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DIABETES AND DIVING (PART 1)

DIABETES (PARTICULARLY INSULIN DEPENDENT DIABETES) HAS BEEN AN ABSOLUTE CONTRAINDICATION TO DIVING FOR SEVERAL DECADES. AS MEDICINE HAS PROGRESSED AND THE ABILITY OF THE DIABETIC TO MONITOR AND CONTROL THEIR DIABETES HAS IMPROVED, THEY HAVE BEEN TAKING UP MORE CHALLENGING ACTIVITIES (LIKE SCUBA DIVING) IN LARGE NUMBERS. OBVIOUSLY, SOME DIABETICS CAN DIVE SAFELY. AT THE SAME TIME, DIABETICS CONTINUE TO DIE WHILE DIVING AND SOME SORT OF GUIDELINES ARE REQUIRED TO TRY AND DETERMINE WHICH DIABETICS CAN DIVE IN REASONABLE SAFETY AND WHICH SHOULD NOT DIVE.

Many organizations have been studying and trying to deal with this problem over the last 20 years. Dr. Simon Mitchell published an article in this magazine (*Issue 119, Dec06/Jan07*, available on the website) summarizing the experiences of the British Sub-Aqua Club with diabetics who had performed almost 9,000 dives. In 2005 the Undersea and Hyperbaric Medical Society and Diver's Alert Network held a one day workshop where 50 individuals from 7 nations (including Dr. Mitchell) worked out a set of guidelines to allow some diabetics to dive in reasonable safety (*"Diabetes and Recreational Diving: Guidelines for the Future"*, available from the UHMS and DAN). In this column I will discuss the basic anatomy and physiology of diabetes so that you will have a good basic understanding of the disease before we review the diabetic guidelines in the next column.

The following is a VERY simplified explanation of diabetes. All of the food that we eat is comprised of a combination of fat, protein and carbohydrate. Carbohydrates are the main source of energy and are a combination of simple sugars and starches (complex sugars). They are broken down in the gut and absorbed as simple sugars. These simple sugars circulate in the blood, primarily as glucose. Some are taken up by the cells and stored in various chemical combinations for future use (e.g. glycogen) and others are used immediately. Each cell contains a large number of chemical factories called mitochondria. In the mitochondria, the simple sugar is passed through a series of chemical reactions that breaks it down into CO2 (carbon-dioxide), H2O (water) and energy (the sugar is 'burned'). The energy is stored in a triphosphate bond (ATP, adenosine triphosphate) and when the cell requires energy (e.g. when a muscle contracts) a phosphate is removed from the ATP (ATP is converted to ADP, adenosine diphosphate) and work is preformed. In the mitochondria, the ADP is converted back into ATP using the energy derived from the 'burning' of sugar. As I said at the beginning, it is really far more complicated than this!

As can be seen from the preceding paragraph, controlling the level of glucose in the blood is very important. The body controls the amount of glucose that is taken up by cells (lowering the blood glucose level) and the amount of glucose that is manufactured in the liver and released into the blood (raising the blood glucose level). Insulin is the primary hormone that performs this function and it is produces by the beta islet cells in the pancreas.

Two additional factors strongly influence the level of glucose circulating in the blood. The first is the amount and type of food we have eaten. When we eat, sugars are absorbed from the gut as the food is digested and the level of glucose in the blood rises. The pancreas responds by dumping more insulin into the blood. The insulin stimulates the liver and other cells to absorb glucose, bringing the blood glucose level down to the proper level.

The second is the amount of exercise we are performing. When we are resting, the muscles are using very little glucose and the level in the blood tends to rise. When we exercise the muscles absorb large amounts of glucose from the blood and the level of blood glucose falls. The level of insulin in the blood must fall to allow the liver to release more glucose into the blood and to reduce the amount of glucose removed from the blood by other cells so that the level of glucose in the blood does not fall too low.

There are two other very important facts you have to know. First, most cells in the body can also use fats and proteins to generate energy. Glucose is much more efficient, but if the blood glucose level is low, the cells can get by quite well on these other energy sources. The primary exception is the brain. Brain cells can only use glucose for energy and if the blood glucose level falls too low, the brain cells stop working (i.e. you lose consciousness). Just to add insult to injury, if the blood glucose level is too high, you also lose consciousness (for different reasons)!

The second important fact is that the insulin stays in the blood for a while before it is broken down and removed. This is the reason that if you eat a snack that is loaded with simple sugars you are hungry 15 to 30 minutes later. The gut quickly absorbs the simple sugars and the blood glucose level shoots up. The pancreas responds to this high blood glucose level by releasing insulin into the blood. The insulin does its' job by stimulating the uptake of glucose by the cells and the blood glucose level starts to drop. The problem is that all of the sugar in the candy bar is absorbed long before the insulin has been removed from the blood. Therefore, the insulin continues to stimulate the uptake of glucose by the cells even after the blood glucose level has fallen below normal. Your body responds to the low blood glucose level by making you feel hungry, so you eat more. This is the primary reason people eating a typical North American diet are the most obese people on the planet. They consume more simple sugars, usually

SO WHAT DOES IT MATTER IF BLOOD GLUCOSE OR INSULIN LEVELS ARE TOO HIGH? WON'T WE JUST HAVE MORE ENERGY?

in the form of 'junk food' than anyone else. It is far healthier to eat fruit, nuts, vegetables, etc. as snacks because the sugars in them are absorbed much slower. The blood glucose level does not rise as quickly, nor as high, and the pancreas releases much less insulin. In addition, this insulin is gone from the blood by the time your body has finished absorbing the sugars in the snack.

So what is diabetes? It is simply when the blood glucose level is higher than normal because of a relative or absolute lack of insulin. There are many reasons this situation can develop but diabetes can be roughly divided into two types.

Type I diabetes, also known as 'insulin-dependent diabetes' or 'juvenile-onset diabetes' is usually diagnosed in childhood or when the person is still a teenager (before age 30). The pancreas in these people produces very little insulin and they are at risk of going into a ketoacidotic coma. The cause of this type of diabetes is a combination of genetic and environmental factors. Over 80% of these people have a specific genetic makeup and almost all of them have an immune system that has made a mistake and destroyed the beta islet cells in their pancreas. However, genetics alone will not cause you to be a diabetic. Only 10% of Type I diabetics have a close relative who has Type I diabetes and in identical twins (identical genetics) only 50% of the time does the second twin also develop Type I diabetes. Therefore in addition to a genetic predisposition, an environmental factor is required. This may be an infection with a virus where the body mounts an immune response to the virus and the protein in the virus is so similar to a protein in the beta islet cells in the pancreas that both the virus and the beta islet cells are destroyed, it may be exposure to cow's milk rather than human milk in infancy (part of the albumin protein in cow's milk is almost identical with one of the islet cell proteins), or it might be some other factor. Whatever the cause, these people make almost no insulin and if they are not treated, the blood glucose level will rise to the point that they have serious problems and might lose consciousness. The only effective treatment is to inject insulin on a regular basis in an attempt to keep the blood glucose level in the normal range. This requires a complicated series of injections with different types of insulin and very close control of both the type and amount of food consumed and the exercise level, every day. If this type of diabetic injects too much or too little insulin, eats too much or too little food (or the wrong type of food) or exercises more or less than planned, they will lose consciousness. Fortunately, only 10 to 15% of all diabetics are Type I.

Type II diabetes is also known as 'non-insulin-dependent diabetes' or 'adult onset diabetes'. It is usually diagnosed after age 30 with more people developing it the older they get. Unfortunately, it can also occur in children and adults younger than age 30. These individuals will usually not develop ketoacidotic coma but they may develop nonketotic hyperglycemic-hyperosmolar coma. Even though it is a different type of coma, they are still at risk of losing consciousness.
There are several causes of Type II diabetes and we do not yet fully understand it. These people usually produce lots of insulin but in some the body destroys the insulin (another immune system mistake) while in others the cells do not respond properly to the insulin. Finally, some people have a pancreas that does not release insulin until the blood glucose levels are high. There seems to be a genetic factor in that in identical twins, 90% of the time the second twin will also develop Type II >

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diabetes. There are several other, less common types of diabetes including people who produce an ineffective form of insulin and people who develop diabetes as a result of another disease (e.g. alcoholics who destroy their pancreas).

Type II diabetics are usually obese and in some, weight loss, exercise and a controlled diet is all that is required to maintain their blood glucose levels in the normal range. Others will require one or more pills (oral hypoglycemics) and some will also require insulin (even though they are not insulin 'dependent') to control their sugars. A few will progress to develop Type I diabetes and all will become worse with age. The amount of insulin that the pancreas can produce declines with age and by age 85, approximately 25% of people will have diabetes.

So what does it matter if blood glucose or insulin levels are too high? Won't we just have more energy? Unfortunately, no. The body is designed to function with blood glucose maintained within a fairly narrow range and with a normal amount of insulin. In addition to the risk of losing consciousness, if the level of glucose or insulin is too high for too long, we will develop some very nasty problems.

Diabetics are far more likely to suffer from strokes, heart attacks, and other vascular problems than the general population. In fact, diabetes is at least as strong a risk factor for heart attacks and strokes as smoking! Diabetics are quite likely to go blind (diabetic retinopathy), to suffer from kidney failure (diabetic nephropathy), and to lose the feeling in their arms and legs (peripheral and autonomic neuropathies) which eventually leads to the development of non-healing foot ulcers and amputation. For these and many other reasons, it is very important to keep the blood glucose and insulin levels within the normal range as much as possible. It has been clearly proven that if you can maintain normal blood glucose and insulin levels, diabetics do not develop these problems any more frequently than the general population. A few years ago I assisted a plastic surgeon in amputating the left leg of a 40-year-old diabetic. He had not taken his disease seriously and had developed such terrible circulation problems in his legs that the left one had to be amputated above the knee to save his life (uncontrollable infection, the other leg most likely followed shortly thereafter).

The problem with controlling the blood glucose level tightly is that you are more likely to drop the level too low and lose consciousness. This is why many diabetics tend to let their blood glucose levels run a bit high. There are no immediate signs or symptoms, just the terrible problems that develop after years of poor control.

As we have seen, there are many 'kinds' of diabetics. All diabetics are advised to maintain a healthy body weight (most Type II diabetics are obese), to eat a nutritious, balanced diet, and to maintain a regular exercise program. Exercise actually causes biochemical changes in the body that increase the effectiveness of insulin in controlling blood glucose. Unfortunately, these biochemical changes only last for 24 hours after exercise. Therefore, we need to exercise every day. For those diabetics whose pancreas is producing enough insulin, maintaining a healthy weight, diet and exercise are often sufficient to maintain their blood glucose levels in the normal range for years. These individuals don't actually have diabetes (their blood glucose and insulin levels are normal) but they are 'pre-diabetic' and even with a continued healthy lifestyle they will most likely develop mild diabetes as they get older. Before they actually develop diabetes, they can obviously dive safely.

In the next column I will look at diabetes and diving, and review the current guidelines for which diabetics can dive with relative safety.

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