

### **What is diabetes mellitus and what are the symptoms?**

Think about a car that works only if it has gasoline available as a source of energy. Without gasoline, the car will not start. Gasoline is "refined" from crude oil before it can be used as the energy source for the motor. Living animals also require energy to function. More specifically, each living cell that makes up an individual has energy requirements. For animals, ingested food is analogous to crude oil. Ingested food must be "refined" to a usable energy source. For virtually every animal, ingested food is converted (refined) to sugar (glucose), which, in turn, is the energy source for all cells. Because cells in the body tend to function continuously and do not store their own energy supply, energy (sugar) must be continuously available. Therefore sugar continuously circulates throughout the body as a component of normal blood. In this sense, sugar in the blood stream is an energy reservoir (a gas tank) for any cell in need.

If your car has a full tank of gasoline and a working motor, you still need a key to start the motor. Without a key to start the engine, all the gasoline sitting in the tank is relatively worthless. Similarly, cells in the body need a key to have access to the sugar sitting in the blood stream. Without that key—insulin, cells are unable to use sugar, regardless of the amount of sugar in the "tank." An absolute or relative insulin deficiency is the cause of *diabetes mellitus*.

Diabetes mellitus is extremely common. It is estimated that 1 in every 19 Americans has the condition and although less common in dogs and cats, it remains a frequent diagnosis. As previously stated, the key that gives cells access to sugar is *insulin*, a protein created by specialized cells scattered throughout the pancreas. The pancreas, an organ with several important jobs, is located in the abdomen next to the stomach. Insulin from the pancreas is pumped into the blood stream and distributed to cells throughout the body. If the pancreas fails to produce enough insulin, cells no longer have the needed key for using sugar.

Specialized cells in the brain control appetite. Those cells, like all the others, need sugar via insulin to function. When these brain cells begin to "starve" without sugar, they produce a signal demanding that the individual eat more to supply them with energy. However, the problem is not that crude energy is failing to be consumed. Nor is the problem that this crude energy is failing to be refined into sugar. Therefore regardless of the increase in appetite to try and supply the much-needed sugar, no key (insulin) allows cells access to sugar.

Although cells in the brain are demanding that more and more food be consumed, other cells in the body respond to their "starvation" by demanding that fat and muscle in the body be broken down. The breakdown of muscle and fat usually causes obvious weight loss. Breakdown products of fat and muscle can be converted to sugar by the liver. This sugar could supply the energy needs of cells. Once again, regardless of the source of crude energy and sugar (through eating or through breakdown of fat and muscle), the key that would allow use of this energy source is missing.

If the sugar being refined from ingested food and from breakdown of fat and muscle is not taken up by cells for energy, it begins to accumulate in the blood stream. So, the tank is being filled, but the "gasoline" being pumped into the tank is not being used. When too much sugar is pumped into the tank (sugar accumulates in the blood), it begins to overflow or "leak" into the urine. Urine of healthy individuals *never* contains sugar. Sugar cannot appear in the urine by itself. Rather, sugar draws water into the urine just like a dry sponge draws water. Therefore the individual with sugar in the urine produces large urine volumes because of the water being excreted as well. This process can eventually create tremendous water losses. In response to this excess urine volume, individuals with sugar in their urine begin to drink excessively in an effort to maintain water balance (hydration). These responses to the simple lack of insulin are natural and instinctive. They are unavoidable. All individuals (people, dogs, cats, etc.) with an insulin deficiency (diabetes mellitus) have the same symptoms: they all eat excessively, they all lose weight, they all drink excessively, and they all urinate excessively.

Two common forms of diabetes mellitus exist in people. Some people with diabetes have absolutely no insulin. The most common names used for this form of diabetes mellitus are: insulin-dependent diabetes mellitus (IDDM), type I diabetes, and "juvenile-type" diabetes. People with type I diabetes mellitus require insulin therapy (usually by injection) to survive. The second form occurs when an individual has some insulin but either does not have enough insulin to supply all cells when it is needed or they have a condition that interferes with insulin action (the key no longer fits into the ignition). This form also has several names. The most common names are: non-insulin-dependent diabetes mellitus (NIDDM), type II diabetes, and adult-onset diabetes. Approximately 60% of diabetic cats have type I disease and 40% have type II. Virtually 100% of diabetic dogs have type I disease. Although changes in diet, weight loss, exercise, and oral drugs can be used successfully in managing many people with type II disease, insulin administered by injection remains the best treatment for all dogs and cats diagnosed as having diabetes mellitus.

### **What testing is needed?**

The diagnosis of diabetes mellitus is usually extremely straightforward. Your veterinarian probably became suspicious of diabetes mellitus because you (the owner) noticed that your pet exhibited some or all of the following symptoms: weight loss and/or excessive urination, drinking, or eating. The diagnosis is confirmed with finding sugar in the urine and an abnormally increased blood sugar concentration. However, despite this relatively simple diagnosis, your veterinarian will likely recommend additional tests. These additional tests are warranted because most diabetic dogs and cats are middle aged or older and most have other medical problems. Those conditions seen most commonly among diabetics include urinary tract infections, skin infections, and an irritated pancreas (pancreatitis). Heart disease, kidney disease, and anemia are just a few of the non-diabetic diseases sometimes seen in these pets. So, additional blood and urine tests, radiographs of the thorax, and ultrasonography or radiographs of the abdomen are tests well worth the investment.

### **What treatment is needed?**

*Can diabetes be cured?* It is extremely rare for a dog with diabetes to be cured. In only two situations is there even a chance of a cure: dogs pregnant at the time of diagnosis and dogs with a condition called *Cushing's syndrome*. Most of these dogs, however, are not cured of their diabetes even with appropriate care. In total, far less than 1% of dogs with diabetes mellitus have their disease state resolve. The incidence of "cure" is a bit higher in diabetic cats. An estimated 10% to 40% of diabetic cats have their disease resolve sometime during the 12 months following diagnosis. In either dogs or cats, the most important factor in having diabetes resolve is luck.

*Can my pet be treated with pills rather than with injections?* Unfortunately, insulin is almost always given by injection, especially to dogs and cats. Dogs with diabetes mellitus virtually never respond to oral diabetes treatments. Oral medication, as the sole treatment for diabetes, should not be given to diabetic dogs, even on a trial basis. During such a treatment trial, your pet might become extremely ill. This is less likely if insulin were used. A small percentage of diabetic cats respond to oral hypoglycemic medications that are used for humans. The only drugs established as potentially effective in cats are called *glipizide* and *glyburide*. Despite their potential for success in some cats, the recommendation is to treat all diabetic cats with insulin. The only reasons for using oral medications in cats are the following: (1) an owner who refuses to give insulin and who is considering euthanasia rather than giving their cat injections and (2) the insulin-treated diabetic cat that seems to require extremely small doses (one unit per dose once or twice daily) to maintain control.

*Insulin Therapy.* The most important concept to remember is that most diabetic dogs and cats treated with insulin lead healthy and happy lives. Unfortunately, although insulin has been used to treat people that have diabetes mellitus for more than 80 years, it must still be given by injection. The other, and much bigger disappointment, is that despite tremendous amounts of experience in treating diabetic dogs and cats, veterinarians understand that no precise dose of insulin exists as determined by body weight, gender, breed, or any other parameter. Further, several types of insulin are available through veterinary and human pharmaceutical companies. No particular insulin is "perfect" for every dog or cat. Owners of all diabetic dogs and cats must understand that the treatment of diabetes represents a continuing course of *trial and error*.

Your veterinarian will recommend a type of insulin (e.g., NPH [N], Lente [L], Ultralente [U], glargine, or PZI) and an origin (e.g., Humulin [human], or porcine [pig]). Your veterinarian will also recommend a dose and frequency of administration (once or twice daily). Although most diabetic pets seem best controlled when receiving insulin given twice daily, once daily injections may work and once daily regimens are often used initially just to have owners become familiar with the process. Then, if needed, the second injection each day can be recommended. All these choices will be explained to you. They are usually made on the basis of previous experience managing other diabetic dogs and cats. The goal here is not easily achieved: to choose the correct insulin, dose, and frequency of administration. It is always safe to assume that the first regimen chosen may not be as effective as you might like. With trial and error adjustments, however, a treatment protocol can typically be established that will provide your pet with a happy and almost normal existence. Owners should try to be as patient as possible because nature is not easily predicted. Achieving success in the management of a diabetic requires three key ingredients: a skilled veterinarian, a committed owner, and luck. If you do begin to give insulin twice daily, do not think that the timing needs to be exact. Rather, giving insulin at convenient times is fine and if these times vary by 30, 60, or even 90 minutes each day, your pet will be fine.

*Handling Insulin and Injection Technique.* Giving your pet injections is an intimidating prospect for most owners and there is no doubt that dogs and cats can feel the needles. Once you do this for a few weeks, you will become competent and your pet will accept the tiny pin pricks. Don't give up! Dogs and cats do learn to accept this treatment without changes in behavior or personality. Owners should remember a serious and important truth: the single most common cause for a diabetic dog or cat to appear "insulin-non-responsive" and to remain symptomatic is owner error. Mistakes in handling or injection of insulin are unfortunate but fact. Therefore owners must remember numerous bits of information to avoid mistakes.

First, store insulin on the door of your refrigerator right side up. Insulin should not be left at room temperature for prolonged time periods because it might lose potency. If the insulin freezes, you should

obtain a new bottle. Prior to removing insulin for each and every dose, the insulin should be mixed. This is best accomplished by making a fist around the bottle and then slowly rotating your wrist back and forth a few times. You will be taught how to draw insulin into a new unused syringe for each injection by first pulling back on the syringe plunger to the dose, turning the bottle completely upside down, placing the needle into the center of the stopper, injecting the air in your syringe into the bottle to avoid creating a vacuum, and then drawing the correct amount into the syringe. While the syringe needle is still in the upside-down bottle, tap the syringe to force any bubbles or air to the top, squirt those back into the bottle and again draw out the insulin to the correct dose. Then remove the needle from the bottle.

Finally, you will learn how to give an injection. Most owners gently pinch a small amount of skin with the thumb and index finger of one hand behind your pets' neck or somewhere along their back. The needle target is *NOT* between your fingers rather it is in the hollow you have made just below your fingers. Place the needle at a 45-degree angle through the skin below your finger tips and push the needle in as far as it will go (these needles are usually quite short). Remember do not place your thumb on the plunger during needle insertion. Once the needle is fully inserted through the skin, move your thumb to the plunger and press the plunger all the way down. Once you have pushed the plunger all the way down, pull the needle out of the skin.

Alcohol application to the skin prior to injection is not recommended. First, you will not really "sterilize" the skin. More importantly, if the skin starts out dry, you can know immediately that an error has been made if the skin is wet after injection.

Several excellent web sites provide instructions for insulin administration, photographs, and videos. One source is the link through a veterinary company called Intervet.

*Feeding.* The ideal body weight for a diabetic pet is simply one that is normal. Therefore if your pet is too thin, weight gain is important and if your pet is overweight, weight loss will improve insulin effectiveness. Most veterinarians recommend twice daily feeding of diabetic pets. Feeding more frequently is fine (three or more times each day or all day as in cats accustomed to "grazing"). If your pet eats at specific times, it is ideal to feed first, wait until your pet has consumed the meal, and then administer insulin. Because insulin works by allowing cells to utilize sugar, it is important for that insulin to have sugar present. Administering insulin to a pet that then refuses to eat means that the pet is now predisposed to developing a blood sugar level that might be too low or dangerously low. If a pet has many meals through the course of a day, that concern would not be as serious.

Much current research is focusing on determining the best food for diabetic pets. Research has resulted in several pet food companies producing specific diabetes diets. Each of these commercially available diabetes diets is different in some minor or major way. It is currently recommended that you follow the advice of your veterinarian regarding diet with one important overriding factor being kept in mind: the most important attribute of any diet is your pet's willingness to eat that food. A diet is only useful if your pet readily and consistently eats it. That being appreciated, some researchers believe that fiber is of benefit to diabetic pets. However, there are various forms of fiber and the one most likely to be of benefit to your pet can be determined by your veterinarian. Other research has suggested that diets with particular percentages of protein, fat, or carbohydrate can be beneficial. Again, your veterinarian's opinion here is critical, because the diet for one diabetic may not be best for another. Your veterinarian knows all the confirmed and suspected problems in your pet. Those conditions may alter diet choices. For example: one might not want to offer a diet high in fat to a pet that has had pancreatitis, but it may be ideal for another diabetic.

*Insulin Underdose.* If your pet is underdosed with insulin, symptoms of diabetes tend to persist. Therefore if your pet continues to exhibit excesses in hunger, thirst, and urine volume as well as continuing weight loss, one likely explanation is under dosage. Understand that an underdose may occur because your pet simply needs more insulin. However, underdosage also can be caused by using insulin that turns out to be less than ideal for your pet. The most common cause of underdosage is that the person giving the insulin is doing something incorrect. Therefore whenever the owner brings their diabetic pet to the veterinarian, trained personnel should watch the entire owner-injection process to ensure mistakes are not being made.

*Insulin Overdose.* An overdose of insulin causes the blood sugar concentration to decrease too far. This can cause a variety of different problems. Possible observations include profound weakness; the pet may appear drunk or even have a seizure. If low blood glucose is ever suspected, it is best to feed your dog or cat immediately. Do not take your pet to the hospital because the delay may make the condition worse.

If your pet loses consciousness:

1. Be certain your pet is not in danger of being hurt (near the edge of a deck or the edge of a swimming pool, for example)
2. Glance at a clock and note the exact time (diabetic seizures usually last 30 to 90 seconds) and if the episode lasts longer than 5 minutes, veterinary care should be sought
3. 3a) Place Karo syrup (either light or dark Karo syrup) in a syringe (this syringe will be larger than your insulin syringe and will be given to you by your veterinarian) and then squirt small amounts (2 to 5 cc) into the pets' mouth every 5 to 10 seconds or
4. 3b) Place Karo syrup on your fingertips and rub the syrup inside the lips (NEVER place your fingers further inside the mouth as you are at risk for being bitten by an unconscious pet)

Other symptoms of overdosage can be confusing. Some overdosed dogs and cats simply sleep more. Some *overdosed* dogs and cats act as if they are *underdosed*! This common occurrence is the result of low blood glucose triggering glucose to rebound to levels well above normal. The increased blood glucose in this situation can persist for several days. Why does an overdosage occur? Understand that an overdose may occur because your pet simply needs less insulin. However, overdosage also can be caused by using insulin that turns out to be less than ideal for your pet. The most common cause of overdosage is that the person giving the insulin is doing something incorrect. Therefore whenever the owner brings their diabetic pet to the veterinarian, trained personnel should watch the entire injection process to ensure that mistakes are not being made.

*What Should Be Done if an Insulin Dose Is Missed or if a Mistake Is Made During an Injection?* Sometimes someone may forget to give insulin. Other common occurrences include your pet moving suddenly during an injection or you simply make a mistake and are not certain if your pet received the correct dose of insulin, if your pet received no insulin, or if your pet received a portion but not all of the dose. None of these situations should be unduly worrisome. The correct response to any of these occurrences is to simply give the correct dose of insulin *when it is next scheduled*. If an entire dose is missed, your pet will be fine. However, if a portion of a dose was given and then you give another dose immediately, there is risk of overdosage. A missed dose or an underdose is always preferred to an overdose.

*Monitoring Insulin Therapy.* Numerous methods of monitoring diabetic dogs and cats exist to better improve chances of a successful outcome. No one method is better than another and most complement each other. The most important tool in determining if your pet is responding to therapy appropriately is your (the owners') opinion. The goal of treating a diabetic dog or cat is to have an owner be pleased with

their pets' response. It is not reasonable to expect your pet to be 100% normal in all aspects, but it is reasonable to have your pet be comfortable, interactive, and relatively healthy. Most diabetic pets urinate more than normal and most maintain an excellent (ravenous?) appetite. Weight loss should not be a problem. Your veterinarian may recommend certain tests periodically. These include checking the blood sugar concentrations throughout the day either in the hospital or you may wish to attempt to do this yourself at home. Veterinarians may want you to check the urine of your pet periodically (each morning, for example) for sugar and something called *ketones*. Finally, some blood tests tell the veterinarian what the average blood sugar level has been for the previous few days. Each of these tests should complement watching you administer insulin and your opinion regarding response to treatment.

*Urine Monitoring.* Many veterinarians like to have owners of diabetic dogs check the dogs' urine daily for sugar and ketones. Sugar levels in urine of well-controlled diabetic pets tend to fluctuate dramatically day to day. Ketones, however, should always be negative. If sugar levels are constantly at their highest level, poor control is likely. If ketones appear after weeks or months of being negative, one should be concerned. This may indicate that your pet has a serious problem and your veterinarian should be notified.

*Cataracts.* Almost all diabetic dogs become blind within the first year after diagnosis. Blindness is due to development of cataracts in the lens (in the center of the eye). Cataracts are opaque and do not allow light from the outside to enter the back of the eye for vision. This side effect of diabetes is virtually unavoidable. Blind dogs do quite well, especially indoors in a familiar environment. Cataracts can be surgically removed to restore sight in most dogs. Some dogs will be blind even if cataracts are removed and others have cataracts that cannot be removed.

*What Should Be Done if the Urine is Positive for Ketones or if My Pet Refuses to Eat or if My Pet Begins to Vomit?* Any of these abnormalities are reason for concern. The best advice to follow if any of these situations are encountered is to contact your veterinarian or immediately take your pet to your veterinarian or to a local veterinary emergency clinic. It is better to bring your pet to the veterinarian unnecessarily than to ignore a serious complication.

### **Conclusion**

Treating a dog or cat for diabetes mellitus can be challenging but it can also be extremely rewarding. Most of these pets are happy and healthy. We encourage you to try treating your diabetic pet. If you have concerns, please talk with your veterinarian, the technicians who work at the hospital, and check out web sites that will provide you with a wealth of information.