

Diabetes Mellitus in Small Animal Practice An Overview

by

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Diabetes mellitus may be defined as a metabolic disturbance in which there exists either an absolute or relative deficiency of insulin. The incidence approaches one diabetic per one thousand dogs. The disease predominates in females and is more frequently seen in small breeds, notably the terriers. Ovariohysterectomy does not affect the incidence of the disease.⁶ The majority of the patients fall within the range of seven to ten years of age.⁷

Clinical Signs and Pathogenesis

Diabetes mellitus is a symptom complex, not a disease entity, and the underlying causes have not been well defined but probably are multiple and involve both pancreatic and extra-pancreatic factors. The disease has been associated with massive acute pancreatitis, chronic pancreatitis, pancreatic neoplasms, islet degeneration of undetermined etiology, and, in the cat, with generalized amyloidosis that has involved the pancreas. Normally secreted by the beta cells of the islets of Langerhans, insulin reduces blood sugar by assisting its utilization in peripheral tissues and its entrance into metabolic liver pathways. Insulin also encourages the synthesis of protein and fat. In the absence of an adequate supply of insulin, or in the presence of increased resistance to its action,

there is decreased oxidation of carbohydrates, decreased cell permeability to glucose, and increased catabolism of fat and protein.

Growth hormone and the glucocorticoids are antagonistic to insulin and tend to elevate blood sugar levels by inhibiting the utilization of glucose by the liver and peripheral tissues and by stimulating gluconeogenesis and the degradation of fats to fatty acids. Diabetes mellitus can result whenever an imbalance between these hormones and insulin exists.

The clinical signs of diabetes mellitus can be readily understood when one examines the pathophysiology of the disease. In absolute or relative insulin deficiency, the sugar in transport in the blood cannot enter cellular metabolic pathways. The resultant hyperglycemia leads to glycosuria as the renal threshold for reabsorption is exceeded. The osmotic diuresis that occurs is manifested by polyuria and is a potential source of dehydration to which the animal responds by increasing its water intake. Food intake likewise increases; because sugar cannot penetrate the cellular membrane, the animal is starving on a cellular level. Fat and protein are catabolized at a more rapid rate and not replaced in the absence of insulin's anabolic effect. Without insulin the resultant fatty acids can neither be incorporated into fat nor used for energy; the only alternative is their conversion to ketone bodies. The resultant ketoacidosis is associated with vomiting, anorexia, and the presence of ketones in the blood, urine, and on the breath. Untreated, this ketoacidosis progresses to diabetic coma and death.

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The ketonuria of the ketoacidotic animal is accompanied by the loss of fixed bases and sodium, potassium, and calcium cations in the urine as well; the resultant effect is an absolute body deficit in terms of these electrolytes as well as a compromising of the buffering capacity of the body which contributes further to the acidotic state.

In metabolic acidosis, potassium ions leave the cell in exchange for hydrogen ions and plasma potassium levels increase. Even with potassium loss through vomiting and urination, the serum potassium is usually elevated and the characteristic EKG changes (increased amplitude of T wave and bradycardia) may be seen. Dehydration and hemoconcentration will make the relative hyperkalemia appear even more severe. However, on a cellular level, the animal is actually deficient in potassium.

Fifteen percent of diabetic dogs will develop cataracts which are usually bilateral and rapidly progressive even if the disease is successfully controlled.⁴ Surgical removal of the lens is the only treatment. Retinopathies secondary to diabetes mellitus have also been reported and should be considered before lens extraction. These ocular changes are probably the result of abnormal carbohydrate metabolism.⁸

Thus we see the classical triad of signs—polyuria, polydipsia, and polyphagia—as characteristic of the early stages of diabetes mellitus and the more severe symptoms of acidosis manifesting themselves in advanced cases. Elimination of differential diagnoses and a logical approach to treatment, however, requires a profound understanding of the disease process. Concurrent or secondary involvement of other organ systems can present the clinician with further challenge.

Diagnosis

A presumptive diagnosis of diabetes mellitus can be made upon signalment, history, clinical signs, and a strongly positive test for glucose and ketones in the urine. Confirmation, or detection of mild cases, can be made by observing a fasting

blood glucose of 150 mg% or greater, or by using the glucose tolerance test. In the presence of a strongly positive test for urine glucose or the absence of ketonuria one must rule out the possibilities of (1) previous administration of parenteral sugar solutions; (2) recent oral intake of large quantities of sugar; or (3) primary renal glycosuria, an enzymatic defect in the renal tubules which limits tubular reabsorption of glucose. While there are other theoretical etiologies of ketonuria, clinical ketosis is rare in the dog and when it does occur it is almost invariably associated with diabetes mellitus.

Treatment of the Uncomplicated Diabetic

The objective in the medical control of diabetes mellitus is alleviation of the clinical signs discussed above. In an uncomplicated case of diabetes, this objective is achieved by controlled diet and exercise, administration of insulin, and supportive measures for concurrent involvement of other organ systems.

Any one of the high quality commercial foods that is high in protein and low in fat and carbohydrate is satisfactory. The ration should be divided into two equal portions and fed to the dog at the same time each day. Variation in the type and/or amount of feed or time of feeding can lead to disruption of the delicately balanced achieved normoglycemia.

Exercise should likewise be kept as constant as possible. Muscular activity reduces insulin requirements and increased physical activity can result in a hypoglycemic state. Generally it is more prudent to keep exercise constant as varying the insulin dosage daily to compensate for changes in activity is difficult to do accurately and if attempted is a potential source of complication.

There are various types of insulin available on the commercial market today. These can be classified into fast, intermediate, and long-acting hormone products (Table 1). At Iowa State NPH insulin, available in 40 or 80 units per cc concentration, is the treatment of choice for un-

TABLE 1
PROPERTIES OF VARIOUS PREPARATIONS OF INSULIN
(FROM GOODMAN AND GILMAN, REPRINTED IN PART)

TYPE	PREPARATION	UNITS/ML	APPROXIMATE TIME OF ONSET (hours)	PEAK EFFECT (hours)	APPROXIMATE DURATION OF ACTION (hours)	COMPATIBLE MIXED WITH
Fast-Acting	Insulin Injection U.S.P. (regular insulin)	40,80 100, 500	1	2-3	6	All preparations
	Insulin Injection U.S.P. "Insulin made from zinc-insulin crystals" (regular insulin)	40,80 100, 500	1	2-4	8	All preparations
	Prompt Insulin Zinc Suspension U.S.P. (semilente insulin)	40,80	1	4-7	14	Lente preparations
Intermediate-Acting	Isophane Insulin Suspension, U.S.P. (NPH insulin, isophane insulin)	40,80	2	10-20	24	Insulin
	Insulin Zinc Suspension, U.S.P. (lente insulin)		2	10-20	24	Insulin, semilente injection
Long-Acting	Protamine Zinc Insulin Suspension, U.S.P.	40,80	7	16-24	36	Insulin
	Extended Insulin Zinc Suspension, U.S.P. (ultralente insulin)	40,80	7	16-24	36	Insulin, injection semilente

complicated diabetes. The initial dosage for the dog is 0.25 to 0.50 units per pound of body weight per dog, small dogs requiring the upper end of the dosage scale while the lower dosages are often sufficient for larger animals.

The adjustment of the insulin dosage to achieve a stabilized animal can be done with the pet hospitalized or in the home environment. There are significant advantages to the regulation of insulin dosage at home: The animal is more accustomed to the activity of the home and therefore more likely to eat, drink, and exercise regularly. The owner becomes immediately involved in the control of the disease in its initial stages which is apt to prove valuable in the long-term treatment and monitoring of the patient.

The dosage of insulin to be administered daily is determined by monitoring either blood sugar or urine sugar levels. Blood sugar determination is more precise but seldom practical. NPH insulin is given subcutaneously daily one-half hour after the morning meal. At proper dosage level the blood glucose should be less than 200 mg% following the morning meal and in

the 80-100 mg% range after the evening meal. At home the urine should be monitored by the owner daily initially and every third day once the disease is controlled. Any of the commercial dip-sticks capable of monitoring urine glucose and ketones is acceptable. In a properly controlled animal a one-plus glucosuria is acceptable and desirable; ketones should be absent. In essence, because of monitoring limitations, the animal is being maintained as a mild diabetic. All the clinical signs of diabetes—polyuria, polydipsia, weight loss—should be absent.

Lipotropic drugs (Methiscol, USV Pharmaceutical) are given to minimize fatty changes in the liver and kidney which occur secondary to altered metabolism. Vitamin supplementation is also beneficial. Other organ system involvement is treated as indicated.

In summary, then, the uncomplicated diabetic is controlled by supplying a constant level of exogenous insulin which is approximately the amount needed to maintain homeostasis in an animal with minimal variation in critical external factors, notably exercise and oral food intake.

Treatment of the Ketoacidotic Diabetic

The ketoacidotic animal is a clinical emergency that requires immediate and vigorous therapy. Fluid replacement and the correction of circulatory collapse (shock) warrant initial attention. This is best accomplished by using an indwelling jugular catheter which facilitates not only fluid therapy but the determination of central venous pressure and the withdrawal of blood samples for monitoring treatment response. Urinary output should be monitored and general principles of fluid and shock therapy, a discussion of which is beyond the scope of this paper, apply and should be followed with the exception that corticosteroids, which are antagonistic to insulin, should not be administered unless the animal is unresponsive to the recommended treatment regime. Half-strength sodium chloride—2.5% fructose (which is rapidly cleared from the body) is the fluid of choice;⁸ however, lactated Ringer's solution or other balanced electrolyte solutions have been used with satisfactory results.⁸

Regular insulin is administered intravenously at an initial dosage of one unit per pound of body weight. Blood glucose levels are determined every two hours and the previous dosage is doubled and repeated at this time until blood glucose levels start to decline. Continue to monitor blood sugar levels; hypoglycemia is treated judiciously with 50% dextrose intravenously. If blood glucose starts to rise again crystalline insulin is given at a dosage of 0.5 units per pound of body weight. Once a fairly stable situation is achieved, treatment with NPH insulin can be started.

Sodium bicarbonate should be added to the infusion, 10mEq/liter, to aid in correction of acidosis. As the fluid, electrolytes and insulin take effect and the patient begins to respond, potassium returns into the cells in exchange for hydrogen ions and the animal becomes hypokalemic. 10 mEq of potassium can be safely added to the infusion. Oral potassium salts (Kay Ciel Elixir,[®] Cooper) can be given once the animal regains strength.

Ketoacidosis can be complicated by

infection, renal failure, acute pancreatitis, or pyometra, adding further challenge to both diagnosis and treatment and certainly contributing to a poor prognosis.

Long-term Considerations

Any stress can precipitate ketosis in the controlled animal. Concurrent disease in the controlled patient will generally increase insulin requirements; anorexia and/or vomiting in addition will warrant changes in dosage requirements. These animals should be treated vigorously and monitored closely during the course of other diseases. Estrus and pregnancy are potential sources of variation in insulin requirements and intact diabetic females should be spayed. Urinary incontinence may be more frequently seen in post-ovariohysterectomy diabetics than in normal females; this problem responds readily to exogenous estrogen. Surgery in the controlled diabetic is not a problem if approached logically and possible complications taken into consideration before they occur. The use of corticosteroids and/or epinephrine for treatment of other conditions should be avoided if possible.

Hypoglycemia may occur with an overdose of insulin, vomiting, anorexia, or if the animal misses a meal. The owner should be aware of the signs of hypoglycemic convulsions. Usually corn syrup given orally elicits a favorable response.

It should be obvious that the two most important considerations in the management of a diabetic dog or cat are a knowledgeable and enthusiastic clinician and a thoroughly educated and dedicated pet owner. Patients should be seen regularly for thorough evaluation of treatment and general health. However, it is the at-home insulin administration, urine monitoring, and general observation that will determine the long-term success of your endeavors. The majority of cases can be managed effectively and the efforts put forth by the clinician in treating the animal and in informing the client can be rewarding.

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Higher Returns with Music

The sound of music may be money to hog farmers. That is, if preliminary results of a study by a Kansas State University Extension veterinarian are valid.

Dr. Lowell Breeden has conducted a survey on 43 Kansas swine producing farms to determine if music in the farrowing and finishing houses has an effect on production.

"We've known for years that music in the dairy barn has increased milk production and made for less nervous cow," says Breeden. "Now it appears that pigs respond in similar fashion."

The veterinarian said the main effect of music on pigs is on the disposition of the individual animal. "More pigs are weaned per litter, they are more contented, less nervous, and there is less incidence of tail biting," he indicates.

Breeden says the animals in both the farrowing and finishing houses were less apt to jump up and run around every time there was a sudden noise, or when someone came into the building.

While this all sounds encouraging, Breeden says there are some dangers involved. "Too many decibels—units for measuring the volume of sound—may cause a temporary or permanent type of ear damage to the sow as well as to her offspring," he warns.

Breeden recounts one incident where a farmer had the volume turned up "full

blast" in the farrowing house. "We were standing two feet apart and still had to shout at the top of our lungs to be heard by one another.

"It was interesting to note upon reviewing his farrowing charts, that he was losing two to three baby pigs per litter as a result of being smothered when laid upon by the sows," he continued. "The only logical conclusion to draw is that either the sows were becoming deaf or that the music was too loud and the sow couldn't hear the baby pigs squeal, or possibly a combination of the two," he concluded.

Breeden advises keeping radio volumes down to a pleasing, soothing tone in the farrowing and finishing houses. Install extra speakers in other parts of the buildings if necessary.

The veterinarian feels more research is needed to determine if his preliminary results are valid, and if there might possibly be an inter-relationship between a certain type of music and an increase in weight gain and feed efficiency.

Breeden says his survey to date has shown the pigs do have a preference for certain types of music. "At the present time, the music of the 30's and 40's seems to be the best," he concludes. (Cooperative Extension Service, Kansas State University)