

Feline diabetes mellitus



There are key differences between diabetes in cats and dogs. Notably, disease is **type 2** in cats and, in many cases, is **transient** in nature. This 'Practice Pointers' article, from FAB's Feline Expert Panel, discusses risk factors for feline diabetes, provides tips for achieving early diagnosis, and highlights priorities in insulin and dietary management and patient monitoring, as well as potential complications.

Feline diabetes mellitus (DM) is on the increase, with a recent UK survey suggesting that nearly 1 in 200 cats are diabetic. Despite being so common, feline diabetes is surrounded by much confusion. The disease has many differences when compared with DM in dogs, it can be difficult to manage, and both owner compliance and home care form an important part of management.

Treatment goals for feline DM have also changed in recent years with the realisation of just how common 'transient' DM is in cats.

Classification and aetiology

In dogs and humans, type 1 DM predominates, with a combination of genetic susceptibility and immunological destruction of pancreatic beta cells leading to progressive insulin insufficiency. However, in cats type 2 DM is most common, characterised by insulin resistance and impaired insulin secretion.

Whereas the aim was once simply to control the clinical signs of disease, the goals of treatment are now:

- Early detection
- Aggressive treatment early in the course of disease
- Aiming for diabetes to be transient, with only a temporary need for exogenous insulin

In 50-60% of cats, DM may be transient, with cats losing the need for exogenous insulin if the disease is diagnosed early and treated appropriately and promptly

The aetiology of feline diabetes is likely to be multifactorial, involving a variable combination of insulin resistance, impaired insulin secretion, environmental factors (eg, diet), islet amyloid deposition, chronic pancreatitis and genetic predisposition.

Obesity accounts for a high proportion of the growing number of diabetic cats. It causes a reversible insulin resistance that is a result of down-regulation of insulin receptors and reduced efficacy of insulin. The fact that this insulin resistance is reversible means that the **correction and prevention of obesity is a vital aspect of the management of cats with DM**. Appropriate weight loss can result in reversal to a non-insulin-dependent state.

Secondary (type 3) DM describes the development of diabetes due to insulin antagonism as a result of concurrent disease (eg, pancreatitis) or medications (eg, glucocorticoids or progestagens). If corrected early, insulin dependence can resolve, but if insulin antagonism continues, beta cell function becomes impaired, and permanent DM can develop.

In 50-60% of cats, DM may be transient, with cats losing the need for exogenous insulin if the disease is diagnosed early and treated appropriately and promptly. This occurs most typically within 1-3 months of initiating insulin treatment. Some cats then remain subclinically diabetic, never requiring further insulin treatment, while others may revert to an insulin-dependent state again in the future, particularly when subjected to further risk factors (eg, becoming obese or receiving corticosteroid treatment).

This transient diabetes may result from:

- Correction of 'glucose toxicity'. Prolonged hyperglycaemia causes impaired insulin secretion by islet beta cells and increased peripheral resistance. Exogenous insulin administration and reduction of hyperglycaemia can result in resolution of this toxicity, at least initially.
- Management of obesity.
- Resolution of pancreatitis.
- Treatment of concurrent or underlying disease.
- Removal of diabetogenic drugs.

Key differences between canine and feline DM

Dogs	Cats
Type 1 disease	Type 2 disease
Noticeable polyuria/polydipsia (PU/PD) usually present	Owners may not report PU/PD
Usually lifelong insulin requirement	Often transient insulin requirement
More predictable insulin response	Large variation in response to insulin and duration of action
Stress hyperglycaemia not a significant concern	Stress hyperglycaemia makes diagnosis difficult
Postprandial hyperglycaemia occurs	Significant postprandial hyperglycaemia does not occur
Defined meal times recommended	Ad libitum feeding usually recommended
High fibre, high complex carbohydrate diet recommended	High protein, low carbohydrate diet recommended
Usually polyphagic if hypoglycaemic	Cats do not usually become polyphagic when hypoglycaemic

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Risk factors for feline DM

- Diabetes is often thought of as a disease of old cats, but it is more common in the ‘mature’ adult lifestage (7-10 years), although potentially can occur at any age
- Male neutered cats are more frequently affected
- Burmese breed (1 in 53 Burmese cats in the UK are diabetic)
- Indoor/sedentary lifestyle
- Obesity
- Corticosteroid or progestagen treatment

Practical implications of diabetic risk factors

- Routine ‘screening’ of ‘at risk’ cats may allow earlier detection of diabetes.
- Prevention and management of obesity is important for diabetes prevention, particularly in cats with other risk factors.
- Client education may help prevent the development of diabetes in some ‘at risk’ cats by preventing obesity and promoting exercise.
- Owners should be warned about the risk of DM when administering diabetogenic drugs.
- Cats receiving diabetogenic drugs should be monitored for the development of diabetes.
- Extra caution should be taken when using diabetogenic drugs in cats with additional risk factors.

Diagnosing DM

The classical clinical signs of DM include polyuria/polydipsia (PU/PD), polyphagia and weight loss. However, it is common for many of these signs, particularly PU/PD, to go unnoticed by owners, especially in outdoor cats. Sometimes only vague clinical signs are noticed, such as lethargy and poor coat condition. Unless ketoacidosis is present, physical examination is usually largely unremarkable in the uncomplicated diabetic cat. It is important to look for clues for causes of insulin resistance (eg, obesity, skin/oral infections, hyperadrenocorticism, acromegaly) and alternative/concurrent diseases that could explain the clinical signs or complicate the DM (eg, hyperthyroidism, chronic renal disease).

Blood glucose concentrations

Significant (blood glucose >10 mmol/l) persistent hyperglycaemia is the hallmark of DM. However, it is extremely important to be aware of the problem of stress-induced hyperglycaemia in cats as a result of catecholamine production. The cat does not have to appear overtly stressed for this to be an issue; in fact, often the most stressed cats will be ones that do not struggle or vocalise. Blood glucose concentrations can rise above 20 mmol/l, so the degree of hyperglycaemia does not in itself distinguish between stress and DM.

If the cat is hospitalised and allowed time to relax before a further sample is taken, blood glucose levels can return to within normal limits with stress hyperglycaemia. However, it is equally possible for stress hyperglycaemia to result in elevations in blood glucose concentrations that persist for the whole day. It is,

therefore, essential that DM is not definitively diagnosed and insulin treatment initiated on the basis of hyperglycaemia alone.

Urinalysis

The presence of glucosuria can help to distinguish between persistent hyperglycaemia and stress-induced hyperglycaemia. However, it is not unusual for stress to increase blood glucose levels above the renal threshold (12-14 mmol/l), thereby also resulting in glucosuria. The most useful way of using urinalysis to aid in diagnosis, is by asking owners to collect a urine sample at home, in a non-stressed environment. Urine samples can easily be obtained from cats that will use a litter tray by temporarily replacing the normal litter with a non-absorbent litter. Urine bacterial culture should also be performed on all newly diagnosed diabetic cats since urinary tract infections (UTIs) are common sequelae to glucosuria, will not necessarily cause any clinical signs, and will result in insulin resistance if untreated.

Serum fructosamine concentration

Fructosamines are glycated proteins that result from binding of glucose to serum proteins. The concentration of fructosamine is directly related to blood glucose concentration, increasing when blood glucose is persistently increased. The protein has a half-life of 2-3 weeks, and therefore fructosamine concentration gives an indication of the average blood glucose concentration over the preceding 2-3 weeks. Fructosamine can hence help to distinguish between DM and stress-induced hyperglycaemia. However, interpretation is not always straightforward. Fructosamine can be raised if there has been prolonged stress hyperglycaemia (eg, when a cat has been hospitalised) or prolonged hyperglycaemia as a result of Somogyi overshwing. Also, in newly diagnosed diabetics fructosamine may sometimes be normal if hyperglycaemia has only been present for a short period of time. In addition, hypoalbuminaemia and hyperthyroidism can result in falsely low fructosamine concentrations.

Further diagnostics

Any concurrent diseases such as inflammatory, infectious or neoplastic disorders can cause insulin resistance and thereby interfere with treatment. It is therefore essential that any concurrent disorders are recognised and appropriately managed. A thorough physical examination (including assessing for periodontal disease) and further evaluations including haematology, full biochemistry, thyroxine, urinalysis and culture, and survey imaging of every newly diagnosed diabetic cat will allow much better initial management of the diabetes and subsequently minimise complications, treatment disappointments and future financial outlay.

Early diagnosis

Recent survey data suggest there may be up to 15,000 new cases of feline DM in the UK each year. Disease is usually diagnosed when cats are presented with clinical signs consistent with DM. However, given that early diagnosis and treatment will increase the chance of insulin-dependent DM being transient, early detection before clinical signs become evident is obviously preferable. Ways to assist in earlier detection of feline DM are highlighted on page 3.



Stress can be a cause of hyperglycaemia and glucosuria



Optimising early diagnosis

- Perform routine urinalysis annually in all cats from 7 years onwards (though DM can potentially occur at any age)
- Consider more frequent routine urinalysis (every 3-6 months) in Burmese cats and those that are indoor, obese or receiving corticosteroid/progestagen treatment. Particular vigilance is required in cats where two or more risk factors are present
- Encourage home urine sampling using a non-absorbent litter (eg, Katkor/Mikki litter or washed aquarium gravel)
- Add blood glucose measurement to the pre-anaesthetic protocol of any cat over the age of 7 years
- Care needs to be taken in the interpretation of hyperglycaemia/glucosuria in samples collected in the practice because of the possibility of stress-induced hyperglycaemia – following FAB’s ‘Cat Friendly Practice’ principles will help to minimise this and make results easier to interpret (www.fabcats.org/catfriendlypractice)
- Equally, care must be taken not to attribute all blood/urine glucose elevations to stress, as early DM may otherwise be missed
- Always follow up a high blood glucose or glucosuria result with serum fructosamine measurement
- Consider measuring serum fructosamine annually if urine samples cannot be obtained
- Educate owners about observing their cats for early clinical signs of DM
- Regularly weigh (and calculate percentage weight change) and body condition score cats to detect trends in changes in bodyweight or body condition

Treatment fundamentals

- Although most cats have type 2 DM, the majority are, at least initially, insulin dependent.
- Initiating insulin treatment and dietary management as soon after diagnosis as possible will give the best chance of transient DM and resolution of insulin requirements.
- Oral hypoglycaemic agents are not advised as a first-line treatment, unless there is a good reason for not using insulin.
- Manage underlying factors (eg, obesity, corticosteroid treatment).
- Manage client expectations to ensure long term compliance (see box on right). Owners should be informed that it is likely to take 2-3 months to fully stabilise a patient, but that insulin requirements may resolve after 3-4 months if the cat is treated appropriately.

Insulin therapy: key points

- Twice-daily dosing regimes are usually more effective. (NB doses are quoted per injection, not per day.)
- Insulin doses should not be increased by more than 0.5 IU per injection at a time. After any increase in insulin dose, at least 3-5 days (preferably one week) should be allowed before making any further increases in dose. This is because it takes 3-5 days for glucose homeostasis to be re-established after

Cats can be very unpredictable in their response to insulin administration and no one type of insulin or dosing regime will be suitable for all cats

starting insulin therapy or adjusting doses.

- Do not worry if an owner cannot adhere to a strict dosing regime; it is better to achieve 5 days of twice-daily dosing and 2 days of once-daily dosing than for a cat to be euthanased because its owner is worried about always being able to inject twice daily.
- Twice-daily dosing of an intermediate-acting insulin (eg, Caninsulin) is a good first choice.
- Ensure the owner has the correct syringes for the type of insulin being used. A 40 IU/ml syringe is needed for Caninsulin; all other forms require 100 IU/ml syringes.
- In some cats, intermediate-acting insulins do not have a long enough duration of effect.
- In some cats, the longer acting insulin, PZI (protamine zinc insulin), is not absorbed well. Many cats require PZI twice daily.
- Insulin glargine is a newer synthetic insulin analogue that is currently only licensed for use in humans and undergoing assessment in cats. It should only be used off-licence in cats if the veterinary licensed formulations have proven ineffective (eg, PZI is poorly absorbed and intermediate forms have a short duration

Optimising client compliance

- Provide adequate information about diabetes at the initial consultation
- Explain at the outset the expected time for stabilisation, potential complications, possibility of fluctuating insulin requirements, need for home monitoring, etc
- Explain that insulin requirements may be transient if treatment is prompt and aggressive
- Allow clients enough time to discuss any concerns and ensure they understand the disease and what is involved. Many owners are daunted by the prospect of handling insulin and injecting their pet, and need support until they are completely familiar with these procedures. Enlisting nursing staff to provide client support is very helpful
- Some clients can find it easier to use a 40 IU/ml preparation (Caninsulin). This product has earned a FAB ‘easy to give’ award
- Be flexible with instructions regarding timing of feeding and insulin administration, and realistic in what the client can achieve . . . missing insulin dosing a day a week is better than not treating at all

of effect). Glargine forms microprecipitates at the site of injection from which small amounts of insulin are slowly released, producing a fairly constant serum concentration of insulin over 24 hours rather than a peak concentration. There are specific guidelines available for using glargine and it is important that these are followed closely.

Initiating insulin treatment

- Start on ~0.25 IU/kg/per injection (to a maximum of 3 IU/cat), twice daily.
- On day 1, check blood glucose at the estimated nadir (time of peak action of insulin; ie, 4-8 hours after administration) to ensure hypoglycaemia has not occurred. As long as blood glucose is not below 10 mmol/l continue on the same dose.
- Discharge the cat for one week with instructions for the owner on monitoring for hypoglycaemia (see 'client instruction sheet', page 7). No changes to the dose of insulin should be made during this time. This is because it takes at least 3-5 days for glucose homeostasis to adjust after starting or altering insulin doses. During this time the owner can also monitor urine ketones at home and should contact the veterinary practice if ketones become positive.
- To help reduce the risk of reduced absorption of insulin, advise owners not to keep injecting into the same site. The scruff of the neck can be roughly divided into four, and the site changed each day. However, this need not be precise, and it doesn't matter if there are occasions when this is forgotten and the same site as previously is used.
- After a week the cat can be hospitalised for a 12-24 hour, **blood glucose curve** (BGC) comprising 2-4 hourly testing. If there is a significant response to insulin at this stage, then the testing interval around the expected nadir (ie, 4-8 hours after injection) should ideally be reduced to 1-2 hourly to more accurately identify the nadir; before and after the nadir, 4 hourly is acceptable at this stage. If there is not a significant response to insulin, there is little value in testing more frequently than 4 hourly at this stage.
- The aim of a BGC at this time is to ensure there are no periods of hypoglycaemia, and to assess if there is any response to that dose and, if so, roughly when the nadir is occurring. The nadir can be difficult to predict since there is a wide variation in the duration of action of the different insulins between cats, so the nadir always needs to be determined in the individual.
- If there is no reduction in blood glucose, increase the insulin dose by a total of 0.5 IU per injection.
- Once the nadir blood glucose is less than 15 mmol/l, consider performing a more complete BGC.

Performing and interpreting BGCs

- The aim of a BGC is to identify the blood glucose concentration at the nadir, obtain a more precise time for the nadir, evaluate the duration of effect of the insulin and ensure there is no Somogyi overswing effect (see later). Once this information has been amassed, subsequent BGCs may only require 4 hourly sampling, particularly if the cat is clinically stable.
- A BGC is performed by first checking the cat's blood glucose concentration, giving it its usual breakfast and dose of insulin, and then determining its blood glucose level every 1-2 hours over a 12-24 hour period. Twelve hours may be sufficient if blood glucose has increased back to its pre-insulin concentration after 12 hours; if it hasn't, the curve should be continued for 24 hours. If the level of the blood glucose at its nadir (lowest point in the curve) is not adequate then the dose of insulin may need to be increased. If the duration of action is too short, it may be necessary to change to a longer acting insulin (eg, PZI administered twice daily, or glargine) or switch from once to twice daily administration, if sta-

BGCs can provide very useful information but studies have shown that in an individual cat they will vary widely from day to day. It is therefore very important that major changes to treatment are not based on a single curve. All BGCs need to be interpreted in conjunction with the cat's clinical status, fructosamine results and the environment the patient was in when the curve was performed. The most important aspect to consider with BGC results is trends of change, so comparing against previous results is an important part of interpretation. It is useful to think in terms of a week, rather than a 24-hour period, aiming to keep the BGC consistent from week to week (ie, monitoring trends), while accepting that daily fluctuations are a normal occurrence

bilisation using once daily administration had been attempted. After recommending the change, the cat should be discharged on the new regime and the whole process repeated after a further 7 days. Only one change to the insulin regime should be made at a time.

- Ideally the blood glucose concentration should be maintained between 5 and 14 mmol/l.
- Unfortunately, BGCs can be of very limited value in cats that develop stress hyperglycaemia when hospitalised.
- To reduce the risk of this occurring it is best to blood sample from a peripheral ear vein rather than perform jugular or cephalic sampling:
 - A warm swab is held over the peripheral ear vein to help dilate the peripheral vessels;
 - The edge of the ear is smeared with Vaseline to prevent blood running into the hair coat;
 - The ear is held gently but firmly between four fingers, which act in pairs to raise the vein and prevent its movement;
 - The vein can then be pierced using either a fine hypodermic needle or a lancet. Holding the vein still for a few seconds will allow a bleb of blood to form;
 - This can then be transferred to the glucometer test strip or, where appropriate, the glucometer can be applied directly to it.
- It is meaningless to perform a BGC in a cat with stress hyperglycaemia. In such cases, it is often possible to train owners to check their cat's blood glucose level, and even to perform BGCs, at home.

Dietary therapy: key points

- High fibre, moderately fat-restricted diets are usually successful weight loss diets for obese cats.
- High protein and low carbohydrate diets are recommended for diabetic cats of any bodyweight and can also be used as a weight loss diet.
- Feeding a high protein and low carbohydrate diet will result in better glycaemic control and increase the chance of being able to discontinue exogenous insulin.



There is no value in performing a complete BGC until the cat is receiving a dose of insulin that is having a significant effect on blood glucose concentrations since the nadir and duration of effect will be impossible to evaluate

- Dry foods tend to contain much higher proportions of carbohydrate compared with wet foods, so a wet diet is generally preferable.
- Examples of commercially available high protein/low carbohydrate diets include Purina Veterinary Diets DM and Hill's m/d, and to a lesser extent Royal Canin Feline Diabetic. If prescription diets are not an option, look for supermarket diets with the lowest carbohydrate and highest protein proportions.
- Cats do not develop significant postprandial hyperglycaemia and therefore it is not necessary to have a strict regime for insulin administration in relation to feeding.
- Administering insulin during or after feeding is most practical, to ensure that the cat is eating before insulin is given.
- Cats that are fed ad libitum and 'graze' their food throughout the day and/or night should continue this regime providing they are not gaining weight. Cats that eat their food all at once should be given two meals (half the total calorie intake at each meal), at the time of insulin injections if on twice-daily insulin treatment. Maintaining a consistent feeding regime, and monitoring the amount of food eaten daily, are most important.
- Any concurrent disease should be considered in relation to dietary choice; eg, if chronic renal disease is also present, a diet with lower protein content may be selected.

Which diet to choose

High insoluble fibre, moderately fat-restricted diets have been previously shown to improve glycaemic control in diabetic cats. However, these diets are less palatable and may result in inappetence in some cats, in addition to the larger faecal volume and subsequent risk of constipation in some individuals. Cats have a high dietary protein requirement and use amino acids and fat for energy, rather than carbohydrates. High carbohydrate diets increase the risk of obesity in cats, and in diabetic cats predispose to higher postprandial blood glucose concentrations. More recently, therefore, high protein and low carbohydrate diets have been developed for diabetic cats and have proved to have a significant effect on improving glycaemic control and achieving resolution of the insulin-dependent state.

Weight loss programmes for obese cats

Feline obesity has become an increasing problem in recent years, and may be associated with the current trend of feeding ad libitum dry food, together with the fact that more cats are being kept solely indoors. Weight reduction in obese cats will significantly improve glycaemic control, and many cats will even revert to a subclinical diabetic state, no longer requiring exogenous insulin.

Weight loss can be difficult to achieve in cats and it is important to set realistic goals to maintain client compliance. Situations where there is one obese cat in a multicat household are even more difficult to manage, but helpful tips include feeding the other cats on a high surface that an obese cat cannot jump on to, or feeding them in a box with only a small entry hole that an obese cat cannot get into. A 15% weight loss over a period of 15-18 weeks (ie, approximately 1% weight loss per week) is an appropriate initial goal. Weight reduction should be performed by reducing calorie intake

to about 75-80% of maintenance requirements. It is best to feed a diet restricted in calories, rather than simply decrease the volume of food, to ensure adequate intakes of protein and essential nutrients.

It is important that weight loss does not occur too rapidly, as obese cats experiencing rapid weight loss are at high risk of developing hepatic lipidosis. It is therefore essential that cats are weighed every 1-2 weeks. Once the initial goal is attained, a new target can be set until the cat has reached an ideal body weight.

Cats that 'graze' their food throughout the day and/or night should be allowed to continue this; however, cats that eat their food all at once should be given two meals (half the total calorie intake at each meal), at the time of insulin injections if on twice-daily insulin treatment.

In addition to diet, exercise also forms a vital part of any weight loss programme. Most obese cats are extremely inactive and increasing their activity levels by even just 10-15 minutes a day can make a big difference. This can be done variously by playing with the cat, making it walk upstairs or around a room to get its food, feeding in different places around the house, using 'puzzle' feeders to make the cat work a little to get its food, etc.

Monitoring diabetic control**Approaches**

Four main aspects need to be considered in relation to monitoring longer term diabetic control.

- **Owner observations.** Feedback relating to the presence and severity of clinical signs is a vital part of monitoring and owners should be instructed to keep a diary recording:
 - Weight and body condition score;
 - Demeanour;
 - Appetite;
 - Thirst (be realistic here – a subjective assessment by the owner is usually helpful so don't insist that water consumption is measured if it will be impractical to do so);
 - Coat condition;
 - Urination (weighing the litter tray regularly at the same time of day can give a useful subjective indication of changes in urination).

It is also extremely important to educate owners about the signs of hypoglycaemia, so that they recognise any hypoglycaemic episodes as soon as possible, and are aware of the best course of action to take. An example client instruction sheet, containing the basic information that owners need to know, and the clinical signs that they need to monitor, appears on page 7; copies may be downloaded from www.fabvets.org. More detailed information sheets are also useful in educating the client about the disease and how it can be appropriately managed.

- **Serum fructosamine concentrations.** These can be assessed monthly during the initial stabilisation period.
- **Serial blood glucose concentrations.** As discussed earlier, BGCs need to be interpreted carefully.
- **Monitoring for diabetic complications.** These include progression to diabetic ketoacidosis if diabetes is not adequately controlled, periods of hypoglycaemia (particularly if the cat's insulin requirements are variable), and conditions that may increase insulin requirements such as UTIs, or result in variable insulin requirements such as pancreatitis.

Reassessments

In the longer term, once stabilised, diabetic cats should be reassessed at least every 3-6 months. Each check should comprise as a minimum:

- Review with the owner of the cat's diabetic diary, and discussion of any changes noted in clinical signs;
- Full physical examination;
- Assessment of weight and body condition score, and calculation of percentage change in weight since previous visit;
- Serum fructosamine measurement.

In addition, the following tests would be useful, where possible:

- Blood pressure measurement;
- Full urinalysis including urine protein:creatinine ratio and culture;
- Routine haematology;
- Serum biochemistry.

If the cat is free from clinical signs and physical examination is unremarkable, then adequate glycaemic control is likely, and measurement of serum fructosamine will assist in confirming this. If fructosamine is low/normal, it may indicate cessation of insulin requirements in a transient diabetic. If clinical signs of persistent hyperglycaemia or episodes of hypoglycaemia are reported, or if there is evidence of weight loss, or other complications such as a peripheral neuropathy, then further diagnostics should be performed.

Periodic monitoring of urine for glucosuria and ketonuria in the home environment can also be useful for monitoring glycaemic control. It is not particularly helpful for owners to make frequent urine glucose measurements, as this often results in them making their own adjustments to insulin doses. However, periodic measurements are useful in detecting the transient diabetic whose insulin requirements are reducing, as absence of glucosuria would be suggestive of this. It is also useful for owners to check periodically for urine ketones, to try to detect ketoacidosis in the early stages before the cat becomes too unwell.

Remember! Many diabetic cats will only be transiently diabetic so care needs to be taken to ensure detection of:

- Low blood glucose (< 10 mmol/l) prior to insulin administration
- Low/normal fructosamine concentration
- Persistent absence of glucosuria

All the above may indicate resolution of exogenous insulin requirements

Problems with stabilisation

It is not uncommon for problems to be seen in the early stages of care of the diabetic at home. These are often related to the storage and administration of insulin so are usually quite easy to identify and remedy.

Common problems include:

- Treatment routine not adhered to (ie, insulin given at a different time each day);

Common causes of poor stabilisation

- Problems with storage and/or administration of insulin (see text)
- Inappropriate insulin dose/preparation, failure of insulin absorption or inadequate duration of action
- Infections – most commonly mouth, skin and urinary tract infections. The effect on insulin requirements is often vastly underestimated. Every effort should be taken to ensure a healthy oral cavity through routine dental care. UTIs are very common in diabetic cats; they will not always be accompanied by signs of cystitis and an inflammatory sediment is not always evident, so urine culture should be routinely performed. Treatment of a UTI should involve appropriate antibiotics based on culture and sensitivity testing, and be continued for at least 2 weeks
- Recent weight gain, resulting in increased insulin resistance
- Pancreatitis – over 50% of diabetic cats are likely to have pancreatitis. Cause and effect is difficult to establish but the presence of pancreatitis often results in very variable insulin requirements. Chronic pancreatitis can be difficult to diagnose and cats may show few clinical signs associated with it. Measurement of feline pancreatic lipase immunoreactivity (fPLI) is the most sensitive test available for diagnosing pancreatitis, but even this is not 100% sensitive so a normal fPLI does not exclude pancreatitis. In practice, achieving a diagnosis of pancreatitis is unlikely to alter the way a cat's DM is treated, and treatment for the pancreatitis itself is merely symptomatic; however, it helps to explain why a cat may have extremely variable insulin requirements. These patients can be very difficult to control
- Diabetogenic drugs (corticosteroids, progestagens)
- Renal/hepatic disease
- Additional endocrine disease (eg, hyperthyroidism, acromegaly, hyperadrenocorticism)

- Variable quantity or type of food being fed;
- Incorrect insulin storage;
- Incorrect insulin mixing/injection technique.

The first thing that should be done when there are any problems with stabilisation is to ask the owner to demonstrate how they mix and inject insulin, to check that this is being carried out correctly.

If these problems are eliminated as a cause of the poor stabilisation, then further investigations may be needed to identify the problem. In some cases it will be necessary to re-admit the cat for more detailed assessment, which may include a 24-hour glucose curve.

Commonly encountered problems

Hypoglycaemia

Hypoglycaemia can arise as a complication of insulin treatment in a number of ways. For example, the insulin dose may have been increased too rapidly (particularly if stress hyperglycaemia is mistaken for poor glycaemic control), previous insulin resistance may have resolved, or a cat may have reverted to a non-insulin-dependent state.

It is important to be aware that hypoglycaemia can be difficult to recognise early in cats, because, in contrast to dogs, cats do not always exhibit polyphagia when they become hypoglycaemic. Often the earliest sign that owners note is that the cat goes and hides more than usual.

diabetic cats

CLIENT INSTRUCTION SHEET

cat:

Name Date diabetes diagnosed

Weight at time of diagnosis Estimated ideal weight

diet:

Food

Amount to be fed Frequency/timing of feeding

insulin:

Insulin type Dose

storage instructions The insulin bottle should be kept in the door of the fridge at all times. It is important that it is not frozen or left out at any time, as this will damage the insulin.

administering the insulin When the insulin bottle is taken out of the fridge it should be *gently* turned up and down to mix the contents (do not shake the bottle vigorously as this will damage the insulin). The correct amount of insulin should be drawn up in the appropriate syringe provided by your vet, and injected under the skin on the scruff of your cat's neck, as demonstrated by your vet. More than one type of insulin syringe is available, and it is very important to use the correct type. The wrong syringe might mean your cat receives an incorrect amount of insulin, which can be dangerous.

additional medication:

monitoring your cat for signs of inadequate control of diabetes:

Please keep a diary for your cat, recording the following observations:

- **Bodyweight** Take recordings at least every 2 weeks if your cat is on a weight loss programme. A subjective assessment of body condition should also be made regularly
- **Demeanour** eg, Bright and active, or lethargic and weak
- **Appetite** Amount eaten daily; eg, normal amount, less than normal (approximately how much less?) or cat more hungry than normal?
- **Thirst** Amount drunk daily; volume (either measured or approximate) or normal/increased/decreased?
- **Coat** General condition
- **Urination** Frequency/volume of urination; if cat uses a litter tray, normal/increased/decreased frequency and/or volume of urination (eg, more or larger 'clumps' of litter). Weighing tray daily (at the same time) can also give a measure of any change in volume of urine being produced
- **Urine ketones** Measured periodically using a dipstick, as directed by your vet

monitoring your cat for signs of insulin overdosage (hypoglycaemia):

Signs of hypoglycaemia (low blood sugar) can occur at any time but are most likely at the time of maximal insulin action, which is usually around 4-8 hours after giving insulin, depending on the type of insulin your cat is receiving. The lower the blood sugar levels go, and the more rapidly they drop, the more severe the signs will be. In order of increasing severity these include:

- Wanting to hide, lethargy, weakness
- Hunger
- Disorientation and/or apparent blindness
- Shaking, wobbliness
- Collapse
- Seizures

Hypoglycaemia can be life threatening if left untreated so it is very important that early signs are recognised and treated

what to do if you notice any of these signs:

If signs are mild and your cat will eat, offering food may be enough to relieve the signs. If signs are more severe, or if your cat will not eat, glucose syrup, honey, jam or sugar water can be rubbed on the gums. Your veterinary surgeon should then be contacted for further advice. **If signs have progressed to collapse or seizures, an emergency vet should be contacted immediately.**

If hypoglycaemia develops, insulin treatment should be discontinued until hyperglycaemia recurs and then reinstigated at half the previous dose. If blood glucose levels are still low or normal when the cat is receiving 1 IU or less of insulin, then resolution of the insulin-dependent state should be suspected.

Somogyi overswing

The so-called Somogyi overswing is a normal physiological response to hypoglycaemia induced by excessive insulin administration. It commonly occurs when insulin doses are increased too quickly with inadequate monitoring, or in cats that have very fluctuating insulin requirements. When blood glucose concentrations fall below 3.5 mmol/l, or when they decrease very rapidly, counter-regulatory hormones such as glucagon and adrenaline are secreted, resulting in a rebound hyperglycaemia and insulin resistance within a few hours. This hyperglycaemia persists for at least 24 hours in most cases, and can last for up to 72 hours, or occasionally even longer. Clinical signs of hypoglycaemia are rarely seen, and therefore the cat will present as not responding to insulin.

The speed of reduction in blood glucose is often the trigger for Somogyi overswing, so overt hypoglycaemia may not be present. The overswing can occur very rapidly following injection and requires half-hourly to hourly blood glucose measurements following insulin administration to be detected. Insulin should be withdrawn for 3 days prior to this to ensure that any rebound hyperglycaemia has resolved.

If the Somogyi phenomenon is not recognised, and insulin doses are further increased, the result is an even more severe rebound hyperglycaemia. Diagnosis is made by demonstrating hypoglycaemia or a rapid fall in blood glucose (eg, > ~10 mmol/l in one hour), but can be missed if blood samples are taken less frequently than every hour following insulin administration. Furthermore, the reduction in blood glucose will not always be evident if the subsequent rebound hyperglycaemia and insulin resistance last for more than 24 hours. In addition, serum fructosamine may be elevated if rebound hyperglycaemia is prolonged.

If there is a possibility of overswing occurring, it is advisable to reduce the insulin dose to 0.25–0.5 IU/kg for a few days and assess the cat's response. In the short term, hyperglycaemia is a 'safer' state than insulin-induced hypoglycaemia. If no improvement in clinical signs is observed, and no reduction in blood glucose demonstrated, then another cause of insulin resistance should be considered.

Fluctuating insulin requirements

Some cats have very fluctuating insulin requirements, potentially exhibiting signs anywhere on the spectrum from uncontrolled diabetes through to hypoglycaemia. The most usual reason for this is the development of a concurrent disease that causes a mild insulin resistance, which later resolves spontaneously or waxes and wanes. Inflammatory diseases such as chronic pancreatitis are commonly associated with these fluctuating requirements. These cases can be extremely difficult to manage, and this is one situation where home blood glucose monitoring can be very useful.

Insulin resistance

The majority of diabetic cats can be controlled with 1 IU/kg of insulin (per dose, not per day). Insulin resist-

ance is generally defined as insulin requirements exceeding 2 IU/kg.

Many disorders can interfere with the action of insulin. In cats the most common causes of insulin resistance include obesity, chronic pancreatitis and chronic infections (eg, oral infections, UTIs and gingivostomatitis). Other concurrent disorders such as chronic renal disease and hyperthyroidism can also have a significant impact. Less common but very important causes of severe insulin resistance in cats are acromegaly and hyperadrenocorticism; uncontrolled DM is the most common presentation of both of these unusual endocrinopathies. Medications such as corticosteroids and progestagens (eg, megestrol acetate) are also important causes of insulin resistance.

Prognosis

The long-term outlook for cats with DM depends on how easy it is to stabilise their diabetes, whether they have any other diseases and how severe these are. Cat and owner compliance also plays an important role in determining the prognosis in the individual patient. Many diabetic cats have an excellent quality of life and are extremely rewarding cases to treat.

The most common causes of death in diabetic cats appear to be related to pancreatitis, UTIs, renal disease and cardiac disease.

Acknowledgements

The diabetes prevalence data quoted on page 1 was provided by Pet Protect.

Further reading

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Further information in the 'Feline diabetes mellitus' series:

● Vet nurse pointers: 'Supporting the diabetic cat and its owner'

● Cat owner pointers: 'Diabetes: what does it mean for my cat and me?'

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