Diabetes mellitus (DM) is one of the top two endocrinopathies in cats, with a prevalence estimated to be approximately 0.5% of cats seen in private practice. Unfortunately, data suggests feline DM has been increasing in prevalence since the mid-1980s. This parallels the increase in obesity in our feline patients. Other risk factors for DM in cats include sex (60-70% of cases are neutered males), age (prevalence is highest in cats over 7 years), presence of concurrent diseases (e.g., chronic pancreatitis), and treatment with some medications (e.g., glucocorticoids).

The diagnosis of DM is made on the basis of classical clinical signs (polyuria, polydipsia, polyphagia, and weight loss) as well as documentation of persistent hyperglycemia and glycosuria. Some patients will have elevations in liver enzymes at the time of diagnosis, although the complete blood count is often unremarkable. Ketonuria may be present in cats with complicated DM although it is not associated with decreased survival time. Cats with long standing uncontrolled DM may have peripheral neuropathy.

Stress hyperglycemia is a well-known phenomenon in cats, making it difficult to determine the true cause of hyperglycemia in some patients. In one study of sick cats presented to a university clinic, hyperglycemia was found in 36% of patients.\(^1\) However, upon further investigation, only 2% were diagnosed with DM. Measurement of serum fructosamine is helpful in this situation, as is home measurement of urine glucose.

Our understanding of the risk factors, pathogenesis, and treatment options for feline diabetic patients has improved dramatically in the last 10-15 years. A recent study showed that cats with newly diagnosed DM have a fair to good prognosis, with 46% living longer than 2 years.\(^2\) Successful management of cats with DM includes four important goals of treatment:

1. Minimizing clinical signs
2. Improving quality of life
3. Preventing complications
4. Achieving a non-insulin dependent state when possible

In newly diagnosed patients with uncomplicated DM, these goals can be accomplished by attention to 5 key points:

1. Identify and address common complications and concurrent diseases
2. Design a weight management plan
3. Use specific dietary therapy
4. Start insulin therapy promptly
5. Invest in owner education

**Identify and address complications and concurrent diseases**

At the time of diagnosis, as well as while monitoring diabetic patients, care should be taken to identify concurrent problems that could influence response to therapy or prognosis. For every patient, ensure you have taken a good medical history, performed a thorough physical examination (including blood pressure assessment), and obtained a minimum database (complete blood count, serum chemistries, total T4, fPLI, urinalysis and culture). The most common concurrent problems are infections, especially in the oral cavity and urinary tract. In
fact, 10% or more of diabetic cats have urinary tract infections even when the urine sediment is inactive. Therefore, urine culture should always be part of the diagnostic plan.

Insulin resistance is defined as an insulin dose > 1.5 U/kg or 6 U/dose. Common causes are bacterial infections and concurrent diseases, such as hyperthyroidism, chronic kidney disease, inflammatory bowel disease, pancreatitis, and neoplasia. A thorough evaluation should be made to identify and, when possible, treat any concurrent diseases. High serum creatinine concentration at the time of diagnosis of DM has been associated with a poor outcome, likely because it is linked to chronic kidney disease. Acromegaly is an uncommon disease associated with severe insulin resistance in cats.

Design a weight management plan

Obesity is strongly linked to DM in cats as it causes insulin resistance and changes in glucose tolerance. Many diabetic cats are overweight or obese at the time of diagnosis although they have a history of recent weight loss. Fortunately, the insulin resistance induced by obesity may be reversible with appropriate weight loss. A nutritional assessment should be performed for every diabetic cat in accordance with guidelines published by the American Animal Hospital Association and the World Small Animal Veterinary Association. This includes assessment of body condition and muscle condition, and the development of a feeding management plan designed to achieve normal weight. The feeding management plan includes a specific dietary recommendation as well as a plan to modify the cat’s environment to increase activity and provide enrichment. A few diabetic patients are underweight at the time of diagnosis, and they also require a nutritional assessment and a plan to achieve normal body weight.

Use specific dietary therapy

Overweight or obese diabetic patients should be on a weight management diet and meals should be portion controlled. Frequent monitoring and adjustment of the feeding plan is needed to achieve safe and effective weight loss. As many of these patients lose weight, their need for insulin decreases, so close monitoring for dose adjustment is required to avoid hypoglycemia. Normal or underweight cats can be fed a high protein, low carbohydrate diabetes management diet (e.g., Purina DM Dietetic Management, Hill’s Prescription Diet m/d, Royal Canin Diabetic). Canned formulations typically have lower carbohydrate concentrations than dry diets and provide increased water intake as well. Normal weight cats should also be fed in a portion controlled manner to avoid weight gain, while underweight cats can be fed free choice. The timing of insulin injections relative to meal times is important for canine and human diabetics, but probably not for feline patients. Since cats normally eat several small meals during the day, post prandial hyperglycemia is not an important problem for regulation of DM in cats.

Start insulin therapy promptly

One of the first questions owners of cats with DM ask is whether lifelong insulin treatment will be needed. Patients most likely to achieve remission share these common factors:

1. They are newly diagnosed
2. They have no concurrent diseases causing insulin resistance
3. The owner is able to achieve good glycemic control
4. They are fed a diabetic management diet

Diabetic remission is typically defined as the ability to maintain normal blood glucose (BG) without insulin for at least 4 weeks, without the reappearance of clinical signs. If diabetic remission occurs, it is most likely within the first 4-6 months of treatment in cats with good glycemic control. Trying to control DM with diet alone or with oral hypoglycemic medications and delaying the start of insulin therapy markedly reduces the chance of remission. The type of insulin used for the best chance at achieving remission may be less important than instituting
therapy as soon as possible and having a plan for close monitoring. The duration of remission is highly variable and unfortunately, at least 25% of cats that achieve remission subsequently become overtly diabetic and must receive insulin again.

Most human insulins are 100 units/mL (U100) and 3/10 cc (0.3 mL) micro-fine or ultra-fine U100 syringes should be used for those products. However, veterinary insulins (e.g., Caninsulin/Vetsulin, ProZinc) are 40 units/mL (U40), and U40 syringes must be used. It is critical for veterinary staff and owners to be aware of the concentration of the insulin being used for a given patient and to use the correct syringes for the insulin in order to dose accurately and safely.

While no true feline insulin is available commercially, there are products available that provide excellent therapeutic control (Table 1). The choice of insulin is based on several factors, such as:

1. What insulin products are available
2. What is affordable and convenient for the owner
3. The ease of dosing (U40 versus U100) for individual owners
4. Product licensing (veterinary use versus human use)
5. Product support (only available with veterinary insulin)

Table 1: Comparison of insulin products

<table>
<thead>
<tr>
<th>Insulin</th>
<th>Licensed in Cats</th>
<th>Manufacturer</th>
<th>Formulation</th>
<th>Median Maintenance Dose*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProZinc</td>
<td>Yes</td>
<td>Boehringer Ingelhein Vetmedica</td>
<td>U40 recombinant PZI</td>
<td>0.6 U/kg, BID</td>
</tr>
<tr>
<td>Caninsulin/Vetsulin</td>
<td>Yes</td>
<td>Intervet/Schering Plough</td>
<td>U40 Porcine zinc</td>
<td>0.5 U/kg, BID</td>
</tr>
<tr>
<td>Lantus</td>
<td>No</td>
<td>Sanofi Aventis</td>
<td>U100 Insulin glargine (recombinant human analog)</td>
<td>2.5 U/cat, BID</td>
</tr>
<tr>
<td>Levemir</td>
<td>No</td>
<td>Novo Nordisk</td>
<td>U100 Insulin detemir (recombinant human analog)</td>
<td>1.75 U/cat, BID</td>
</tr>
</tbody>
</table>

*Based on lean body weight

One important caveat is that compounded PZI insulin should be avoided. One study of 12 compounded products found that only 1 met product specifications. Variability in the formulation of compounded insulins could lead to serious problems with glycemic control.

It is difficult to predict in advance insulin is best for each patient, so clinicians should be familiar with at least two types of insulin appropriate for treating cats. The critical factor for insulin potency and duration of action is absorption. A common cause of inconsistent response to insulin in humans is poor absorption, even under ideal conditions. The same is likely true in cats.

Once factor affecting insulin absorption is the choice of injection sites. The intrascapular area may be the easiest site for teaching owners to give injections, but it has less blood supply and is more prone to fibrosis than the lateral abdomen, lateral thorax, or the flank area. As soon
as owners are comfortable giving injections in the intrascapular area, encourage them to move the injection site.

The typical starting dose of insulin regardless of type is 0.25-0.5 U/kg BID (often 1-2 U/cat, BID) based on lean body weight. Use the higher starting dose for cats with initial blood glucose >20 mmol/L (360 mg/dL). The appropriate maintenance dose for each patient will be the dose that controls clinical signs, but maintenance doses >1.5 U/kg are uncommon. Due to the unpredictability of the individual response to different insulins, it is important to be conservative when selecting insulin doses, either initially or when switching a cat from one type of insulin to another.

Once a newly diagnosed diabetic cat has been thoroughly evaluated and started on insulin therapy, recheck the patient in 1 week. At that time, evaluate weight and body condition score, clinical signs, and owner compliance with the therapeutic plan. A blood glucose curve (BGC) can be performed in the clinic, or in some cases, it may be obvious that a dose increase is necessary without performing the BGC. This is also a good time to introduce the concept of home blood glucose measurements for clients that are interested and able.

Veterinary technicians are the best team members to teach owners how to take blood glucose measurements at home and familiarize them with the equipment and techniques. Human glucometers are readily available and inexpensive, but they are calibrated for human blood. Over- and under-estimates of blood glucose can occur due to a different distribution of glucose between plasma and red blood cells. Therefore, it is useful to calibrate a client’s glucometer against the clinic’s in-house chemistry analyzer by comparing blood glucose measured on the same sample. Glucometers calibrated for feline use are more accurate (e.g., AlphaTRAK, www.abbottanimalhealth.com) and use small blood volumes, although they are more expensive.

At the 2 week visit, once again evaluate weight and body condition score, clinical signs, and owner compliance as well as the results of a BGC (performed at home or in the hospital). Performing a BGC is more reliable than spot-checking blood glucose, but interpretation must always be in light of what the patient and owner are telling you. Due to day-to-day variation (and even night-to-day variation), it is often better to evaluate a series of BGC performed over several days rather than a single curve. Re-evaluations are then performed weekly until the patient is stabilized. Targets for blood glucose are a daily average of 6-14 mmol/L (100-250 mg/dL) and a nadir of 4.5-8 mmol/L (81-144 mg/dL). Dose adjustments should be 0.5-1.0 U and should not be made more often than about 7 days apart. Perform a BGC within 1-2 weeks of making any change. Typically, it takes 8-12 weeks to stabilize newly diagnosed diabetic cats.

Cats are unique in that their DM may be transient or intermittent, necessitating careful ongoing monitoring. This is best accomplished by regular veterinary visits (every 3-4 months) to evaluate clinical signs (preferably from a diary kept by the owner), body weight and condition, and periodic assessment (every 3-6 months) of a minimum database (CBC, chemistries, urinalysis). Additional evaluation tools include serum fructosamine and BGC (performed in the clinic or by the owner at home). BGC are most valuable at certain time points:

- During stabilization
- When signs of hypoglycemia are noted
- 1-2 weeks after any insulin dose change
- When any signs of poor glycemic control are noted

Owners should be particularly vigilant for clinical signs of hypoglycemia, which may be subtle in the early stages (e.g., lethargy, mild ataxia). Even if owners are not able to perform BGC regularly, knowing how to check their cat’s blood glucose can help identify hypoglycemia. The insulin dose should be decreased by 25-50% and the cat should be monitored closely for remission.

BGC are not possible in all patients, either due to owner constraints or the temperament of the cat. In those cases, the owner’s observations (clinical signs, appetite, behavior, etc.) and
home monitoring of urine glucose can be combined with periodic physical examinations and a minimum database including serum fructosamine. Urine glucose measurements are best used to monitor trends over time as well as impending remission or return of hyperglycemia. Insulin doses should be more conservative in these patients and they may be less likely to achieve good glycemic control and remission.

If difficulty is encountered in stabilizing a new diabetic patient, ask these questions:
- Is the owner handling and administering the insulin correctly?
- Are infections (e.g., urinary tract, oral cavity) or concurrent diseases present?
- Is the cat on a diabetes management diet?
- Are there problems with the weight management plan?

Invest in owner education
Providing owner education is a critical component of successful management of feline diabetic patients. An informed owner is better able to understand optimal disease management.

5 Tips for owners of diabetic cats:
1) The sooner your cat’s diabetes is controlled, the better your cat will do and the more likely remission will occur. Most cats that achieve remission (e.g., control of disease without insulin) will do so within 4-6 months of initiating treatment if it is going to occur.
2) Don’t change your cat’s insulin dose without consulting your veterinarian. When a dose is changed, it takes about 7 days for your cat to adjust, so that frequent changes in dose are actually counterproductive.
3) Decide to make insulin treatment a positive experience for your cat from the start. Always use a new syringe for each injection as this will reduce any stinging or pain. Give the injections when your cat is enjoying a pleasurable experience, such as getting a treat or getting brushed.
4) Home monitoring is very important as your cat’s insulin needs are likely to change over time. You will want to keep a log of your cat’s appetite, water intake, urine output, and general energy level and attitude. [Figure 4] It’s also helpful to keep a daily log of insulin dose and time of administration as well as type of food and amount eaten. Feeding your cat at the time of the insulin injection helps you monitor your cat’s appetite. Learning how to check blood glucose levels at home is easy and can be a very valuable part of stabilizing a new diabetic and monitoring an existing diabetic patient.
5) Learn the signs of hypoglycemia (low blood glucose), such as weakness, lethargy, trembling, and trouble walking. If you suspect hypoglycemia, a small amount of corn syrup on your cat’s gums will be helpful while you call your veterinarian.

Resources for owners of diabetic cats:
Partners in Animal Health (Cornell University College of Veterinary Medicine)
- Caring for your diabetic cat (video)
Veterinary Partner
- Home testing of blood glucose for diabetic cats (video)
- [http://www.veterinarypartner.com](http://www.veterinarypartner.com)
Merck Animal Health
- Canine and feline diabetes, insulin injection tips (video)
Resources for veterinarians
Pet Nutrition Alliance - Nutritional assessment guidelines and tools
- http://www.petnutritionalliance.org

- Available free at: http://jfm.sagepub.com/site/Guidelines/Guidelines.xhtml

References: