus coeruleus (Gorman). This is believed to be the controller of the autonomic storm accompanying a panic attack. The false alarm triggered by the hypercapnia is due to an

FIGURE 2



Adapted from Smoller

abnormally low alarm threshold believed to plague patients with panic disorder. This model suggests a reason for the chronic hyperventilation seen in some panic patients as an attempt to maintain the P_{CO_2} below levels which would trigger a false alarm. The theory does not account for the clinical observation that paper bag rebreathing, a solution to the hyperventilation model, does not exacerbate the panic episode with the ensuing elevation in PCO_2. Paper bag rebreathing may function primarily as a distraction or placebo until the panic subsides (Smoller).

The severity of panic disorder varies with both the individual and the situation in which the person is placed. **Table 2** lists situations which might provoke a panic attack. 477 patients were asked to rate their fears based on these situations. The percentage represents how many of the total number of patients stated that it would either induce a

TABLE 2

Situations (%)	Panic Provoking (%)	No Problem
Closed-in places	25	17
Heights	23	18
Being alone	11	51
Unfamiliar places	8	21

adapted from Marks

panic episode or that it would not be a problem for them. These represent only four of a number of situations represented in the interviews. These situations may be particularly relevant to recreational scuba diving. Many inexperienced divers may tend to have some of these feelings during their first open water dives. **Table 3** lists the worst fears of patients with panic disorder during the time of a panic episode. The rank is out of a total of twenty different fears. Again, these may be relevant to diving based on the consequences of a particular fear overcoming the cognitive abilities of a diver and consequently endangering both the panicked diver as well as fellow divers.

TABLE 3

Rank out of 20	Fear
1	Feelings of panic
2	Fainting or collapsing
3	Losing control
4	Causing a disturbance
5	Going mad
7	Dying
9	Having a heart attack
17	Confusion; being unable to think clearly

adapted from Marks

Underwater Physiology

As noted earlier, the underwater environment experienced by scuba divers creates a necessity for a number of physiological compromises. Water is 800 times denser than air with a column of water 33 feet deep (one atmosphere) weighing the same as a column of air of the same size that extends over seven miles (Lee). Water pressure increases 14.7 pounds per square inch, or one atmosphere, for every 33 feet of depth. There are two ways that pressure at a given depth is denoted, absolute pressure and gauge pressure. At sea level, gauge pressure is zero while absolute pressure is one. Absolute pressure takes into account the total pressure of water plus the pressure of the atmospheric air above the water. Gauge pressure takes into account only the pressure of the water. For example, at a depth of 33 feet the absolute pressure is two atmospheres absolute (p.s.i.a.) and one atmospheric gauge (p.s.i.g.). At a depth of 66 feet, the pressure is 3 psia or 2 psig. Since a given volume of water has a constant density regardless of depth the underwater pressure can be found by multiplying the number of feet at a given depth by .445. This is because seawater increases .445 pounds per square inch for every foot of depth. The most common form of depth gauge used in recreational scuba diving uses the pounds per square inch of gauge pressure. At the surface, the diver's pressure gauge will be calibrated to read zero.

Another consideration of diving is the phenomenon of gas compression. This is stated through Boyle's Law of gases; at constant temperature, the volume of a gas will vary inversely with the absolute pressure, while the density of a gas varies directly with the (gauge) pressure (Lee). In other words, a sealed amount of air at 33 feet underwater will occupy half the volume it did at the surface while being twice as dense. This occurs in the diver's air cavities as well. The air in a diver performing a breath hold from the surface to 1 psig has half the volume of gas with twice the density in the air cavities such as the lungs, sinuses, and inner ears. Other bodily tissues such as bone, muscle, and skin are approximately the same density as water and are therefore incompressible by water. Hence, only the hollow air cavities of the body are subject to the squeeze by surrounding water pressure. A diver under normal circumstances breathes air from a tank which keeps the pressure in the air cavities in constant balance with the ambient water pressure. This prevents a painful squeeze from occurring when a diver performs a deep dive.

Dalton's Law of Partial Pressures helps explain a phenomenon known as nitrogen narcosis or rapture of the deep. The Law states "The total pressure exerted by a mixture of gases is the sum of the pressures that would be exerted by each of the gases if it alone were present and occupied the total volume" (Lee). Atmospheric air contains 79.02 percent nitrogen, 20.94 percent oxygen and .04 percent carbon dioxide along with other trace gases unimportant for this discussion. The partial pressure of nitrogen in air imposes limits on the depth one can dive safely. This is due to the narcotic effect nitrogen induces when breathed under pressure. The result is a loss of logical reasoning as the narcosis deprives a diver of his senses. Rapture of the deep begins at depths somewhere around 100 feet and worsens with increasing depth and duration of the dive. The overall experience is very similar to the effects of alcohol intoxication. A diver experiencing nitrogen narcosis may want to laugh or cry or perform any number of unusual and dangerous behaviors such as removal of the regulator and attempting to feed the fish from the tank's air supply. Under such situations, the diver is dangerous to both himself and to other divers. A "narked" diver has lost good judgement and is unable to cope with even the simplest task. Upon returning to the surface the narcosis is completely resolved with no residual hangover. The only way to avoid nitrogen narcosis while breathing compressed atmospheric air is to limit dives to 100 feet.

With such limitations imposed on the body while underwater, the United States Navy has set standards by which divers can time their dives without experiencing the undue effects of decompression sickness. The recreational scuba diver should not perform decompression dives and thus decompression tables and practices will not be discussed. The consequences of decompression sickness will be addressed later. Recreational scuba divers have the option of using set dive tables to plan no-decompression dives. For example, the PADI dive tables state that a diver can perform a dive to a depth of 140 feet with a bottom time of 10 minutes without pausing for a decompression stop on ascent (Lee). With the advent of dive computers, the diver can now rely upon this tool for assistance in planning and correcting dive times much quicker while on the surface or underwater. For example, the Oceanic Datamax Sport dive computer allows for dives to depths of 160 feet for seven minutes. This is deeper than the PADI dive tables list.

Physiological Consequences of Diving Accidents

Even by following strict dive table guidelines problems may still occur. As stated earlier, over half of the 1991 cases of decompression sickness reported by DAN occurred with divers operating within dive table allowances. Case studies of divers with varying degrees of decompression sickness will be reviewed to demonstrate the risks of recreational diving.

Case 1: In case one the patient had signs of neurological involvement from a no-decompression dive in which none of the other divers experienced any symptoms. The patient was an experienced male diver, aged 42 years. There were 12 divers in the group who spent 19 minutes at 110 feet with a 3 minute safety stop at 10 feet on ascent. Twenty minutes after surfacing, the patient had numbness and parasthesias in the left leg. Upon arrival to the launch ramp the symptoms had abated. The next morning, the patient had a return of the symptoms and was transferred to a chamber for recompression (Waite). This case is instrumental in describing the danger of stating that symptoms experienced by a diver cannot be decompression sickness because the dive was performed according to no-decompression dive tables. Consequently, in cases of panic attack, in which an emergency ascent is performed, the diver may experience symptoms of decompression

TABLE 4

Symptom	Percent of 1249 Cases of DCS
Pain	40.7
Altered Skin Sensation	19.2
Dizziness	7.8
Extreme Fatigue	5.7
Headache	5.7
Weakness	4.8
Nausea	2.9

Adapted from Bennett

sickness (DCS) even if the profile of the dive was within no-decompression limits. **Table 4** presents a listing of symptoms of 1249 cases of decompression sickness in recreational scuba divers reported to the Diver's Alert Network (Bennett).

Case 2: The next case demonstrates the hazards of flying after diving. The guidelines are important for recreational divers who tend to fly to a vacation destination, attempt to perform as many dives as possible in their limited time and then fly back to their homes. Case two describes a 40 year old skin diver who spent approximately four hours at a depth of 80-100 feet for the purposes of spear fishing. While diving he injured his upper right arm on some coral. About one hour and thirty minutes after surfacing he developed some mild pain in his upper right arm. The pain became progressively worse and the patient decided to fly himself to a recompression chamber for treatment for possible decompression sickness. During the flight the pain became severe and the patient nearly lost control of his plane on two occasions. When he landed he was immediately transferred to a chamber and recompressed. When the treatment was completed, the patient had only minimal pain and a neurological exam was normal (Waite). The location of the nearest recompression facility must be taken into account for a diver experiencing decompression sickness. If there is not a chamber within a short flight at low altitude other measures may be taken in order to keep the decompression sickness from worsening with the decrease in pressure due to a high altitude flight.

Case 3: This next case presents the ingenuity of a physician in treating decompression sickness without access to a recompression chamber. During a 40 foot quarry dive the patient ripped his dive-suit and made an emergency ascent. Upon surfacing he lost consciousness and sank beneath the surface. He was dragged from the water and transported to a nearby hospital. The physician recommended recompression. No chamber was available and the patient was taken back to the quarry and dressed in his dive gear. Although unconscious, a face-mask was rigged that kept his regulator in place and with the assistance of four divers, the patient was kept at a depth of 24 feet for 150 minutes. Upon surfacing, the patient and attendant divers were developing hypothermia. The patient was then taken back to the hospital for rewarming (Waite). Although not an ideal situation, this case demonstrates that decompression sickness can be treated without access to a chamber by submerging the patient with the help of experienced attendant divers. Furthermore, in a case resulting from a panic ascent, the unconsciousness due to decompression sickness can in fact be helpful. This would preclude the patient from experiencing a recurring panic episode and struggling to get back to the surface while being recompressed at depth.

These first three cases represent relatively mild cases of decompression sickness which can be quickly remedied with appropriate and immediate medical attention. The diver who experiences a panic attack and makes an emergency ascent to the surface may become such a case. There are however, much more severe cases which result in permanent injury or death. These types of cases will be addressed later. First, the various physiological results of a panic ascent will be described. If a panicked diver is free to break for the surface (the source of panic is not entanglement) gas embolism, a common cause of diving fatalities, may result (Sweeney). This condition is caused by overexpansion of the lung, and consequent alveoli rupture, by excessive air pressure during a rapid ascent. The result is a tearing of lung tissue and leakage of air from the lungs and into the bloodstream. Once in the bloodstream, blood corpuscles form clots around the air bubbles which then may become lodged in the joints or may travel to the brain causing rapid and permanent damage. The common cause for this condition is due to a diver performing a breath-hold while ascending from any depth greater than three feet.

Other conditions related to a case of gas embolism include; subcutaneous emphysema, mediastinal emphysema and pneumothorax. In subcutaneous emphysema, air from the ruptured lung escapes to tissue just beneath the skin. This often results in swelling and crepitance around the neck and supraclavicular fossa. Mediastinal emphysema refers to escaped air creating spaces in areas surrounding the trachea, larynx, great vessels, heart, etc (Lee). The patient may have substernal tightness that worsens with deep inspiration or swallowing. The presence of either kind of emphysema is in itself not life-threatening. However, when either subcutaneous or mediastinal emphysema are present, this may indicate gas embolism, a life threatening condition. Pneumothorax is a relatively rare extra-alveolar air syndrome which occurs in only approximately 9-10% of lung overinflation cases (Waite). Pneumothorax is the presence of air spaces between the lungs and the chest wall. This may result in the collapse of a lung and extreme difficulty in breathing.

Cases four and five delineate instances of cerebral arterial gas embolism in which the patient died from ensuing misdiagnosis. In both situations rapid recompression at a chamber with skilled personnel would have most likely saved the lives of these divers.

Case 4: Case four is of two divers performing an open sea descent to 120 feet for 5-10 minutes. One diver ran out of air and both made an emergency ascent. Upon surfacing, both divers rested briefly and then began swimming for shore. One of the divers then experienced loss of vision and was subsequently towed back to shore by the buddy diver. The victim was unconscious at the shoreline and transported to a hospital three miles away. At the hospital all resuscitative efforts failed and the patient was pronounced dead. The coroner listed the cause of death as "asphyxiation secondary to salt water drowning."(Waite).

Case 5: Case five is of a navy diving student swimming in 10 feet of water for 45 minutes in a swimming pool. On surfacing he immediately sank to the bottom. He was pulled from the pool, CPR was initiated and he was transported to a nearby emergency room. The victim was noted to have extensive subcutaneous emphysema and a severe pneumothorax of the right side. Forty days later, he was declared brain dead, life support was removed, and he was pronounced dead (Waite).

These cases represent what may occur in a case of panic. The diver who ran out of air and made for the surface was inexperienced, having just recently been certified, and most likely panicked. The shallow water case is representational of a dive training class. Though not directly applicable to panic, in that there was no equipment malfunction, depletion of air supply, or entanglement to cause panic, this case is important because scuba students train in similar pools at the same depth. Students who may be susceptible to panic are not safe from the effects of arterial gas embolism even in the seemingly safe confines of a dive training pool.

Discussion

Recreational scuba diving may be associated with many risks when one takes into account the physical limitations the underwater environment imposes on the human body. For an individual prone to panic attacks, these risks may be life-threatening. In this environment a diver may experience feelings of being closed-in, at great heights, of being alone, and/or of being in an unfamiliar place. All of these feelings are listed in **table 2** as being situations considered panic provoking.

The onset of a panic episode underwater can be better understood through investigating Smoller's three models of panic disorder. The hyperventilation model suggests a person with panic disorder is a chronic hyperventilator. This person can maintain a chronic respiratory alkalosis with only a few additional breaths and when stressed can sufficiently convert this chronic alkalotic state into a symptomatic acute hypocapnic alkalosis. As scuba diving can be a stressful sport given any number of situations (e.g. equipment problems, lack of air, threatening marine life, etc.) a chronic hyperventilator might easily convert to the symptomatic alkalosis, thereby inviting a panic attack. The cognitive-behavioral model describes how the individual's fear and misinterpretation of physical sensations leads to the catastrophizing of these sensations culminating in a full-blown panic attack. Chest tightness is implicated as an anxiety-related physical sensation which may cause a panic episode. This may easily be experienced by a diver over the course of a recreational dive. On ascent, the buoyancy compensator (B.C), worn as a sort of vest as part of scuba gear, will expand as the air inside expands, according to Boyle's Law. This may cause chest compression if the diver is not sufficiently aware enough to release the air. Furthermore, if the air is not let out the diver will begin to rise with the expanding B.C. This may cause a sensation of losing control, ranked in **Table 3** as the third of twenty fears which may cause panic. A biological vulnerability to panic disorder is explained by the CO_2 hypersensitivity and suffocation false alarm model. This model suggests that the central chemoreceptors sense hypercapnia which in turn causes increased firing of the locus coeruleus and the subsequent autonomic storm accompanying a panic attack. During a recreational dive, either through a conscious decision or not, there may be an attempt by the diver to conserve air through hypoventilation. The sensitivity of the suffocation alarm may be so low that relatively mild hypoventilation may result in an apparently spontaneous panic attack (Smoller).

The limitations of the physical environment of scuba diving may cause a number of problems for the diver attempting a panic ascent. Numerous causes for the panic ascent have already been mentioned (e.g. lack of air). Nitrogen narcosis, mentioned earlier, might be an inducer of a panic ascent. In table 1, the DSM-IV criteria listed as 8, 9, and 10 (feeling dizzy, derealization, and fear of losing control) are very similar to the feelings experienced by a "narked" diver. The ensuing loss of cognitive ability during nitrogen narcosis may well promote a panic attack. During the emergency ascent, the diver may hold his breath thereby creating a lung barotrauma leading to cerebral arterial gas embolism, pulmonary emphysema, mediastinal emphysema and/or pneumothorax.

The cases presented earlier are helpful in demonstrating the need for a trained and experienced physician to diagnose any diving related maladies. In case one, there was no apparent reason for the individual to have decompression sickness. A diver making a panic ascent must be observed closely following arrival at the surface. Even if the dive was performed within no-decompression dive limits, decompression sickness may occur. If it is necessary to recompress a diver, cases two and three are instrumental in demonstrating both the hazards of air transport to the victim experiencing decompression sickness and the ingenuity of using the water which caused the illness to remedy the situation. Cases four and five delineate further the importance of a proper diagnosis for any symptoms experienced after surfacing from any depth. Failure to do so, even from a dive training pool, can result in the death of the scuba diver.

Conclusion

Recreational scuba diving has become increasingly popular in recent years. With the increasing numbers of participants, the risk associated with the sport needs to be addressed. Some authorities suggest it should be classified as a high-risk sport (Morgan) while others suggest that the dangers of the activity have been down-played due to the commercialization of the diving community (Roos). Panic is an important topic in assessing the risk to recreational divers. The National Underwater Accident Data Center, NUADC, for the period of 1976 to 1988 indicated that 19% of diving fatalities reported involved probable panic (Morgan). Furthermore, in a sample of 245 male and female divers, 54% experienced panic or near-panic behavior while diving on one or more occasion (Morgan). The physiological consequences of a panic attack while diving can be deadly.

Instructors, physicians and dive students should be made of aware of the risk to persons prone to panic attack. Instructors need to be trained in recognizing the manifestations of frank panic during instruction and discourage these students from continuing. More subtle cases of panic disorder must be screened out by a physician while performing a medical clearance physical for a recreational diving student. The physician can make subtle inquiries and through the answers screen out potentially panic prone divers. Such questions as "How many visits to the emergency room have you made?" as opposed to "Have you ever visited the emergency room?" will elicit a more complete history versus a blanket denial of previous illness or injury (Davis). The nature of the E.R. visits will often be revealing to the astute physician. Persons with histories of asthma attacks or hyperventilation syndrome may indicate an underlying panic disorder. The students themselves need to be warned of the hazards of diving if panic prone. The idea needs to be stressed in scuba diving books and manuals much more than it is currently. For example, one of the most popular scuba diving books, *The Encyclopedia of Recreational Diving*, does not cover panic or the problems that can result due to panic (Morgan). If this concept is made clear to students while in class, those prone to panic episodes may then self-screen themselves and discontinue a scuba class thereby avoiding injury or death.

Scuba diving should be considered a high-risk sport and participants screened for such activity. Not only does a panicked diver put himself in jeopardy, he risks the lives of others in a group with the loss of cognitive abilities seen during panic. Individuals with elevated anxiety levels are more likely to experience a panic episode while diving due to the number of stressors involved in the sport. These persons should be selectively screened out and encouraged to find other avenues for recreation.

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