LONG-TERM MONITORING OF THE DIABETIC DOG AND CAT
Clinical Signs, Serial Blood Glucose Determinations, Urine Glucose, and Glycated Blood Proteins

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Proper management of the diabetic dog or cat depends on the interpretation of clinical signs, urine glucose values, and periodic serial blood glucose monitoring. These parameters are helpful in both the initial regulation of the diabetic animal and when the dog or cat becomes unregulated later in the course of the disease. Return or persistence of clinical signs such as polyuria and polydipsia, or the development of cataracts in a previously well-regulated diabetic, will indicate the need for better control. Trends in urine glucose, monitored by the owner, also may signal the onset of dysregulation. Other tests, such as fructosamine and glycosylated hemoglobin, can aid in the determination of the long-term regulation status of the animal. Serial blood glucose measurement, however, is used most frequently to assess the dose, type, and frequency of administration of insulin in a particular animal.

CLINICAL SIGNS AS INDICATORS OF BLOOD GLUCOSE CONTROL

In a newly diagnosed diabetic animal or a previously regulated diabetic, clinical signs are an important indicator of the state of glucose control in that animal. Persistent or recurrent polyuria and polydipsia

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in the absence of other underlying diseases that cause these signs (i.e., renal failure, hyperthyroidism, hyperadrenocorticism, and so forth) signal that euglycemia is not being maintained and further regulation efforts are needed. It is important to distinguish pollakiuria from polyuria because the ramifications of each are different. Pollakiuria is more often associated with lower urinary tract infections, which are common in diabetic animals. On the other hand, polyuria may be an indication of poor glycemic control or an underlying disease such as hyperthyroidism.

Body weight should be monitored at each visit. The patient should be evaluated for any trends in weight fluctuation. Weight loss of more than 10% of body weight warrants further investigation. Weight loss despite an excellent appetite is often a sign of inadequate glucose control. In some instances, it can be difficult to discern if the weight loss is the result of the low fat diet appropriate for the diabetic animal or unregulated diabetes mellitus (DM). Assessment of blood glucose and a urine sample should aid in determining whether the weight loss is a result of uncontrolled DM or a desirable effect of caloric restriction. The presence of ketonuria signals poor glucose control and is indicative of a catabolic state. Owners may be asked to monitor urine glucose and ketone levels on a weekly basis and report any trends in ketonuria or glycosuria.

Recurrent infections of the skin, urinary tract, or respiratory tract also may be an indication that hyperglycemia is persistent. Urinary tract infections are common. Because diabetic animals may not have increased numbers of inflammatory cells in their urine samples, it is wise to culture the urine to confirm the presence of an infection. Cataract formation in diabetic dogs is common and irreversible. The development of cataracts is an indication of inadequate blood glucose control and the need for reassessment.

Uncommon sequelae to long-term, unregulated DM include diabetic neuropathy, which is more frequent in cats; hepatic lipidosis; pancreatitis; diabetic retinopathy; diabetic nephropathy; and diabetic gastroparesis or altered intestinal motility resulting in diarrhea. If identified in a diabetic patient, close attention should be paid to proper regulation of blood glucose.

THE BLOOD GLUCOSE CURVE

Serial blood glucose monitoring is used to generate a blood glucose curve. When the blood glucose determinations are plotted on a graph versus the time of day, a smooth parabolic line should be generated (Fig. 1). Although blood glucose monitoring is a valuable aid for regulating a diabetic patient, it should not be used as the only criterion for assessing diabetic control. The glucose curve should be interpreted in light of all the clinical and laboratory findings for that particular animal. For example, if the owner is satisfied with treatment, the body weight is stable, and the animal shows no clinical signs of diabetes, an insulin dose
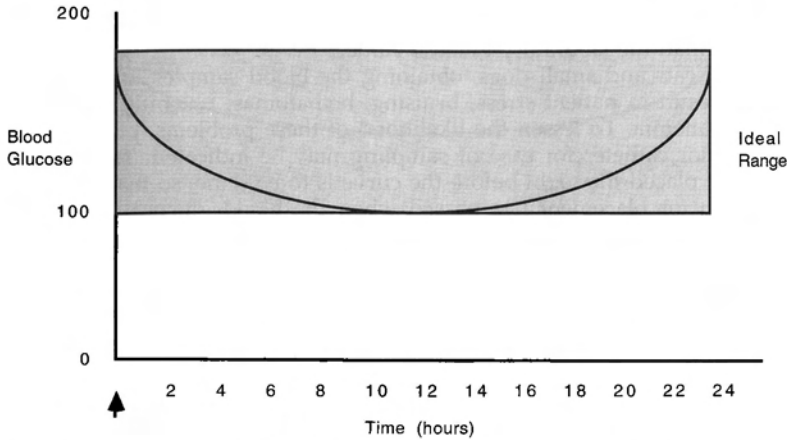
Figure 1. Ideal blood glucose curve for an animal on once daily insulin therapy (arrow indicates insulin injection).

adjustment may not be necessary even though the blood glucose curve is not ideal.

To perform a glucose curve, several key guidelines should be followed. First, the animal should be fed the same amount and type of food at the same time that it is fed at home. The insulin should be given at the same time as is normally given, preferably from the same bottle. Additionally, the animal should be exercised in a manner similar to that in the home environment. Alternately, the owner may be asked to admit the animal before insulin administration. An initial sample may be taken, and the owner asked to administer the insulin and food to make the dog more comfortable in strange surroundings. This also allows the veterinarian or veterinary technician to assess the ̇owner's insulin injection technique.

Blood samples are taken at 1- or 2-hour intervals beginning with the insulin injection and continuing for at least 12 hours and ideally 24 hours. Samples may be handled in one of several ways. The samples may be collected and placed in red top tubes (Becton-Dickinson, Rutherford, NJ), allowed to clot for 30 minutes, and centrifuged so that the serum may be removed and analyzed immediately or placed in a second tube with the time and date on the label for later batch analysis. Alternatively, the samples may be collected in appropriately labeled sodium fluoride tubes (Becton-Dickinson, Rutherford, NJ) and refrigerated until analysis. It is also possible to use blood glucose monitoring devices designed for use in human diabetics (see later). These devices use glucose test strips and require only a drop of blood for each analysis. This is beneficial to cats and small dogs that may develop iatrogenic blood loss anemia from frequent blood sampling. If a blood glucose monitor is used, at least one sample should be checked by a laboratory

to assess accuracy. Generally, these devices will read 10 to 15 mg/dL lower than the laboratory glucose value.

In cats and small dogs, obtaining the blood samples for the curve may result in patient stress, bruising, hematomas, phlebitis, and iatrogenic anemia. To lessen the likelihood of these problems, placement of a jugular catheter for ease of sampling may be indicated. The catheter can be placed the night before the curve is to be done, so that the stress of catheter placement has passed when the blood glucose monitoring begins. Collection of samples is accomplished using the "three syringe technique." Nonsterile gloves are worn to protect the patient from hospital-acquired infections. First, 3 mL of the patient's blood is drawn into 0.5 mL of heparinized saline; this sample is capped and saved after gentle mixing. A second empty syringe is used to collect 1 mL of blood for glucose determination. The heparinized 3 mL of blood originally saved is given back to the patient and then the catheter is flushed with 2 mL of heparinized saline. This last syringe is left in place to maintain a closed system and aseptic technique.

INTERPRETATION OF THE BLOOD GLUCOSE CURVE

There are three important steps in the interpretation of the blood glucose curve.[11] These include (1) assessment of the effectiveness of the insulin; (2) assessment of the glucose nadir; and (3) assessment of the duration of insulin action.

The effectiveness of the insulin can be judged by looking at the shape of the curve and calculating the *blood glucose differential* (the difference between the highest and lowest blood glucose values).[11] If the curve is relatively flat, without much difference between the highest and lowest blood glucose values (i.e., a low blood glucose differential), the insulin may not be having its desired effect (Fig. 2). The blood glucose concentration, however, must also be taken into account. A low blood glucose differential with serial blood glucose concentrations ranging between 100 and 180 mg/dL indicates excellent glycemic control, whereas a low glucose differential with blood glucose concentrations greater than 250 mg/dL is indicative of insulin underdosage, poor insulin administration technique, short duration of insulin action, stress, or insulin resistance (Table 1).[11] If a dog or cat is receiving more than 2.2 U of insulin per kg per dose and is still hyperglycemic for much of the day, insulin underdosage is unlikely to be the cause of the poor regulation, and an attempt should be made to identify other disorders underlying the poor regulation.

Evaluation of the blood glucose nadir is the second step in assessment of the glucose curve. The *glucose nadir* is the lowest blood glucose concentration achieved during the 24-hour period. This value should ideally be 80 to 125 mg/dL.[11] Occasionally, an animal may exhibit two glucose nadirs after one dose of insulin; this is one good reason for a full 24-hour blood glucose curve.
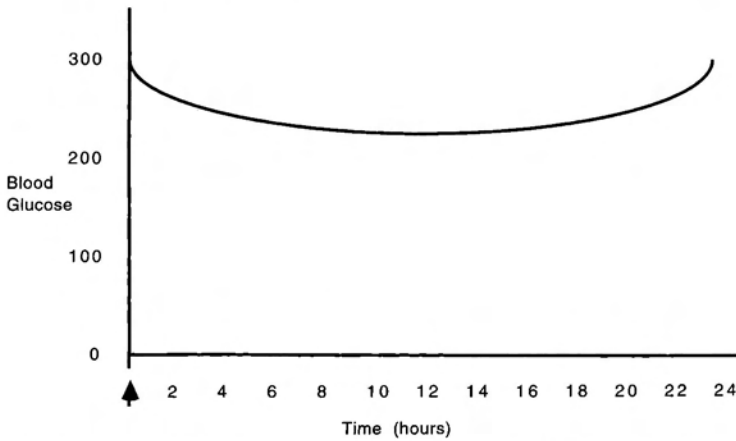
Figure 2. This glucose curve illustrates a low blood glucose differential with poor insulin activity (arrow indicates insulin injection).

Finally, interpretation of the glucose curve involves the determination of the duration of action of the insulin. This is best assessed when the blood glucose nadir is close to 100 mg/dL. After the nadir, the blood glucose concentration should steadily increase in most animals, especially postprandially. When the blood glucose concentration is more than 200 to 250 mg/dL, the insulin action is waning or gone. The duration of action is determined as the time from the insulin injection until the time when the blood glucose is more than 250 mg/dL.

ADJUSTMENTS IN INSULIN THERAPY

Adjustments in insulin therapy may include a change in dosage, insulin type, or frequency of administration of insulin. Table 2 lists the various types of insulin and their characteristics, which may be helpful when making adjustment decisions.

Table 1. REASONS FOR DIFFICULTY IN DIABETIC REGULATION

Management errors	Insulin antagonism
Improper administration of insulin	Hyperadrenocorticism
Improper handling of insulin	Exogenous steroid administration
Inappropriate diet	Hypothyroidism[5]
Inconsistent exercise	Diestrus
Increased metabolism of insulin	Progestogen administration
Hyperthyroidism[2]	Infection
Fever	Pheochromocytoma
Underlying infection	Obesity
Anti-insulin antibodies	Acromegaly[10]

Table 2. CHARACTERISTICS OF VARIOUS INSULIN PREPARATIONS

	Type of Insulin	Route of Administration	Onset of Action	Peak Effect (hours)	Duration of Action (hours)
Short acting	Regular	IV, IM, SQ	0–30 minutes	1/2–5	1–10
Intermediate acting	NPH	SQ	1/2–3 hours	2–10	6–24
	Lente	SQ	0–60 minutes	2–10	8–24
Long acting	Ultralente	SQ	2–8 hours	4–16	8–28

Modified from Nelson RW: Disorders of the endocrine pancreas. *In* Nelson RW, Couto G (eds): Essentials of Small Animal Internal Medicine. St. Louis, Mosby-Year Book, 1992, p. 561; with permission.
IV = intravenous; IM = intramuscular; SQ = subcutaneous.

Change in Dosage

If the value of the blood glucose nadir is less than 80 mg/dL, a reduction in insulin dosage is indicated. This is true even if the animal is hyperglycemic at some other point(s) along the curve because it is possible that insulin-induced hyperglycemia is occurring (i.e., Somogyi effect).[9, 12] The amount of reduction that is necessary depends on the patient. Usually a 10% to 25% decrease is adequate for patients on an acceptable dose of insulin ($\leq$ 2.2 U/kg).[11] If the animal is receiving more than 2.2 U/kg of insulin, it may be best to reduce the dosage to 0.5 U/kg and begin the regulation process over again.

If the lowest blood glucose concentration is more than 125 mg/dL, then an increase in the dose of insulin is warranted. The individual patient and its degree of hyperglycemia must be taken into account when the dosage increase is made. Generally, the larger the patient and the higher the blood glucose concentration, the larger the adjustment. Usually increases of 0.5 to 1 U (small dogs and cats) and 1 to 3 U (larger dogs), however, are appropriate. It is always safer to err on the side of a small adjustment in insulin dose, because hyperglycemia is not immediately dangerous while hypoglycemia can be life-threatening.

Change in Type of Insulin

If the action of the insulin is clearly gone by 8- to 12-hours after insulin injection (blood glucose >200–250 mg/dL), the patient is a candidate for either longer-acting insulin or twice daily insulin therapy (Fig. 3). If the animal is on an intermediate acting insulin, i.e., neutral protamine Hagedorn (NPH) or lente insulin, then therapy with a longer acting insulin (ultralente) may be instituted (Table 2). Generally, unless the glucose curve indicates differently, the same dose of the longer acting insulin is used. Ultralente can have a delayed onset of action that may result in morning hyperglycemia.[13] This may be attenuated by mixing regular or lente insulin with the ultralente (see article on insulin therapy).

Although uncommon, it is possible for the duration of action of insulin to be longer than 24 hours, or in the case of twice daily insulin
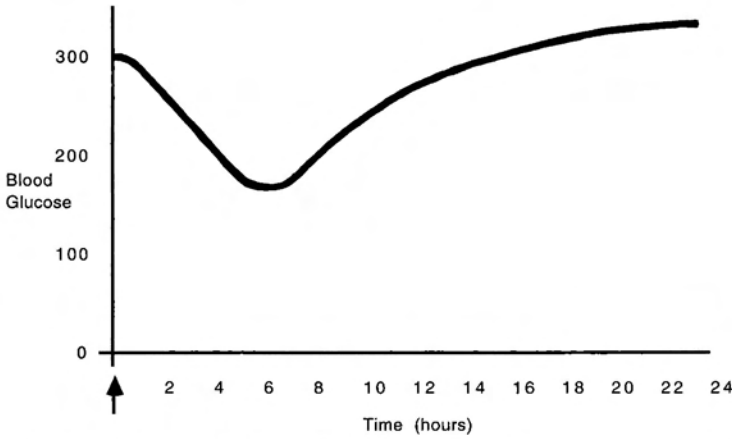
Figure 3. This glucose curve illustrates insulin with too short a duration of action (arrow indicates insulin injection).

administration, the duration of action of insulin may be longer than 12 hours. If the insulin is acting for more than 24 hours, the glucose curves may be quite variable on a day to day basis. Evidence of overlap of insulin effect from one day to the next may be apparent as insulin-induced hyperglycemia. If, in a given patient, prolonged insulin action is thought to play a role in the regulation difficulties, then a change to a shorter acting insulin is indicated (Table 2). In many patients, however, overlap in insulin duration of action may actually be beneficial. In some cases, particularly in patients on twice daily insulin, overlap of insulin
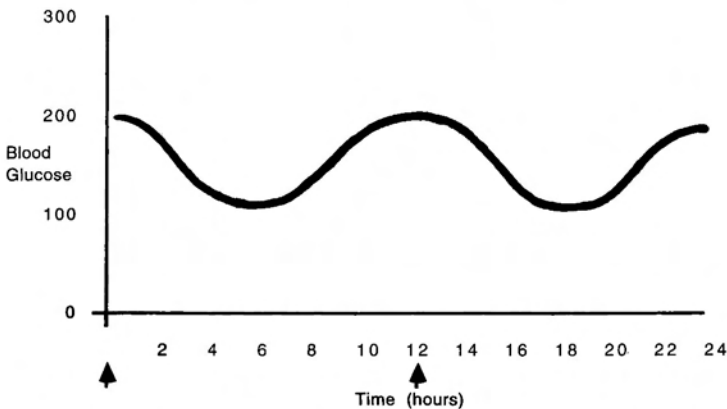

Figure 4. A glucose curve from an animal well regulated on twice daily insulin injections (arrows indicate insulin injections).

action may attenuate wide swings in blood glucose leading to more optimal control. The overlap in insulin action serves to blunt the postprandial increase in blood glucose.

Change in Frequency of Administration

The second option when a longer duration of insulin action is required is a change in frequency of administration of insulin. If this regimen can be worked into the owner's schedule, it is often ideal for the patient (Fig. 4). An animal on twice daily insulin can be regulated on an intermediate or long-acting insulin preparation depending on the duration of action of the various insulin types in that individual. For instance, if lente or NPH insulin has a 10- to 12-hour duration of action and ultralente has a 14- to 16-hour duration of action in a particular animal, then twice daily lente or NPH therapy is indicated. On the other hand, if lente or NPH has a 4- to 6-hour duration of action compared with 10- to 12-hour duration for ultralente in a patient, then ultralente should be used twice daily.

When changing to twice daily injections, it is helpful to compare the blood glucose concentrations at the times the injections will be administered. If they are roughly equal then the insulin dosage can be the same for each injection. If the evening glucose is more than 50 mg/dL less' than the morning value, a reduced evening dosage of insulin may be administered. Usually an adjustment in type or frequency of insulin administration or a change in dosage is made, not both at the same time.

After a change in dose, frequency, or type of insulin, it is best to allow for a 5- to 7-day equilibration period before attempting another glucose curve. This will allow the body to adjust to the change and achieve a steady-state pattern (Fig. 5).

PROBLEMS WITH SERIAL BLOOD GLUCOSE MONITORING

Serial blood glucose measurement, although the best means of assessing diabetic control, is not without problems. Probably the most frequently encountered problems relate to patient-associated factors. Many diabetic animals are so stressed in the hospital that release of glucocorticoids and epinephrine may result in insulin resistance and inaccurate results. In addition, when out of their normal environment, many pets will not eat as they do at home, or they may not eat at all. The administration of insulin to these patients may result in hypoglycemia and subsequent hyperglycemia. Having the owner feed the animal before and during hospitalization may remedy this situation. Within an individual animal, glucose curves may vary considerably because of factors such as diet, exercise, concurrent illness, and counter-regulatory
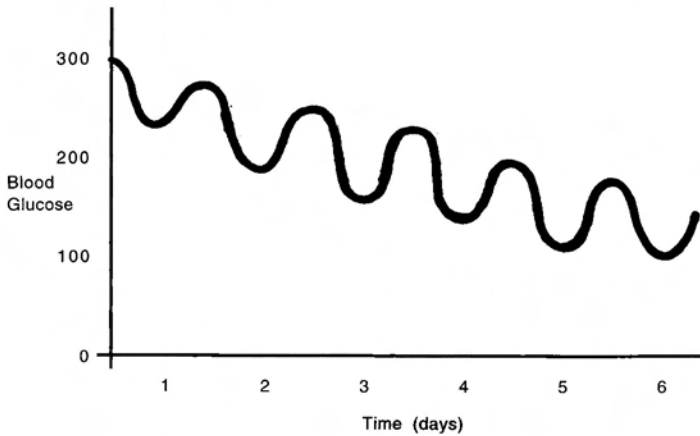
Figure 5. This curve illustrates the concept of equilibration of blood glucose during a period of several days on the same insulin dose.

hormone secretion. For this reason, results of a curve should not be applied to any future regulation problems the animal may have, especially if the clinical signs of DM have recurred.

Problems caused by the veterinarian may also follow serial blood glucose monitoring. Iatrogenic anemia is a very real possibility in small dogs and cats. It is best to take samples every 2 hours and take as small a sample as possible from these patients to avoid this problem. Septic or nonseptic phlebitis can occur rarely and is prevented by placement of an intravenous catheter to minimize venipuncture and by maintaining aseptic technique. Miscommunication and overdosage of insulin resulting in hypoglycemia can also be a problem.

There is no doubt that performing a blood glucose curve is time consuming and somewhat expensive; however, the benefits of improved diabetic regulation probably outweigh the inconveniences.

BLOOD GLUCOSE MONITORING MACHINES

The development of blood glucose monitoring devices designed for home monitoring of human diabetics has definitely benefited the veterinary profession, making evaluation of multiple blood samples economically feasible. These devices are inexpensive, accurate, give quick results, and require only a drop of whole blood for measurement. The most important feature when purchasing such a device is its accuracy (see later). It is always ideal to pair at least one sample of the glucose curve with a serum glucose performed by standard techniques (serum chemistry autoanalyzer) when performing a glucose curve with a glucose monitoring device.

Accuracy may be affected by operator-related errors and by machine-related variables. Because most of the machines are simple to use and come with step-by-step instruction manuals, operator error is minimized but may still play a role in decreased accuracy if drops of blood are not of consistent size and incubation times are not exact. Before performing a glucose curve, the unit should be standardized according to the manufacturer's instructions. Some glucose monitoring devices are inaccurate at high altitude (<4000 ft). Most units have control samples for calibration purposes. For reasons of consistency, it is best to have the same person run all glucose samples for a given diabetic's blood glucose curve.

Accuracy of the machines may decrease in some models for various reasons. For instance, some units may be affected by blood oxygen content because oxygen plays a role in the chemical reaction on the strip.[4] Patients on oxygen therapy may have false low readings because of increased oxygen partial pressure. Studies on the affect of altitude on the accuracy of blood glucose monitors are conflicting. Patient hematocrit, shock, dehydration, severe infections, and other conditions also may affect the accuracy of some models. Accuracy may be decreased outside the normal blood glucose range in some models as well. It should be noted that normal whole blood glucose values are lower than normal serum values because of different enzymatic methodologies and blood sample types; therefore, some variation between the blood glucose meter and the autoanalyzer results should be expected. Out-of-date or improperly stored test strips may also result in decreased accuracy.

Joseph et al[6] recently have compared three glucose meters for use in veterinary hospitals. They found that all three meters tested (Accu-Chek II [Boehringer Mannheim Corp, Indianapolis, IN], Glucometer II [Miles Inc, Elkhart, IN], and Glucoscan 2000 [Lifescan Inc, Milpitas, CA]) were very accurate compared with a Beckman Glucose Analyzer (Beckman Instruments, Fullerton, CA) using glucose oxidase methodology. The Accu-Chek II, which using the Chemstrip bG (Boehringer Mannheim Corp) reagent strips, was found to be more accurate in the hypoglycemic and hyperglycemic ranges, however. In an independent research firm's evaluation of 11 glucose monitoring devices, the Glucometer III, Accu-Chek III, Tracer II (Boehringer Mannheim), and the One Touch (Lifescan) systems were rated to be above average in accuracy.[4]

URINE GLUCOSE MONITORING

In the past, it was common to monitor a diabetic animal by measurement of urine glucose, usually in the first morning urine sample. Charts were printed in many textbooks that recommended a change in insulin dose based on the morning urine glucose concentration. Most animals were also maintained on once-a-day insulin therapy. Logically, any insulin action would be absent in most cases 24 hours after insulin injection, and the blood glucose levels would be high, except in those well-controlled diabetic patients. Adjusting the insulin dose based on urine sampling alone

then lead to detrimental effects such as insulin-induced hyperglycemia. Using this method of monitoring, it is impossible to evaluate the dose or duration of action of the insulin in a given patient.

Certainly, there is still value in monitoring urine glucose; however, it alone should not be used as a point on which to base a therapeutic change. The major advantage is that the trends in urine glucose concentration can be used in a regulated animal to detect lapses in regulation early in their course. Additionally, urine glucose determination may help during the initial regulation process as an indication of how close blood glucose control is to that 100 to 180 mg/dL range. Because the animal is at home and theoretically unstressed, urine glucose may be a more realistic reflection of overall regulation. Lastly, urine glucose can be an indicator of insulin-induced hyperglycemia. If the insulin dose is increased in a diabetic patient such that hypoglycemia results, the urine glucose concentration often increases because of the subsequent hyperglycemia.

Collecting urine samples from dogs is accomplished easily by most owners. The use of a long-handled cup holding device made out of aluminum rod makes collection easier. Alternatively, flat pie pans often can be scooted under a female dog without disturbing her. Most dogs get used to having urine collected even though they may have been reluctant at first.

Cats are another matter. Urine collection may be facilitated by using only a small amount of litter in the litter tray so that the urine is not all absorbed and can be aspirated into a syringe. Some owners have placed plastic wrap over a portion of the litter and collected the urine that pools in that for testing. Also, kitty litter that has a color change indicator system has been developed that can be sprinkled on the top of the regular litter making the owner's job easier (CatScan, Health Check, Division of Anitox Corporation, Buford, GA).

During the regulation process, the urine glucose can be monitored daily (morning) or twice daily (morning and evening) to assess trends in blood glucose control. As blood glucose approaches the normoglycemic range, urine glucose should decrease to trace or one plus amounts. It may even be negative in the evening if glycemic control is precise. If urine glucose concentration is consistently high, evaluation of blood glucose is indicated.

After an animal is regulated, urine glucose monitoring need not be performed as frequently. Taking a sample two to three times a week may be adequate. If the urine glucose begins to increase in a previously well-regulated animal, then it is time to monitor the urine glucose more intensely, i.e., daily to twice daily. If the urine glucose is increased consistently, blood glucose monitoring is indicated.

LONG-TERM MONITORING USING GLYCOSYLATED HEMOGLOBIN AND FRUCTOSAMINE

Long-term glycemic control of diabetic cats and dogs can be assessed by measuring glycosylated hemoglobin or fructosamine concentrations in hemolysates or serum, respectively. Although these tests are commonly used in human diabetic patients in whom strict glucose
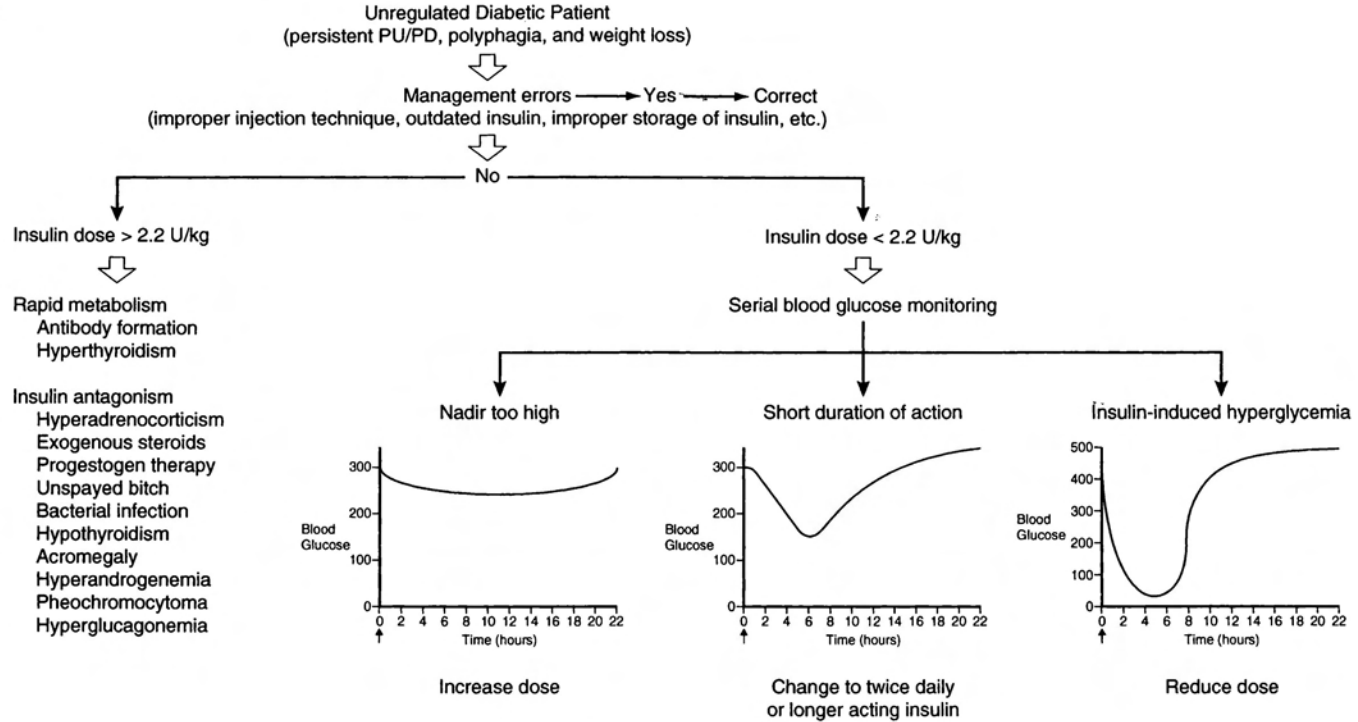
Unregulated Diabetic Patient
(persistent PU/PD, polyphagia, and weight loss)

⇩

Management errors ——→ Yes ——→ Correct
(improper injection technique, outdated insulin, improper storage of insulin, etc.)

⇩

No

Insulin dose > 2.2 U/kg

⇩

Rapid metabolism
   Antibody formation
   Hyperthyroidism

Insulin antagonism
   Hyperadrenocorticism
   Exogenous steroids
   Progestogen therapy
   Unspayed bitch
   Bacterial infection
   Hypothyroidism
   Acromegaly
   Hyperandrogenemia
   Pheochromocytoma
   Hyperglucagonemia

Insulin dose < 2.2 U/kg

⇩

Serial blood glucose monitoring

Nadir too high

Increase dose

Short duration of action

Change to twice daily
or longer acting insulin

Insulin-induced hyperglycemia

Reduce dose

Figure 6. Algorithm for the unregulated diabetic dog and cat.

regulation is acheived or when early, subclinical DM is suspected, their clinical usefulness in veterinary medicine is limited by lack of availability. Stress-related hyperglycemia will result in inaccurate serial blood glucose concentrations. In this instance, glycosylated hemoglobin or fructosamine measurements may be helpful in the initial diagnosis of DM, particularly in cats, and in determining the precision of glucose control over the previous weeks.

Glycosylated hemoglobin is formed by the nonenzymatic, irreversible binding of glucose to hemoglobin molecules within erythrocytes. Because the erythrocyte glucose metabolism is insulin-independent, the intraerythrocyte glucose concentration increases as plasma glucose increases. The extent of glycosylation, therefore, is related directly to the degree of hyperglycemia.[3]

The majority of glycosylated hemoglobin is in a fraction called HbA_{1c}, which binds glucose to the amino terminus of the hemoglobin molecule. Normal dogs have a mean glycosylated hemoglobin of 2.95 $\pm$ 0.149%, whereas diabetic dogs have a mean concentration of 4.97 $\pm$ 0.609%.[15] Interpretation of glycosylated hemoglobin must take into account the technique used to measure the glycosylated hemoglobin because acute hyperglycemia can alter the results of testing depending on assay methods. Glycosylated hemoglobin reflects glycemic control over the previous 5 to 9 weeks; a 3- to 4-week lag period is required between the lowering of blood glucose into normal ranges and the return of glycosylated hemoglobin to normal concentrations.[3]

Fructosamine refers to serum proteins, such as albumin, that have undergone glycosylation.[7, 8] The concentration of fructosamine is related directly to blood glucose concentration; however, because of the shorter lifespan of albumin in comparison to hemoglobin, fructosamine concentrations reflect blood glucose regulation over the previous 1 to 3 weeks.[7, 8]

Fructosamine assays are readily available in kit form for automated use. An advantage of the fructosamine assay over glycosylated hemoglobin determination is that it will detect deteriorating glycemic control more rapidly.[14] Hypoalbuminemia will cause low fructosamine concentrations as an artifact. Therefore, the following formula has been suggested to adjust fructosamine concentrations for hypoalbuminemia: adjusted fructosamine = 2.82/albumin $\times$ fructosamine (dogs) or 2.5/albumin $\times$ fructosamine (cats).[7, 8]

Fructosamine concentrations in normal dogs and cats are 2.54 $\pm$ 0.42 mmol/L and 2.83 $\pm$ 0.32 mmol/L, respectively.[7, 8] Diabetic dogs consistently exhibit fructosamine concentrations above the reference range of 1.7 to 3.38 mmol/L.[8] The mean fructosamine concentration of cats with DM was 5.93 $\pm$ 1.35 mmol/L.[7]

SUMMARY

Management of diabetic dogs or cats requires the use of all available monitoring technology (Fig. 6). First, one should ask questions about the clinical control of DM. Are the clinical signs of DM resolved, and is the

owner satisfied with insulin therapy? Other important questions would include: Is the dog or cat developing long-term complications of diabetes such as neuropathies or cataracts? Is body weight remaining stable? Is the dog or cat showing any signs of hypoglycemia? One should determine if the blood glucose curves are close to ideal for the type of insulin being administered. Urine glucose and ketones should be negative or trace as assessed by the at-home monitoring by the owner. In the problem diabetic, long-term glucose control can be assessed by serum fructosamine or glycosylated hemoglobin determinations. Regulation of the diabetic patient is accomplished when the owner is satisfied with the therapy and when the serum glucose monitoring parameters are acceptable.

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