Diving & The Body Systems

Diving with conditions of the endocrine, pulmonary and cardiac systems

By Dr. Guy de Lisle Dear, DAN Associate Medical Director
With Additional Reports From Joel Dovenbarger

Continuing the series of DAN’s most frequently asked questions, DAN’s Associate Medical Director Dr. Guy Dear explores the topic of scuba diving and various conditions of the endocrine, pulmonary and cardiac systems.

Other articles in this series include:
• “I’ve Been Stung: What Should I Do?” By Paul S. Auerbach, M.D., M.S., January/February 1998 issue;
• “High-Pressure Ophthalmology: DAN Answers Divers’ Most-Asked Questions About Their Eyes,” by Frank K. Butler Jr., Captains, Medical Corps, United States Navy, May/June ’98 issue;
• “DAN Explores Fitness and Diving Issues for Women,” by Donna M. Uguccioni, M.S., DAN Vice President & Medical Director Dr. Richard Moon, and Dr. Manda Beth Taylor, DAN Consulting Physician, January/February ’99;
• “CNS Considerations in Scuba Diving: How Your Diving Fitness Can Be Affected By Your Central Nervous System Health,” by Dr. Hugh Greer, DAN Southwest Regional Coordinator, May/June ’99.

Fitness & Diving with Chronic and Long-Term Illnesses

As scuba diving’s appeal broadens to all ages, more individuals with some type of health concern are asking about fitness requirements for scuba diving. Many years ago, when physicians trained in diving medicine began discussing recreational scuba fitness requirements, a “model diver” was created.

This model diver was the accumulation of medical expertise, diving physiology and known disease processes. Restrictions to scuba diving included medical conditions and illnesses that might impair or limit a diver’s ability to perform underwater.

Unfortunately, very little research data existed to support many of these theoretical restrictions to scuba diving. Now, as it was then, it would be unethical to place individuals at risk of injury just to prove actual risk is less than what we might expect.

Some restrictions have changed over the years, however. For example, 10 years ago the fear of hypoglycemia kept any person taking medication for diabetes out of scuba diving. Today, individuals who control their diabetes with oral medication may dive; and perhaps, once DAN’s research on diving with diabetes is completed, the scuba training agencies may accept a select group of insulin-requiring persons with diabetes.

There are still prospective students who are going to be turned away because of a medical condition, not just because they have a medical problem but because of the severity of their symptoms. In general, any condition that may impair mental or physical performance, induce pain or loss of consciousness, or cause nausea or vomiting must be evaluated before diving. Additionally, there are some medical conditions that may be affected by diving physiology, such as some blood disorders which are sensitive to changes in blood volume.

This article presents some very difficult frequently-asked questions that concern chronic and long term illness. Dr. Guy Dear, one of DAN’s Associate Medical Directors, has put together some very detailed answers to help explain these medical concerns to divers and their physicians so that, together, they can make an informed decision about scuba diving.

This is one way we at DAN strive to increase general medical knowledge in the scuba diving community and prevent injuries and deaths related to these medical conditions.

Joel Dovenbarger, Vice President, DAN Medical Services

Body System: Endocrine

DIABETES

Condition: Diabetes mellitus (DM) is a disorder of the endocrine system, manifested by one of two things: an insufficient production of insulin or the resistance of the body’s cells to the actions of insulin despite normal or high levels.

People with DM often have excessively high blood glucose (BG), called hyperglycemia, or an excessively low BG, better known as hypoglycemia.

Diabetes mellitus itself has two major forms: Insulin-requiring diabetes (IDDM, Type 1),* for which insulin must be given by injection to control blood sugar levels; and non-insulin-dependent diabetes (NIDDM, Type 2), which may be controlled by diet or by oral medications (oral hypoglycemic medications).

The main risk to the diver is the occurrence of hypoglycemia, that can manifest itself as confusion, sweating, rapid heartbeat, unconsciousness and even death. High blood sugar levels, or hyperglycemia, may also cause unconsciousness, although this usually develops much more slowly than hypoglycemia.

Impaired consciousness underwater leads to almost certain death. Although hypoglycemia occurs most commonly in Type 1, it can also occur in individuals taking oral hypoglycemic medications.

Hypoglycemia experienced during a deep dive may be wrongly perceived as nitrogen narcosis.

Although hypo- or hyperglycemia can occur daily, other problems can develop over the long term, in persons with diabetes. These maladies include retinopathy (alterations in visual acuity), neuropathy (numbness in legs), nephropathy (alterations in kidney function), and cardiovascular disease.

* Note: The acronym “IDDM” actually stands for the older term “insulin-dependent diabetes mellitus,” although the newer term for this condition is termed “insulin-requiring diabetes mellitus,” and is still represented as “IDDM.” The diabetes community currently is in transition between nomenclatures.
disorders of the kidneys, coronary artery disease, and changes in the nervous system, including abnormal nervous conduction and atherosclerosis, that can cause poor circulation in the limbs.

**Fitness and Diving:** Divers with diabetes are at risk of sudden loss of consciousness. This carries the ultimate risk of drowning and implies additional risks for their dive buddies. Individuals with diabetes, however well the diabetes is controlled, should not be deemed as fit to dive without restriction. Those who meet certain criteria can dive provided they dive in accordance with detailed, specific procedures (See “Diabetes & Diving: Current practices demonstrate that many with diabetes do take the plunge”, By Guy de Lisle Dear, M.B., FRCA, Alert Diver, January/February 1997). Divers with diabetes should be examined periodically for complications of their disorder that may disqualify them on the grounds of additional risk.

**Medication Used in Treatment:**

Sulphonylureas (drugs that posses hypoglycemic action) such as glipizide, glibenclamide, chlorpropamide and tolbutamide may interact with numerous other drugs used to lower BG. Biguanides (metformin) may cause self-limited (gastrointestinal side effects and may cause problems* in individuals with renal, liver or heart diseases.

Acarbose (an alpha-glucosidase inhibitor) is also used in conjunction with other agents when the more simple sulphonylureas do not work adequately to control blood glucose. Insulin acts to lower BG. In general, diving with diabetes is not recommended. An additional consideration: insulin requirements may change substantially with demands of exercise and diving.

---

**Body System: Endocrine**

**Thyroid**

**Condition:** The thyroid is a vital gland that secretes a hormone (thyroxin) that helps regulate body metabolism. In excess quantities (hyperthyroidism), it can increase the heart rate or produce cardiac problems, affect respiratory rate, decrease body weight and even interact with the central nervous system. Symptoms of hyperthyroidism also include discomfort or anxiety. Cardiac effects include tachycardia (fast rate), serious dysrhythmias and heart failure. Hyperthyroidism also causes muscular weakness and periodic paralysis in individuals of Chinese descent. Lower-than-normal levels of thyroxin (hypothyroidism) may cause fatigue and slow or absent reflexes. Hypothyroidism is also characterized by a slow heart rate and slow metabolism; it may cause heart failure.

The thyroid glands output can be controlled by medication, radiation, radioactive iodine or surgery; this is to reduce the function of the thyroid, or it can reduce the amount of hormone released. Once the hormone level has been reduced to within the normal range (assessed by blood test), and the signs and symptoms of hyperthyroidism have resolved, then a diver with a thyroid condition may resume diving. Note: This assumes, however, that the diver has no other major health problems and the diver can achieve a suitable level of physical performance.

Individuals who are treated (by medication, radiation, radioactive iodine or surgery) may become truly hypothyroid (have reduced thyroid function) and may require supplemental thyroxin (Synthroid®) to actually raise their hormone level back into the normal range. It is vital for all ity from oxygen therapy, pulmonary toxicity from oxygen component therapy and graft-versus-host disease.

---

Additional Information:

- The National Institute of Diabetes and Kidney Diseases or (NIDDK) — www.niddk.nih.gov/
- “Diabetes & Diving. Current practices demonstrate that many with diabetes do take the plunge — How safe is it?” by Guy de Lisle Dear, M.B., FRCA, DAN Assistant Medical Director, Alert Diver, January/February 1997.

---

**Additional Information:**

- American Thyroid Association — www.thyroid.org/patient/patient.htm
- Thyroid Foundation of Canada — home can.net/thyroid/canada.html

**Body System: II — Primarily Heart and Lungs**

**Cytotoxic Drugs, Cancer Effects**

**Condition:** Cytotoxic drugs (cell-killing drugs) are used primarily for the treatment of cancer or some more serious generalized autoimmune diseases such as rheumatoid arthritis. As far as generalized fitness is concerned, the underlying disease may have more impact on diving than the treatment.

Cancer patients also often have lung conditions that can cause problems such as: chronic lung diseases, opportunistic lung infections, lung metastases, radiation treatment to the lungs (causing fibrosis), pulmonary hemorrhage, pulmonary oxygen toxicity from oxygen therapy, pulmonary toxicity from blood component therapy and graft-versus-host disease.
**Fitness and Diving:** After cancer and its treatment, lung tissue is less able to stretch safely, and fibrosis caused by cytotoxic may render the diver more liable to a burst lung on ascent. Certain drugs, such as bleomycin, are contraindications to diving. Bleomycin causes a special type of serious lung fibrosis (and possible adult respiratory distress syndrome) in response particularly to increased levels of oxygen. For anyone treated with this drug, any inspired oxygen level above 0.25 ATA should be avoided.

The cytotoxic drugs may leave residual effects even long after their withdrawal. Functional assessments of both cardiac and pulmonary status by formal testing are important before diving is considered. Life expectancy needs to be assessed before starting dive training.

Medication Used in Treatment: The incidence of either pulmonary or cardiac problems is shown in brackets.

- Bleomycin (pulmonary 1-10%)
- Busulfan (pulmonary 1-10%)
- Cytarabine (pulmonary 20%)
- Chlorambucil (pulmonary , occasional)
- Cytotoxic agents and / or by bone marrow transplantation

**Body System: Blood**

**SICKLE CELL ANEMIA**

Condition: Sickle cell disorders are the most common hemoglobinopathies (abnormal red blood cells) encountered in the United States. Sickle cell anemia (HbS) results from a mutation that changes the amino acid at position 6 on the beta chain from glutamic acid to valine. The homozygous state produces sickle cell anemia.

Sickle cell trait (HbAS) is the heterozygous (carrier) state; it can be affected by low oxygen levels. Sickle cell trait occurs in 8 percent of African Americans in the United States. Oddly enough, HbS confers a protective advantage against malaria infection.

In general, however, sickle cell disorder has no advantages. Sickle cells are dehydrated, stiff and viscous; they flow poorly though small blood vessels, which poorly oxygenated cells on blood flow.

The problems associated with leukemia depend on the stage of diagnosis, often made by chance on a routine blood count.

**The problems associated with leukemia depend on the stage of diagnosis, often made by chance on a routine blood count.**

**Body System: Blood**

**LEUKEMIA**

Condition: Chronic lymphocytic leukemia (CLL) is the most common type of leukemia; it may account for approximately 10 percent of all leukemias. The problems associated with leukemia depend on the stage of the disease present at the time of diagnosis, often made by chance on a routine blood count. Complications include anemia, low platelets and low white blood cell count. A favorable response can be expected in most individuals treated with chemotherapy, radiation or both.

Acute leukemia accounts for 10 percent of all human cancers, and it is the leading cause of cancer deaths in adults younger than 35 years old. There are two main types: acute myelogenous leukemia (AML) and acute lymphoblastic leukemia (ALL). The cause of acute leukemia remains unknown. Treatment is usually by cytotoxic agents and / or by bone marrow transplantation.

Individuals with leukemia are very sensitive to infections because of their low white blood cell count. Unfortunately, for adults, the response to treatment is not good as with children with the same disease. Several adjunctive measures are useful to treat the diseases associated with leukemia: antibiotics and antifungal agents; blood cell growth factors; and blood transfusions, which may raise red cell and platelet counts.

**Medication Used in Treatment:** The treatment of sickle cell syndrome includes hydration, oxygenation and analgesics for the painful crises. Some new research projects include attempts to prevent RBCs from sickling and to reduce the effects of sickled red cells on blood flow.

**Additional Information:**
- Hypoxia, cold or dehydration can cause the RBCs to sickle. This may cause a sickle crisis, often manifested as pain. The sickle crisis may affect the bones, chest, abdomen and spleen. The pulmonary circulation is also particularly vulnerable to pulmonary vascular occlusion because it receives blood that has been deoxygenated, which allows sickling to happen. Chest symptoms may include pain and fever. Infections, such as pneumonia, meningitis and osteomyelitis are major problems. Effects on the central nervous system include stroke in about 8 percent of individuals with HbS. Red blood cell count (RBC) lifespan is shortened in all varieties of sickle cell disorders (normal RBC: 120 days; HbSS (sickle cell trait): 17 days; HbSC: another form of HbS): 28 days). HbS patients commonly become severely anemic.

**Fitness and Diving:** Recurrent sickle crises can impair an individual’s ability to exercise. Pain associated with sickle cell disorder can confuse the diagnosis of DCI. Pulmonary function is also affected by HbS. Local hypoxia and the occlusion of vessels can affect nitrogen loading and unloading during dive decompression. Diving may make HbS worse, too. For persons with sickle cell disorder, diving is not advised.

**Body System: Liver**

**HEPATITIS**

Condition: Hepatitis A — formerly called infectious hepatitis, is most common in children in developing countries, but is seen frequently in adults in the Western world.

Hepatitis B — formerly called serum hepatitis, is the most common form of hepatitis, with 300 million carriers in the world and an estimated 1.2 million carriers in the United States.

Hepatitis C — formerly called non-A, non-B hepatitis. More than 3.9 million Americans are carriers of the virus.

Hepatitis D — formerly called delta hepatitis, is found mainly in intravenous drug users who are carriers of the hepatitis B virus, which is necessary for the hepatitis D virus to spread.

Hepatitis E — formerly called enteric or epidemic non-A, non-B hepatitis, its symptoms resemble those of hepatitis A. It is caused by a virus commonly found in the Indian Ocean area, Africa and in underdeveloped countries.
Many cases go undiagnosed because the symptoms suggest a flu-like illness or may be very mild or absent. As a result, individuals with acute or chronic active hepatitis should not dive.

Little is known of the three and possibly five other viruses identified recently. Other viruses, especially members of the herpes virus family, including the cold sore virus, chicken pox virus, infectious mononucleosis virus (EBV) and others can affect the liver.

Non-viral forms of hepatitis can be caused by drugs or chemicals, such as alcohol, or autoimmune processes. Alcoholic hepatitis is slow in onset but often fatal and cannot be reversed except by transplantation. Some parasites and bacteria can also cause hepatitis as a secondary effect.

About 26,000 Americans die each year from chronic liver diseases and cirrhosis. Deaths from liver and gallbladder diseases in 1993 reached 51,332, making hepatitis the seventh leading disease that causes death. It is estimated that approximately 75 to 80 percent of cirrhosis cases could be prevented by eliminating alcohol abuse.

In 1994, an estimated 33,200 people were infected with hepatitis C virus (HCV). There are an estimated 3.9 million people chronically infected with hepatitis C, and about 12,000 die from it each year. The CDC (Centers for Disease Control and Prevention) estimate that annual deaths from hepatitis C will increase to 38,000 by 2010. Hepatitis B is responsible for 5,000 deaths annually. 3,000 to 4,000 from cirrhosis, 1,000 to 1,500 from primary liver cancer and 350 to 450 from fulminant, or severe, hepatitis.

Fitness and Diving: These diseases are serious and have variable infectivity. The fecal-oral or water-borne route can spread only hepatitis A and E. The oral route may transmit hepatitis B: the virus may be excreted in saliva. The most common symptoms are fatigue, mild fever, muscle or joint aches, nausea, vomiting, loss of appetite, vague abdominal pain and sometimes diarrhea. Many cases go undiagnosed because the symptoms suggest a flu-like illness or may be very mild or absent. As a result, individuals with acute or chronic active hepatitis should not dive.

Medication Used in Treatment: Until recently, there has been no way to treat viral hepatitis infection. Interferon alpha-2b produces a remission of the disease in 30-40 percent of persons with chronic hepatitis B and 20-25 percent of those infected with chronic hepatitis C. However, once individuals stop taking the drug, 50 to 80 percent of them will suffer a relapse. Only 10 percent of hepatitis B cases are cleared of the virus.

For treatment of hepatitis C, another drug, ribavirin, is currently pending with the Food and Drug Administration. However, several available vaccines can prevent hepatitis B. They are all safe and effective, and they seem to prevent infection if begun within a few days of exposure.

Some types of cirrhosis can be treated, but often there is no cure. At this point, treatment is mostly supportive and may include a strict diet, diuretics, vitamins and abstinence from alcohol.

Additional Information: The following websites have excellent information from which this summary was made, notably:
• The American Liver Foundation — http://www.hepnet.com/
• The Canadian Hepatitis Information Network — http://www.hepnet.com/

The lungs and kidneys are also affected by lupus. Lung damage and fibrosis occur in 50 percent of lupus cases. Body System: Generalized LUPUS Condition: Lupus erythematosus (LE) is a generalized inflammatory disease induced by poorly functioning T cells (part of the white blood cell family). The cause of LE is unknown. It is a type of autoimmune disease and affects many organs in the body. Approximately 90 percent of individuals with LE are female. Onset is usually found between ages 20 to 45. With lupus, the damage to various organs is caused by the immune complexes being deposited in the tissues.

There are five forms of LE: Systemic LE (SLE), which occurs in 75 percent of lupus sufferers, has the most serious outcome. Painful joints may include avascular necrosis of the femoral head, which is the destruction of the end of the femur due to poor blood flow. This occurs in 90 percent of cases. FEVERS, malaise, a typical “butterfly rash” or other skin problems are common. Heart lesions are common but they may not cause obvious disease.

The lungs and kidneys are also affected by LE. Lung damage and fibrosis occur in 50 percent of lupus cases. Lupus can affect the central nervous system, causing stroke and nerve palsies or weakness. Drug-induced LE may be short-lived, however, and it usually has minimal lasting effects.

Fitness and Diving: Due to the multiple areas of damage from LE, diving is not recommended for anyone with any form of the disease. Confusion with symptoms of DCI and problems of fitness can arise, and the poor function of heart and lungs make diving inadvisable. In such a wide-ranging disease, all body systems can be affected before observable symptoms appear.

Medication Used in Treatment: Drugs that may be used to treat an LE type diagnosis include isoniazid, procainamide and hydralazine.

Treatment by numerous drugs include: sunscreens for photosensitive rashes, steroid creams for skin lesions and oral steroids for more severe disease. Aspirin and NSAIDs (like ibuprofen) may decrease pain. Antimalarials such as chloroquine or low-dose steroids are used for severe skin problems. The cytotoxics cyclophosphamide and azathioprine have also been used.

Additional Information: The following websites have excellent information from which this summary was made, notably:
• The American Liver Foundation — http://www.hepnet.com/
• The Canadian Hepatitis Information Network — http://www.hepnet.com/