

Canine Diabetes Mellitus

Alice Huang, VMD, DACVIM
Purdue University



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P Profile

Definition

- Canine diabetes mellitus (DM), classified as either type I or type II, is a generally treatable condition caused by insulin deficiency.
- At diagnosis, most diabetic dogs are suspected of having type I.
 - Type I patients, characterized by permanent inability to produce insulin, often require exogenous insulin administration.
 - DM has a potential immune-mediated cause (though this is not firmly established).
 - Diabetogenic drugs, pregnancy, and chronic pancreatitis are also possible causes of canine DM.

Systems

- As an immunosuppressive disorder, DM can affect many systems; urinary tract and kidney infections, and other bacterial infections may result.
 - Because of chronic hyperglycemia, uncontrolled DM can result in cataracts.

Genetic Implications

- Although the exact mechanism of pancreatic β -cell loss in canine diabetes has not been determined, certain breed associations suggest a genetic component.^{1,2}

Incidence/Prevalence

- Since 1970, 0.13%–0.64% of dogs are affected with increasing incidence.^{1,3}
- Population characteristics (eg, genetic and demographic associations) may influence incidence.

Signalment

Breed

- Some breeds are at higher risk for diabetes, (eg, Australian terriers, Samoyeds, Keeshonds) while others appear resistant to its development (see **Canine DM Breed Prevalence**, page 49).^{1,3}

Age & Range

- Most dogs are diagnosed >8 years of age.
 - The large age range may reflect different genetic susceptibilities to DM, drug exposures, or presence of disease resulting in insulin antagonism.³

Gender

- Females are at increased risk, regardless of neuter status.
- Neutered males are at greater risk than intact males.^{1,3}

Causes

- The cause of β -cell loss is likely multifactorial:
 - Autoimmunity.
 - Genetics.
 - Environment.
 - Diseases resulting in insulin antagonism.^{4,5}

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Risk Factors

- Certain breeds.
- Females.
- Neutered males.
- Previous hyperadrenocorticism.
- Obesity.
- Inactivity.
- Cushing's disease and DM may exist as comorbidities.

Pathophysiology

- Insulin deficiency results in hyperglycemia by causing⁶:
 - Uninhibited hepatic glucose production.
 - Impaired entry of glucose into tissues.
 - Accelerated protein and lipid catabolism.
- Persistent hyperglycemia results in glucosuria when the renal tubular threshold for glucose excretion >180–220 mg/dL.
- Increased proteolysis leads to muscle wasting and poor wound healing.
- As the accelerated lipid catabolism persists, hepatic lipidosis develops and ketoacidosis can result secondary to enhanced ketone body production.
- Endothelial damage and immunosuppression ultimately occur.⁶

Signs

History

- Polyuria.
- Polydipsia.
- Polyphagia.
- Weight loss.
- Owners occasionally report acute blindness secondary to cataract formation.

Physical Examination

- There are no classic findings in non-ketotic or healthy diabetic dogs.
- While many DM patients are overweight, others may be thin and muscle wasted.

- Some have cataracts and anterior uveitis on ocular examination.

Dx Diagnosis

Definitive

- Diagnosis is based on signs and history, as well as documentation of persistent hyperglycemia and glucosuria.
- Stress hyperglycemia may occur in hyperexcitable dogs.
 - Lower frequency than cats.
 - If DM is suspected, measurement of serum fructosamine should be considered.

Differential

- Hyperadrenocorticism is the most common differential for DM.
- Chronic kidney disease, a common cause of polyuria, polydipsia, and weight loss, is seldom associated with hyperglycemia or glucosuria.
- Pheochromocytoma and pancreatitis infrequently cause hyperglycemia, polyuria, and polydipsia.

Laboratory Findings & Imaging

- There is no consistent pattern of laboratory or imaging abnormalities among diabetic dogs.
 - Findings depend on patient, disease severity, and comorbidities.
- Common laboratory abnormalities are a direct result of insulin deficiency:
 - Hyperglycemia.
 - Hypertriglyceridemia.
 - ALP and ALT elevations.
- Less common abnormalities are not consistently observed and may reflect comorbid conditions.
- Hematologic and biochemical changes may include mild anemia, hypercholesterolemia, hypertriglyceridemia, hyperglycemia, hyperketonemia, and mild increases in serum ALT and ALP.⁶
- If dealing with a DKA patient, electrolyte abnormalities, azotemia, and/or

Any degree of hypoglycemia can occur with insulin therapy.

acidosis may also be noted on the biochemistry panel.

- Ketonuria and evidence of urinary tract disease (pyuria, hematuria, bacteriuria) may be present on urinalysis.
- Abdominal imaging may reveal non-specific hepatic changes.
- Evidence for concurrent diseases (eg, pancreatitis, renal failure) may be detected with abdominal imaging.

Tx Treatment

Inpatient or Outpatient

- In healthy diabetics, ± trace to small amounts of ketonuria can be managed on outpatient basis.
- Hospitalization may be required for patients with DKA or concurrent diseases.

Medical

- Intermediate- or longer-acting insulin is the mainstay of therapy and should be administered as soon as possible after diagnosis and stabilization.
- Short-acting insulin (eg, regular insulin) is predominately used in the hospital for clinically ill diabetics as increased potency increases risk for hypoglycemia.
 - Once out of crisis and eating consistently, the patient can be switched to longer-acting insulin.

Nutritional Aspects

- Minimizing postprandial blood glucose fluctuations is the principal goal of dietary therapy.
- Most studies suggest that fiber-rich diets, particularly insoluble fiber, result in improved glycemic control.^{7,8}
 - The ideal dietary composition is

ALP = alkaline phosphatase, ALT = alanine transaminase, DKA = diabetic ketoacidosis, DM = diabetes mellitus, NPH = neutral protamine Hagedorn, PZI = protamine zinc insulin

debatable, as improved glycemic control may be attributed to the high-fiber, low-carbohydrate, low-fat, or combination content.

- Diet change is not recommended during stabilization.
- If diabetes is difficult to regulate, increase fiber.
- Diets should be palatable to ensure predictable consumption.
- Equal-sized meals should be offered q12h (with insulin administration).
- Overweight dogs require weight reduction programs, as obesity contributes to insulin resistance.

Alternative Therapy

- No alternatives to insulin therapy are available.
- Oral hypoglycemic agents should not be considered, as most diabetic dogs are insulin dependent at diagnosis.

Clinical Remission

- Diabetic remission is extremely uncommon in dogs.
- If remission occurs, it will probably be secondary to early withdrawal of diabetogenic drugs (eg, glucocorticoids, prostaglandins).

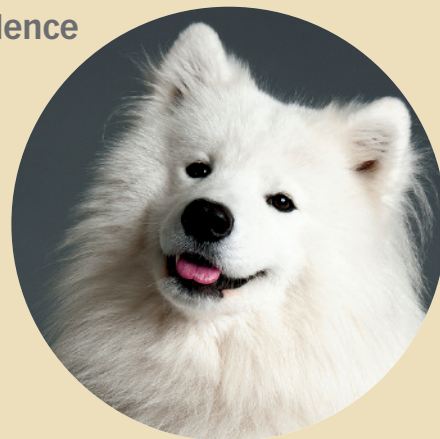
Client Education

- Treatment of DM is lifelong and owners should be prepared for complications.
- At-home insulin therapy, dietary management, and careful monitoring are cornerstones to maintaining a diabetic dog.
- Clients must be taught to administer insulin, store insulin, and obtain appropriate syringes (U-40 vs U-100).
- A consistent diet and feeding schedule can facilitate glycemic control, as can weight reduction (if necessary).
 - Clients should be taught to monitor urine glucose and ketones at home through the use of strips such as Keto-Diastix (bayer.com).

Canine DM Breed Prevalence

Increased Risk for DM^{1,9}

Australian terrier
 Samoyed
 Miniature schnauzer
 Standard schnauzer
 Miniature poodle
 Pug
 Toy poodle
 Fox terrier
 Keeshond
 Bichon frise
 Finnish Spitz
 Lhasa apso
 Cairn terrier



Low Risk for DM^{1,9}

Boxer
 Golden retriever
 German shepherd
 American pit bull terrier

- Clients can also be taught to perform blood glucose curves (BGCs) at home with a handheld glucometer, such as the AlphaTrak2 (alphatrakmeter.com).
 - Generated data can be interpreted by the veterinarian without the complication of clinic-associated stress.

Rx Medications

Drugs & Fluids

- Short-acting insulin (eg, regular insulin, insulin lispro) is predominantly used in the hospital for clinically ill diabetics or DKAs, as increased potency increases risk for hypoglycemia.
- Intermediate-acting insulin is the common choice,¹⁰ as it results in the best glycemic control.
 - Human recombinant neutral protamine Hagedorn (NPH) insulin.

- Comparable with NPH insulin, lente insulin (Vetsulin, merck-animal-health-usa.com) is currently unavailable.

- Long-acting insulin effectively reduces the blood glucose level but varies in absorption, time to nadir, and duration of action, increasing risk for hypoglycemia and Somogyi effect.^{10,11}
 - Insulin detemir, insulin glargine, and protamine zinc insulin (PZI).
- Treatment should be initiated q12h, although starting doses differ for insulin types.

Contraindications & Precautions

- Some dogs develop insulin resistance because of antibody formation, particularly from use of bovine insulin, but less frequently from human recombinant insulin (eg, NPH insulin).
 - Development of antibodies would result in persistent hyperglycemia and lack of efficacy of the insulin being used.

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- Any degree of hypoglycemia can occur with insulin therapy.

Prevention

- Although there is no evidence that canine diabetes can be prevented, modulating associated risk factors (eg, obesity, inactivity, hyperadrenocorticism) may influence risk for development.

Complications

- Uncontrolled diabetes can lead to:
 - Cataract formation.
 - Bacterial infections (usually urinary tract).
 - Ketoacidosis.
 - Hepatic lipidosis.
 - Persistent weight loss.
- DM can also be complicated by comorbid conditions (eg, pancreatitis, infections, hyperadrenocorticism).
- Attempting to control diabetes with insulin therapy can lead to iatrogenic hypoglycemia.

Course

- DM is not a progressive disease and can be stabilized with appropriate treatment.
- Outcome depends on degree of glycemic control, presence and severity of concurrent diseases, and owner commitment.
 - Dogs can do well for many months to years with diligent care.

Future Follow-up

- 12-hour blood BGCs should be performed q10–14d from each insulin dose change until the patient is clinically well.
- Fructosamine measurements may be useful when assessing the average glucose concentration over the previous 2 to 3 weeks.

- Owners can be taught to perform at-home BGCs, allowing frequent monitoring of dogs that are difficult to regulate.
 - Once well controlled, BGCs may be performed based on owner observations (eg, BGCs should be performed if the dog becomes more polyuric, polydipsic, or ill) or q3–6mo to ensure lack of subclinical hypoglycemia.
- Urinary tract infections are commonly identified in diabetic dogs; urine cultures should be performed regularly.



In General

Relative Cost

- Diagnostic workup for suspected uncomplicated DM: \$\$–\$\$\$
- Treatment and follow-up care for uncomplicated DM: \$\$–\$\$\$

- Diagnostic workup for suspected complicated DM: \$\$\$\$–\$\$\$\$\$
- Treatment and follow-up care for complicated DM: \$\$\$–\$\$\$\$\$

Cost Key

- \$ = up to \$100
- \$\$ = \$101–\$250
- \$\$\$ = \$251–\$500
- \$\$\$\$ = \$501–\$1000
- \$\$\$\$\$ = more than \$1000

Prognosis

- Fair with diligent care and monitoring.

Future Considerations

- Studies that more definitively evaluate the impact of diet on canine DM would be valuable.
- Continuing research into use of alternative insulin would be advantageous as only NPH insulin provides consistent glycemic control in dogs.^{10–13} ■ **cb**

TX at a Glance

- Control hyperglycemia
- Prevent ketone formation
- Optimize body weight
- Comorbidities
- Educate client

Drugs

- NPH insulin 0.25–1 U/kg SC q12h after a meal and titrated to clinical efficacy
- Alternatively, insulin detemir, insulin glargine, Vetsulin, or PZI

Diet

- Maintenance
- High fiber if patient is overweight or diabetes is difficult to control

See **Aids & Resources**, back page, for references & suggested reading.

BGC = blood glucose curve, DKA = diabetic ketoacidosis, DM = diabetes mellitus, NPH = neutral protamine Hagedorn, PZI = protamine zinc insulin