animals (usually rodents) and then thoroughly evaluating the substance in larger animals (monkeys or dogs) before testing it in human divers. The animals and humans are trained to perform similar complex tasks; then they are treated with the drug and exposed to normal and increased pressure conditions in a dry hyperbaric chamber. Because there are thousands of drugs available on the market, we have selected representative compounds from major drug classes for test and evaluation.

Results of these evaluations have demonstrated how widely the effects of drugs vary when introduced to the hyperbaric environment. Some specific observations follow (* indicates statements based on information where human evaluations have been conducted).

* Analgesics Aspirin and Acetaminophen (Tylenol) have been tested at depths to 180 fsw, and even moderately high doses (3-4 tablets) have not produced behavioural or physiological problems.

* Antihistamine (Benadryl) At prescribed doses we have consistently observed decreased performance, mental clouding and reduced fine motor co-ordination.

Decongestants (Sudafed) Behavioural effects of decongestants under pressure are not as toxic as those observed with the antihistamines, although we have seen some slowing of judgement and co-ordination. In addition, researchers and clinicians suggest that decongestants may predispose divers to cardiac arrhythmias.

Depressants Pentobarbital and alcohol have been evaluated, and the effects did not appear to get worse under pressure. However, alcohol intoxication, which can cause nausea or vomiting, would certainly be a problem for the diver.

Diuretics No behavioural effects have been observed at normal doses.

Hallucinogens Delta-9-tetrohydrocannabinol (THC), the active ingredient in marijuana was evaluated in animals. The effects of marijuana, which interferes with cognitive processing and neuromuscular control, get worse under pressure, and these effects are magnified as the partial pressure of oxygen increases.

* Motion Sickness Remedies Dramamine, an antihistamine-type motion-sickness preparation which is actually a combination of antihistamine and stimulant, does not appear to produce any significant behavioural problems at depths to 180 fsw.

Stimulants Dexedrine, Wethedrine, and the antidepressant Monoamine-oxidase-inhibitors interact with pressure conditions to interfere with judgement and muscle co-ordination at depths as shallow as 50 fsw. These drugs also may have undesirable cardiovascular effects.

Tranquillizers Chlorpromazine, Librium and Valium caused changes in the dose-response curves from animal subjects when these compounds were evaluated under pressure. The magnitude of the effect was dose-and pressure dependent. In addition, although we have no data for humans, lack of alertness or overconfidence resulting from tranquillizers would certainly be troublesome at 100 fsw.

Now, these findings need qualification:

1. Although the studies were carried out under carefully controlled laboratory conditions, they were not done in the water, and the addition of that factor and its associated variables (eg. cold, anxiety, fatigue} certainly could alter the effect of drugs.
2. As you've seen, we have not completed all of the evaluations with humans. Some of the conclusions are based on animal research and, therefore, direct inferences about humans must be made with caution.

In summary, there are three important facts that you should remember when you plan a dive: 1) Changes in your body chemistry occur while diving; 2) many variables affecting drug action can come into play during a dive; and 3) the interaction of these facts (1 and 2) cause drugs to change unpredictably.

Recommendations

- It would be wise to avoid all drugs while diving.
- Remember that over-the-counter preparations can be as toxic as prescription or abused drugs.
- If you must dive under medication be informed. Get full information from your diving medical officer, realize that even the most benign compound may become behaviourally toxic under pressure, and dive with extreme caution.

Reprinted from FACEPLATE

THE FLYING DIVER

Dr Christopher W Dueker

A glance through a dive magazine reveals the many opportunities available to recreational scuba divers for exotic vacations. Unfortunately the dictates of schedules, land transportation, etc. often mean that a seven day trip includes just four days of diving. Consequently, the diver may be tempted to spend his entire vacation diving right up till flight time. This may result in on unexpected case of decompression sickness.

On land, a diver's tissues are completely saturated with nitrogen at a pressure equivalent to the partial pressure of nitrogen in the atmosphere. During a scuba dive, the body absorbs more nitrogen since the nitrogen pressure increases with depth. This excess nitrogen is eliminated during ascent to the surface. Usually some excess nitrogen (compared to the pre-dive state) remains in the tissues upon surfacing. Decompression tables are designed to keep the surfacing nitrogen below the level likely to trigger decompression sickness. Combinations of dive depth and duration are matched with tables permitting either direct or delayed ascent. It takes over twenty-four hours to completely eliminate the excess nitrogen. This slow surface elimination of nitrogen forms the basis of the "repetitive dive tables".

Going above sea level in any fashion driving, hiking, ballooning, or flying causes the pressure on the body to fall. Oxygen and nitrogen pressures are lower in Denver than in San Francisco. Sea level nitrogen pressures are just as excessive at 18,000 feet (one half atmosphere) as nitrogen pressure is at 33 feet compared to sea level. Aviators are subject to decompression sickness at high altitudes. Of course, they also suffer from hypoxia unless oxygen is supplied by mask or by aircraft pressurization. Pressurization of cabins almost eliminates the risk of decompression sickness in aviation. Military aviators have the opportunity to make low pressure chamber excursions to altitudes equivalent to 25,000 to 40,000 feet. These exposures are done to familiarize crews with low pressure problems. To prevent hypoxia, oxygen is breathed throughout the "flight". Before leaving sea level, the crew breathes oxygen to reduce their nitrogen stores. Complete nitrogen elimination would take more than twenty-four hours, but a significant amount can be eliminated with thirty to sixty minutes.

Despite all precautions, decompression sickness does occur in high altitude exposures. The incidence varied from 0.012 percent to 0.38 percent with the group studied. Of interest, about 25 percent of the cases of decompression sickness occurred at an altitude lower than 25,000 feet (0.37 atmospheres). This, in the presence of oxygen, pre-breathing refutes the widely held belief that decompression sickness is difficult to induce during low pressure exposures. The data comparing diving and altitude decompression sickness are not available; however, the major reports give a diving decompression sickness incidence of about 0.047 percent for air diving.

Aviators have one major advantage over divers. Returning to sea level alleviates aviation decompression sickness since it is a recompression from altitude. About 28 percent of the cases completely resolve when sea level is reached. The remainder sometimes require chamber treatment.

When a diver becomes a flyer, the problem of nitrogen elimination gets more complicated. The excess nitrogen remaining offer a dive increases the likelihood of decompression sickness upon further decompression to altitudes above sea level. The total nitrogen equals that remaining after the dive plus the body's normal amount. As atmospheric pressure decreases, the stored nitrogen becomes excessive and may cause decompression sickness. Essentially the flying diver is at risk from a combination of diver's decompression sickness and aviator's decompression sickness.

The potential risk of decompression sickness associated with flying after diving is very great.[1] Fortunately, there have been very few such cases reported. Two factors explain the low incidence. First, gas elimination progresses during the time the diver moves from the dive site to the airplane. The inefficiency of travel usually makes this a relatively long time. Second, commercial airplanes are pressurized so that ambient pressure does not decrease to those levels seen in low pressure chamber excursions.

Most divers have been subjected to several "rules" about flying after diving. Confusion abounds since there is no well established standard for flying after diving. Considerations include: the dive depth, dive duration, surface interval before flying, number of dives made, altitude reached, duration of flight, and the diver's physical status. Because of the many possible dive/flight combinations, it is not surprising that no single rule suffices.

The problem of altitude reached is minimized by the virtual standardisation of commercial airplane pressurizations. Planes usually fly with 8.6 pounds-per-square-inch added to ambient pressure (of course the added pressure varies so that the total does not markedly exceed 14.7 psi). Thus pressure remains at sea level until above 20,000 feet. At the usual maximum altitude of 41,000 feet, cabin pressure is still 10.9 psi (0.74 atmospheres) - equivalent to 8,000 feet altitude. Pressurization failures are very rare and are treated by rapid emergency descent.

Probably the first official directive on flying after diving appeared in 1962 in the Naval Medical Newsletter. Based very loosely an experiments in man, it prohibited flying to cabin altitudes in excess of 18,000 feet within 12 hours following a dive to 30 feet.

This rule was very restrictive and did not appear to consider the much lower attitude during most flights. Several other approaches were taken in the late 1960's to determine new standards.

Navy work with dogs actually suggested a more restrictive policy. It prohibited flying above 8,000 feet within 12 hours of a 2.5 foot dive.

Attempts to facilitate flying after diving led to human experiments for short dives (120 feet for 15 minutes) medium dives (40 feet for 200 minutes) and saturation 30 or 33 feet for 24 hours). The conclusion was that a two-hour surface interval was satisfactory except for dives requiring decompression - then 24 hours was advisable. This investigation has been widely quoted often with very incomplete understanding. Repetitive dives were not studied.

Another approach utilized by the Canadian Defence Research Board has used the decompression computer model to construct non-tested tables even more liberal than those using a two-hour surface interval. A commonly overlooked disclaimer of the Canadian tables is that they are designed only for "must fly" situations. Under normal conditions, a 24 hour wait is advised.

Computers were used in a large, formal study which was the first to utilize repetitive dives. Since the maximum dive depth was 47 feet, and since these schedules are untested, they have received little attention.

Another method using extrapolation from diving tables concluded that flying to 8,000 feet was safe, if the diver was in Group D of the repetitive dive system. This approach is untested and based on the assumption that it is safe to extrapolate from diving experience to altitude exposures.

Several problems make all flying-after-diving policies suspect. Basic to all decompression studies is the realization that individual variation drastically affects results. None of the derived tables has been tested adequately. Computer models suggest tables, but they cannot be assumed to be capable of producing reliable tables.

Most sport divers make several dives in a day, and the best tested tables do not account for this. After several days of diving, the decompression requirements are different than after just one day.

Decompression dives or recompression therapy invalidate all the derived programs.

The experiments which created the two hour surface interval actually ignored certain symptoms: short term pain and skin itching.

Finally, all the existing diving and flying schedules were developed before the current interest in asymptomatic bubbles - "silent bubbles". These bubbles develop in many standard dives and probably would occur in most of the liberal diving and flying programs. The importance of "silent bubbles" has not been firmly established, but they may have long term significance. At any rate the current goal in decompression research is to reduce the incidence of "silent bubbles".

What is the average diver to do? Consider that most commercial and military agencies are moving toward conservative policies; ie. 8-12 hours after "no decompression" dives before flying. Saturation divers may be kept at sea level for up to a week before being allowed to fly. Remember also that 7% of decompression cases develop after six hours on the surface. A plane trip shortly after a dive would aggravate an already developing case of decompression sickness.

There is one way to safely shorten the time between diving and flying: breathe pure oxygen. But this is not usually practical and would be inadvisable over a long period.

The prudent diver plans his diving vacation carefully by putting the heaviest diving days in the middle of the vacation. This provides a day or two for familiarization of the dive site and gives time for maximum nitrogen elimination.

Save snorkelling and shopping for the last day. Remember that the low incidence of decompression sickness in flying divers is due more to the blessing of inefficient travel connections than to any safety factor. The risk is genuine.

1. Any mode of altitude change can be dangerous as demonstrated by divers who got decompression sickness during a post-dive bus trip.

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Epilepsy and Diving

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It is estimated that since the mid 1950's, more than two and a half million people have been trained in scuba diving in the United States of America, with probably somewhere under a million of these remaining as active divers from year to year. The popularity of the sport indicates that at some stage a physician may come in contact with a person who wishes to dive. Although there has been a wealth of knowledge produced in the fields of hyperbaric medicine and physiology, in an effort to delineate the stresses and limits of man's exposure to pressure, there has not been a concomitant dissemination of knowledge of diving medicine amongst the general medical profession.

Some of the stresses which face the diver include the consequence of inadequate medical and physical fitness; the effects of changes in ambient pressure on gas-filled body space and on density of breathing pressure of inert gas, oxygen, or contaminants, such as carbon monoxide; the effects of too rapid a reduction of ambient pressure; immersion in cold water and excessive heat loss; and psychological disturbances due to confinement, isolation, darkness and danger.

In the diving manuals of most Navy and civilian organisations, the importance of medical fitness to dive is always stressed. Perhaps the first step in ascertaining "fitness to dive" is that of ensuring the absence of the various diseases which are incompatible to diving. These conditions may not prevent participation in any other sport, but are especially relevant in diving because of the changes in ambient pressure involved. Also, any disease state which may produce unconsciousness or incapacitation is potentially fatal under water. Although the various Navies of the world have long demanded stringent medical assessments of their prospective and active divers, and most commercial diving organisations are realising their importance, this has not been so in the sport diving field.

Some sport divers may find themselves in the situation where they are more aware of the special medical problems of diving than their medical attendant. It is therefore, of obvious importance that the medical examination should be carried out by a doctor familiar with the medical aspects of diving. There are no doubt, instances of diving fatalities and accidents, which would not have occurred had the victims been assessed medically and advised against diving.

Meckelnburg (1978) states that in the USA all nationally recognised training organisations now require physical examinations of prospective divers before they are allowed to undertake scuba training. Commercial training is even more difficult, and since 1977, regulations promulgated in the Federal Register by the Department of Labour have controlled standards in the diving industry. These regulations produced various reactions amongst different groups - some American diving contractors claimed that to follow the restrictions would put them out of business. The university scientist and scuba shop salesman claimed that it did not relate to them. It thus became obvious that standards may vary with the type of diver.

The population at risk is perhaps difficult to estimate exactly. Apart from commercially employed divers, there are probably large numbers of self-employed semi-professional people or even rank amateurs engaged in underwater work. Such work may vary from harvesting sea life such as abalone to the extremely deep, hazardous, complex off shore diving related to oil exploration.

The problems are enhanced when a person previously self employed as on abalone diver with perhaps little or no training, who may have disqualifying defects, decides that he wants to work for a commercial firm as a qualified diver. Prior to the introduction of more stringent regulations, some of these people could well have been employed by commercial diving companies, and these people could be asked to perform tasks beyond their professional and technical abilities without any consideration of their physical capacity to tolerate the new stresses involved.

Obviously, off shore oil exploration poses the greatest area of risk as many of these diving operations are carried out hundreds of miles from shore where medical and support facilities are lacking and weather conditions may present problems when medical attention is necessary or a casualty occurs. Experience in the North Sea oil fields and from the Gulf of Mexico oil fields indicate that for the year 1974, the fatality rate for off shore diving was 111 fatalities per 10,000 persons per year. This contrasts to an approximate 2.6 fatalities per year per 10,000 persons engaged in general construction industry and mining industry.

In Australia, standards have been laid down by the Standards Association of Australia, Code CZ18 1972. Underwater air breathing - Appendix A - Medical Standards