2026 AAHA Diabetes Management Guidelines for Cats

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ABSTRACT

A substantial number of cats develop diabetes mellitus (DM), a serious endocrine disorder that can lead to other physiologic complications. While DM management can be complex, successful control that alleviates the patient's clinical signs and avoids hypoglycemia is achievable in most cats. Diabetic remission is also possible. The *2026 AAHA Diabetes Management Guidelines for Cats* retain clinically relevant information from the *2018 AAHA Diabetes Management Guidelines* and present new findings and expert opinions. Subjects such as pathophysiology, diagnosis, how to treat and monitor cats receiving SGLT2 inhibitors, various insulin options for cats, how to monitor cats receiving insulin, diet and physical activity recommendations, advantages and disadvantages of at-home glucose monitoring devices, diagnosing and treating diabetic ketoacidosis, and client education are all discussed. The guidelines also cover how to identify patients who are at risk of developing DM and how to differentiate DM from transient or mild hyperglycemia. (*J Am Anim Hosp Assoc* 2026; 62:65–93. DOI 10.5326/JAAHA-MS-7572)

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These guidelines were prepared by a task force of experts convened by the American Animal Hospital Association. This document is intended as a guideline, not an AAHA Standard of Care. These guidelines and recommendations should not be construed as dictating an exclusive protocol, course of treatment, or procedure. Variations in practice may be warranted based on individual patient needs, resources, and limitations unique to each practice setting. Evidence-guided support for specific recommendations has been cited whenever possible and appropriate. Other recommendations are based on practical clinical experience and a consensus of expert opinion. More research is needed to further substantiate some recommendations. As each case is different, veterinary teams must base their decisions on the best available scientific evidence in conjunction with their knowledge and experience. All task force members contributed to the development of the guidelines. Although task force members attempted to reach an expert consensus, individual members of the task force are not responsible for the final guidelines or specific aspects of the guidelines.

CONFLICT OF INTEREST STATEMENT

Andrew Bugbee has received speaking, consultation, and honorarium fees from Boehringer Ingelheim, Dechra, Elanco, Purina, Royal Canin and Zomedica, and research support from ScoutBio/CEVA. Renee Rucinsky has received speaking, consultation, and honorarium fees from Boehringer Ingelheim and Elanco. Audrey Cook has received speaking and consultation fees from Boehringer Ingelheim and Elanco, research support from Dechra, and is an Advisory Board member for VetRec. Patty Lathan has received honoraria and consultation fees from Boehringer Ingelheim, Dechra, IDEXX, Hill's Pet Nutrition, and ScoutBio, and research support from Dechra and IDEXX.

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Abbreviations

ALP, alkaline phosphatase; BG, blood glucose; BGC, blood glucose curve; BHB, beta-hydroxybutyrate; BP, blood pressure; CBC, complete blood count; CGM, continuous glucose monitor; DKA, diabetic ketoacidosis; DM, diabetes mellitus; EDKA, euglycemic diabetic ketoacidosis; GLP-1, glucagon-like peptide 1; HAC, hyperadrenocorticism; HbA1C, hemoglobin A1C; HC, hypercortisolism; IM, intramuscular; IGF-1, insulin-like growth factor 1; IR, insulin resistance; ME, metabolizable energy; NPH, neutral protamine Hagedorn; PD, polydipsia; PBGM, portable blood glucose monitor; PP, polyphagia; PU, polyuria; PZI, protamine zinc recombinant human insulin; SGLT2, sodium-glucose cotransporter 2; SQ, subcutaneous; TT4, total thyroxine; U, units; UG, urine glucose

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Introduction

Diabetes mellitus (DM) can be successfully managed in cats but requires an up-to-date understanding of feline diabetes pathophysiology and a thorough grasp of how to incorporate new treatments into therapeutic approaches. Staying informed about emerging treatment options is crucial. Diabetic feline patients need diligent clinical, observational, and diagnostic assessments and individualized treatment and monitoring plans. Rewarding diabetes management is intertwined with committed client education and communication.

These guidelines retain clinically relevant information from the *2018 AAHA Diabetes Management Guidelines*[1] and present new findings and expert opinion on diagnosing, treating, and monitoring diabetes mellitus in cats, recognizing at-risk patients, and identifying patients with hyperglycemia who do not require diabetic treatment. The refreshed reorganization of these guidelines separates the feline and canine content into two distinct publications to provide veterinarians with an easier reference to managing the disease in each species.

These guidelines cover SGLT2 (sodium-glucose cotransporter 2) inhibitor drugs, a newly approved drug class for use with newly diagnosed diabetic cats, as well as traditional and new insulin formulations for cats and when and how to use each. Easy-to-use at-home monitoring tools such as continuous glucose monitors (CGMs) and glucometers and methods to help detect abnormalities in urine are highlighted. The guidelines also feature new or updated algorithms, tables, and boxes for quick reference on a variety of topics including managing hypoglycemia, addressing diabetic ketoacidosis, and troubleshooting suboptimal responses to therapy. Dietary management is also discussed, and key points in client education on treatment and monitoring, including the financial and time commitments and lifestyle changes, are emphasized.

Diabetes Mellitus Pathophysiology and Management in Cats

Section 1: Overview of Diabetes Mellitus in Cats

Top 3 Takeaways

1. Insulin resistance (IR) and glucose toxicity play key roles in feline DM pathogenesis.
2. Effective management involves lowering blood glucose (BG) concentrations and mitigating factors contributing to IR.
3. Select insulins and SGLT2 inhibitors are licensed for the management of feline DM.

Feline DM pathogenesis is multifactorial, with numerous processes affecting pancreatic beta cell function and viability. However, most feline diabetes develops when insulin resistance places prolonged stress on pancreatic beta cells that may already be genetically vulnerable. (see Box: Causes of Insulin Resistance).[2] Diet formulation and exocrine pancreatic disease may also contribute to the development of DM.[2] Because, in part, of the impact of IR, feline DM shares strong similarities with human type 2 DM, although not all cats fit this pattern and many require exogenous insulin.

The initial consequence of IR is increased insulin secretion. At first this maintains euglycemia but simultaneously drives the accumulation of poorly soluble amylin within pancreatic islets. Progressive amyloidosis impairs beta cell function, which compromises insulin secretion and increases BG. Many diabetic cats appear to spend months in a subclinical/preclinical period, in which BG is significantly elevated but remains below the threshold for glucosuria (~250–300 mg/dL).[3]

Although the systemic effects of moderate hyperglycemia in cats have not been established, glucose toxicity—a complex process that causes widespread compromise to cellular function—occurs in people with BG >200 mg/dL.[4] Feline beta cells appear to be particularly vulnerable to glucose toxicity and either decrease insulin production or undergo apoptosis.[5,6] When insulin secretion is no longer sufficient to keep BG below the renal threshold, clinical signs of DM (polyuria [PU], polydipsia [PD], polyphagia [PP], and weight loss) become apparent. The other classic manifestation of glucose toxicity in cats is peripheral neuropathy.[7] This primarily impacts the rear limbs and causes a plantigrade stance that limits cats' ability to run and jump.

Treating feline DM relies on controlling hyperglycemia by giving insulin or an SGLT2 inhibitor, and by mitigating factors causing IR. In some cats, beta cell function may recover, and medical therapy can be withdrawn; this process is referred to as diabetic remission.[2]

Causes of Insulin Resistance in Cats[a,b]

- Obesity
- Sarcopenia (suspected)
- Sedentary lifestyle
- Inflammatory/infectious conditions
  - Stomatitis/gingivitis
  - Degenerative joint disease
  - Chronic enteropathy
  - Chronic pancreatitis
  - Urinary tract infection
- Medications
  - Glucocorticoids
  - Progestogens
- Endocrinopathy
  - Hyperthyroidism
  - Hypothyroidism (infrequent in cats)
  - Hypersomatotropism (acromegaly)
  - Hypercortisolism

a. Gostelow R, Hazuchova K. Pathophysiology of prediabetes, diabetes, and diabetic remission in cats. *Vet Clin North Am Small Anim Pract* 2023;53(3):511–29.

b. Freeman LM. Cachexia and sarcopenia: emerging syndromes of importance in dogs and cats. *J Vet Intern Med* 2012;26(1):3–17.

Section 2: Recognizing DM in Cats

Top 3 Takeaways

1. Obtain a complete history that includes diet and concurrent medication information and perform a thorough physical examination to detect risk factors for, and clinical signs of, DM.
2. Assess and monitor body and muscle condition scores in all patients.
3. Evaluate results of CBC, blood chemistry, urinalysis, total thyroxine (TT4), and blood pressure measurements in cats with clinical signs that suggest DM.

While diabetes can occur in cats of any age, most present at age 4 or older. One study showed that 82% of diabetic cats were >7 yr old and 50% of diabetic cats were between 10 and 15 yr of age.[8] Male cats constitute a greater proportion of the diabetic population than female cats, and it is unclear if neutering plays a role in diabetes development.[9] Most affected cats are mixed breed (i.e., domestic shorthair or domestic longhair); however, Burmese cats have been shown to have an increased risk of diabetes.[9,10]

Feline diabetes risk factors include:[9,11]

- Obesity (factors that contribute to obesity include neutering, high-carbohydrate diets, and lack of environmental enrichment)
- Sedentary lifestyle
- Middle age and older life stages
- Male

Diabetic cats are often obese, and clients may report that their cats exhibit signs of PU, PD, PP, weight loss, and lethargy. Hindlimb weakness (plantigrade stance) and an unkempt hair coat may be noted on physical examination.[9] However, the physical examination can be relatively normal, and gradual progression of PU, PD, or weight loss may be initially subtle and go unnoticed by the pet caregiver during early stages of disease onset. To catch these early signs, it is important to assess cats' body condition and muscle condition scores at every visit and ensure that team members consistently use the same condition scales (i.e., 5-point versus 9-point scales). See the *AAHA Nutrition and Weight Management Guidelines* at aaha.org for detailed information on body and muscle condition scoring systems. The presence of diabetic ketoacidosis (DKA) along with concurrent disease processes can also affect the examination findings (see Section 12, Diabetic Ketoacidosis).[9]

In cats with clinical signs of DM, BG exceeds the renal reabsorption threshold for glucose (~250–300 mg/dL) and cats will be hyperglycemic and glucosuric. However, these findings are not specific for DM. Evaluate the results of a CBC, blood chemistry, urinalysis, TT4, and blood pressure measurements in cats with clinical signs that suggest DM. Elevated BG in the absence of clinical signs may reflect transient hyperglycemia due to stress.[12] If stress hyperglycemia can be ruled out in an asymptomatic hyperglycemic cat, consider monitoring the patient as one at risk for developing DM (Section 5, Recognizing and Managing Cats at Risk of DM). Mild to moderate persistent hyperglycemia (BG <300 mg/dL) without glucosuria suggests subclinical diabetes,[13,26] so it would be prudent to identify and address possible causes of IR (see Box, Section 1, Causes of Insulin Resistance in Cats). Definitively diagnosing feline DM requires evidence of sustained hyperglycemia (see Section 3, Diagnosing DM in Cats).

The task force referenced Project ALIVE for standardized DM terminology and to define criteria used for DM diagnosis. For more information on Project ALIVE, see https://www.esve.org/alive/search.aspx.

Section 3: Diagnosing DM in Cats

Top 3 Takeaways

1. A feline DM diagnosis requires evidence of sustained hyperglycemia, which includes one or more of the following: increased fructosamine or hemoglobin A1C concentration, or hyperglycemia or glucosuria documented on more than one occasion while in a non-stressed or home environment.
2. Fructosamine concentrations may be lower in cats with hyperthyroidism, protein-losing enteropathy, or nephropathy, independent of BG.
3. Continuous glucose monitors (CGMs) and glucosuria detection products help assess cats' BG status at home.

Recommended Laboratory Tests for Cats with Clinical DM Signs:

- Complete blood count (CBC)
- Chemistry panel with cholesterol, triglycerides, and electrolytes
- Urinalysis with sediment examination
- Serum total thyroxine (TT4) concentration

Confirming a diagnosis of DM in cats exhibiting clinical signs requires proof of sustained hyperglycemia using one or more of the following methods:

- Evidence of increased glycated protein concentrations, such as increased fructosamine.[14] Protein glycation is the nonenzymatic, insulin-independent, irreversible binding of glucose to the parent molecule, and glycation rates are therefore influenced by BG concentrations. Fructosamines are a group of glycated plasma proteins, including albumin, with a relatively short half-life. Fructosamine measurement therefore reflects average BG over the previous 7–10 days.[15] This value tends to be higher in male cats than females[16] and may be lowered by conditions that shorten the half-life of albumin, such as hyperthyroidism and protein-losing diseases.[17,18]
- Glycated hemoglobin (HbA1C; expressed as a percent) is widely used for diabetes diagnosis and monitoring in people, and it reliably reflects average BG in cats over the previous 2–3 mo.[19] Although a commercial test is available to veterinarians, the task force is not aware of any feline HBA1C assays that have been validated in diabetic cats.[20] More studies are needed to assess their clinical use in cats.
- Alternatively, a CGM placed on the patient, a portable blood glucose monitor (PBGM), or glucosuria detection products can assess whether persistent hyperglycemia or glucosuria occurs when cats are at home. CGMs record the interstitial glucose concentration continuously over multiple days. See Section 13, Glucose Monitoring, for more information.
- Concurrent ketosis—diagnosed by a finding of ketonuria or blood beta-hydroxybutyrate (BHB) concentration >1.0 mmol/L (see Box) in a patient meeting DM diagnostic criteria—suggests a more complicated or advanced stage of disease (see Section 12, Diabetic Ketoacidosis).
- If clients are unable to pursue fructosamine testing and/or use a CGM or PBGM, they can try to collect urine samples at home to check for glucosuria. It is ideal for clients to wait at least 2-3 days after an in-hospital examination or stressful event to begin collecting urine and aim to obtain at least 2 urine samples voided on different days to document persistence.[14] If that is not possible, clinicians can consider instituting therapy if clinical suspicion for DM is high, or recheck the cat's weight and laboratory evaluation within 1-2 weeks.

Blood Beta-Hydroxybutyrate

BHB is the earliest and most predominant ketone body produced during diabetic ketoacidosis in cats. Point-of-care whole blood ketone analyzers (ketone meters) are available to measure BHB, and a commercial model has been validated in cats.[a]

a. Weingart C, Lotz F, Kohn B. Validation of a portable handheld whole-blood ketone meter for use in cats. *Vet Clin Pathol* 2012;41(1):114–8.

Section 4: Evaluating Newly Diagnosed Diabetic Cats

Top 3 Takeaways

1. If not yet completed as part of the patient's initial evaluation, perform a comprehensive laboratory evaluation in all newly diagnosed diabetics, including complete blood count; chemistry panel with cholesterol, triglycerides, and electrolytes; urinalysis with sediment examination; TT4; blood BHB; and consider retroviral testing.
2. Identify concurrent problems associated with diabetes or conditions that may interfere with the patient's response to treatment. If cats present in an emaciated state, rule out comorbidities.
3. Diabetic cats who exhibit substantial clinical compromise such as hyporexia, vomiting, and dehydration may have DKA.

The task force recommends a full laboratory evaluation for every diabetic cat before selecting treatment (see Section 3, Box, Recommended Laboratory Tests). This includes a CBC; a chemistry panel with cholesterol, triglycerides, and electrolytes; a urinalysis (UA) with sediment examination; and a total T4 measurement if not done prior to diagnosis. Blood BHB should be measured in all newly diagnosed diabetic cats, as the results may affect treatment choices.[21] While not specific to DM, retroviral testing may be considered part of the minimum database for any sick feline patient evaluation.

Identify whether diabetic cats have complications associated with the disease (e.g., peripheral neuropathy) or concurrent problems often associated with the disease (e.g., pancreatitis). If the cat has signs of cystitis (i.e., dysuria, pollakiuria) and an active urine sediment, perform a quantitative urine culture and sensitivity, and then use the results to guide therapy.[22]

Also identify conditions that may interfere with the patient's response to treatment (insulin-resistance-causing diseases such as obesity, pancreatitis, hyperthyroidism, renal disease, hypercortisolism, hypersomatotropism, and other risk factors such as the use of diabetogenic medications) so these can be addressed appropriately. As insulin is needed for insulin-like growth factor-1 (IGF-1) production in the body, IGF-1 concentrations may be unremarkable at DM diagnosis. However, if after 4-6 weeks of insulin treatment there is concern for IR or signs of hypersomatotropism, evaluating IGF-1 would be appropriate.[23]

Most newly diagnosed diabetic cats present with weight loss, but the magnitude of condition loss can vary. When a newly diagnosed diabetic cat presents with substantial weight loss (>15%), emaciated, or with cachexia or sarcopenia, evaluate for comorbidities such as pancreatitis, neoplasia, exocrine pancreatic insufficiency, hyperthyroidism, or chronic enteropathy. Depending on the cat's specific history and clinical signs, consider performing additional diagnostics such as measuring feline pancreas-specific lipase immunoreactivity, serum folate and cobalamin, and serum trypsin-like immunoreactivity, along with abdominal and thoracic imaging. Diagnose and treat concurrent illnesses accordingly.[9]

Diabetic cats who exhibit substantial clinical compromise such as hyporexia, vomiting, and dehydration may have DKA. Documenting a high anion gap metabolic acidosis (e.g., low bicarbonate, low pH, +/- normal to low chloride at presentation) along with ketonuria or blood BHB >2.4 mmol/L confirms DKA (see Section 12, Diabetic Ketoacidosis in Cats).

Section 5: Recognizing and Managing Cats at Risk for DM

Top 3 Takeaways

1. Use dietary and lifestyle interventions to optimize weight in obese cats who have mild hyperglycemia and monitor their BG and urinalyses at intervals tailored for each patient.
2. Investigate whether concurrent medications or conditions may be contributing to insulin resistance and manage them accordingly.
3. There is currently no evidence to support the use of an SGLT2-inhibitor drug, insulin, or any anti-diabetic drug in at-risk or subclinical cats.

This section concerns management of cats that are found to have intermittent or sustained mild to moderate hyperglycemia unrelated to stress, and who do not display clinical signs of DM. These cats should be considered "at-risk" for developing clinical DM or to have subclinical diabetes. Although some portion of at-risk cats may eventually develop clinical DM, they do not require diabetic therapy until a clinical DM diagnosis is confirmed. Transient stress hyperglycemia is a well-recognized phenomenon that occurs in normal cats but is also observed in at-risk cats. Hyperglycemia due to stress can be severe but is generally <250 mg/dl and by definition is a transient elevation. Glucosuria may occur with severe stress hyperglycemia; ketonuria is not expected. Stress hyperglycemia is confirmed in patients by demonstrating resolution of hyperglycemia after the cat is removed from the stressful situation. The recommended follow-up for stress hyperglycemia is to reassess BG and check urine for glucosuria and ketonuria several days after the stressful event (ideally blood and urine samples are obtained at home). In select cases, it may be necessary to place a CGM or measure a serum fructosamine concentration.

Obtain a thorough history for at-risk patients and evaluate for concurrent diseases or medications that may result in insulin resistance. Take steps to prevent at-risk patients from becoming overtly diabetic. Avoid administering medications such as corticosteroids or progestins.[24] Treat any concurrent diseases (e.g., obesity, chronic inflammatory conditions). Lifestyle and dietary modifications are logical first steps, with the goals of optimizing body weight, minimizing postprandial hyperglycemia, and controlling calorie, protein, carbohydrate, and fat intake. Replace food treats with playtime to encourage movement and potentially contribute to weight loss. Environmental enrichment may facilitate weight loss and reduce obesity,[25] therefore reducing cats' risk of developing diabetes.[26,27]

Monitor at-risk patients regularly. Pet caregivers should weigh at home monthly and be advised to note any changes in water consumption or urine output. Tailor BG and urinalysis monitoring frequency to individual patient indications. CGMs may be helpful to determine which cats need further diagnostic evaluation. In overweight patients, such monitoring reveals whether hyperglycemia corrects with weight reduction. Monitoring is also essential to identify patients whose hyperglycemia does not resolve with previously mentioned interventions, or who develop overt DM.

At present, it is difficult to accurately predict whether or not an at-risk patient will progress to develop overt DM. Progression may be more likely when the patient has a risk factor that cannot be addressed or reversed with treatment. There is currently no known strategy to prevent DM. At this time, there is no evidence to support the use of SGLT2 inhibitor drugs, insulin, or any other anti-diabetic medication for at-risk or subclinical patients.

Section 6: SGLT2 Inhibitor Treatment and Monitoring

Top 3 Takeaways

1. SGLT2 inhibitors are only approved for newly diagnosed diabetic cats.
2. Not all cats are suitable candidates for an SGLT2 inhibitor; thoroughly evaluate patients for comorbidities and start insulin in those with conditions that contraindicate SGLT2 inhibitor use.
3. Monitor cats on SGLT2 inhibitors carefully for ketosis. Monitoring blood BHB is essential.

In the United States, two SGLT2 inhibitors are now licensed for use in newly diagnosed, otherwise healthy feline diabetics not previously treated with insulin and are an appropriate treatment option for a substantial proportion of patients.[28,29,30] Bexagliflozin tablets and velagliflozin oral solution are administered once daily, either directly into the mouth or given with a small amount of food. Oral administration spares clients the challenges associated with injecting insulin and allows for more flexible care plans. Traditional oral hypoglycemic agents such as glipizide (a sulfonylurea) and metformin (a biguanide) are routinely prescribed for people with type 2 DM but are not consistently safe or effective in diabetic cats and therefore are not recommended.[31,32]

The SGLT2 inhibitors lower BG by blocking most reabsorption of glucose in the renal proximal convoluted tubules.[33] This mitigates the clinical signs of DM (i.e., PU, PD, PP) while reversing glucose toxicity and allowing for beta cell recovery. SGLT2 inhibitors act independently of insulin, and there is minimal risk of clinical hypoglycemia due to increased SGLT1-mediated glucose reabsorption.[28,29,30] However, as endogenous insulin is needed to prevent ketosis, these drugs are an unsuitable choice for some cats (see below). Unfortunately, beta cell function cannot be reliably assessed in cats. An assay for quantifying C-peptide concentrations in cats is not currently commercially available.

Patient Selection

Consider an SGLT2 inhibitor for any newly diagnosed diabetic cat that is eating and well hydrated. SGLT2 inhibitors are contraindicated for cats with signs of systemic compromise such as vomiting, hyporexia, cachexia, or lethargy. Perform a thorough physical examination and diagnostic evaluation (CBC, chemistry panel, and urinalysis) for signs of comorbid conditions such as hepatopathy, significant chronic kidney disease (i.e., IRIS Stage 3), or hypercalcemia.[21] Screen any cat older than 7 yr for hyperthyroidism (see the *AAFP Guidelines for the Management of Feline Hyperthyroidism* at catvets.com). As a general rule, insulin therapy is the appropriate treatment for diabetic patients who are not metabolically stable.

Screen for ketosis in every candidate for an SGLT2 inhibitor. BHB measurement is preferred over other methods for assessing ketosis. Inexpensive, handheld ketone meters provide quick and reliable quantification of blood BHB, and the task force considers BHB measurement an essential part of SGLT2 inhibitor drug monitoring. The only currently validated ketone meter for use in cats is the Precision Xtra (Abbott), although non-validated meters have been used anecdotally by some task force members.[34] Alternatively, the acetoacetate concentration may be semi quantitatively assessed in plasma or urine using a standard ketone dipstick.[35]

The package insert states that bexagliflozin should not be initiated if the cat's blood BHB is >3.6 mmol/L, or if BHB is >2.4 mmol/L and the cat has a history of acidosis or renal compromise.[36] Also, the bexagliflozin and velagliflozin package inserts warn not to start these drugs if ketonuria is detected, and detecting ketonuria during treatment should prompt discontinuation of the drug and transition to insulin.[36,37]

Since the original therapeutic recommendations were first released by the manufacturers of bexagliflozin and velagliflozin, the task force members have gained significant experience with this drug class in a variety of clinical situations. Clinicians should be aware of the published BHB recommendations and use them as guidelines. Clients should also be informed of and consent to any deviations from the FDA-approved guidelines, and this should be documented in the medical record. Some cats will mildly increase (<20%) their BHB level from baseline during the first 1-3 days following treatment initiation, with appetite and attitude remaining normal. In these situations, close daily monitoring may allow for continued drug administration if the BHB starts to decline by days 4-7 following therapy initiation, suggesting endogenous insulin production is becoming more effective with the sustained resolution of hyperglycemia. Many cats with a BHB higher than the published guidelines (>3.6 mmol/L) are not clinically ill. In these cases, some task force members may still start an SGLT2 inhibitor with caution and closely monitor the cat. (Figure 6.1). Monitoring includes daily BHB measurement and clinical assessment of patient status.

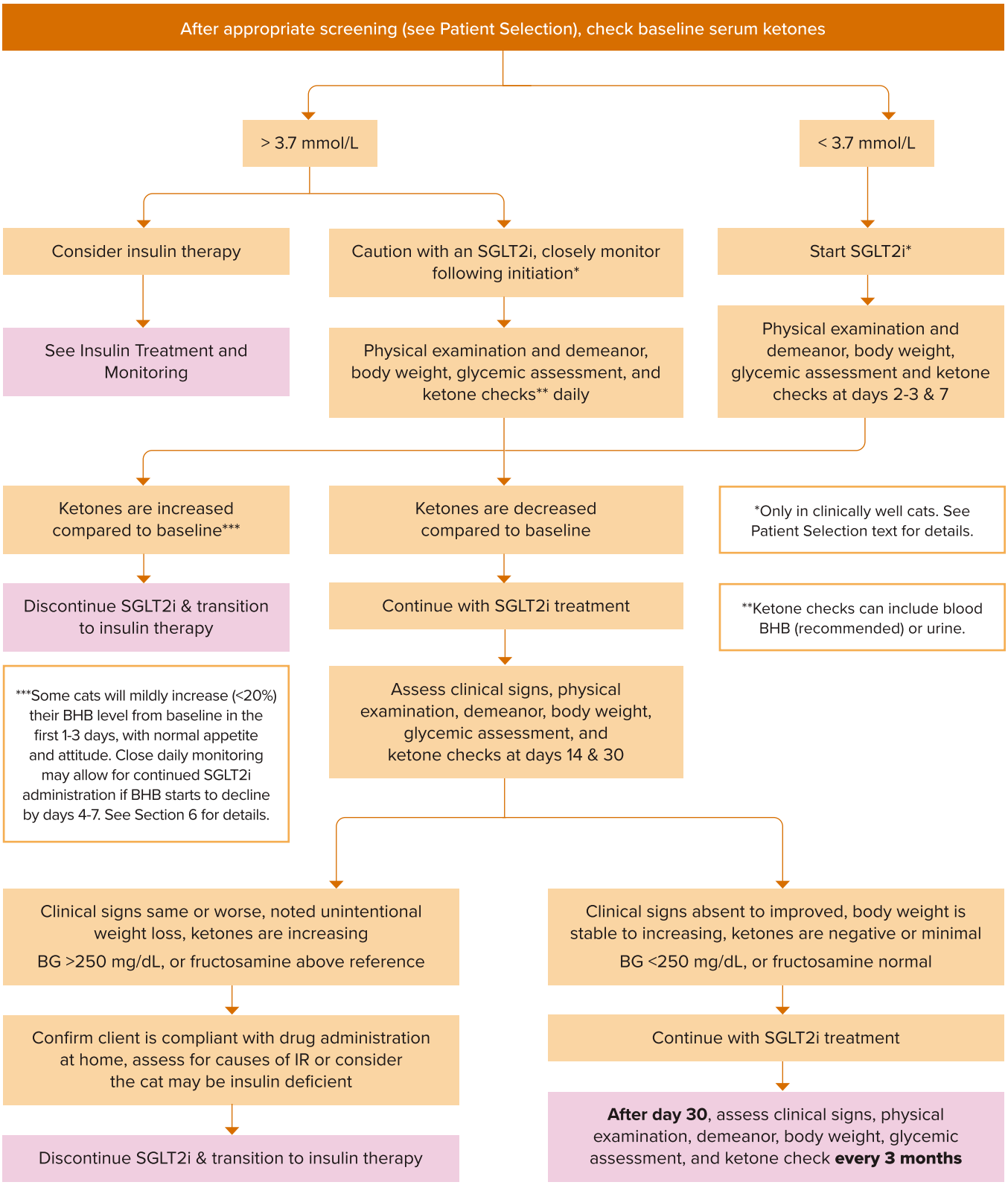

FIGURE 6.1

SGLT2 Inhibitor Treatment in Cats

BG, blood glucose; BHB, beta-hydroxybutyrate; IR, insulin resistance; SGLT2i, sodium-glucose cotransporter 2 inhibitor

Diabetic cats with readily reversible causes of IR, such as recent depot steroid administration, are particularly suitable candidates for an SGLT2 inhibitor.[21] These patients are more likely to go into remission after the cause of IR is removed and are therefore particularly vulnerable to hypoglycemia if treated with insulin.[2] Cats with hypersomatotropism (acromegaly) may also be candidates for treatment with an SGLT2 inhibitor, but the ideal protocol is unknown. A recent study of eight cats with diabetes and concurrent hypersomatotropism reported that the addition of velagliflozin to insulin therapy improved clinical and glycemic control of diabetes in most cats.[38] Ideally, clinicians should consult with a specialist before initiating SGLT2 inhibitor therapy in acromegalic cats as the risk for hypoglycemia is extremely high when used concurrently with exogenous insulin.[38]

Dietary Considerations

Carbohydrate restriction is discouraged in people receiving an SGLT2 inhibitor,[39] but no data in cats address this issue. Although food composition was not standardized in previous studies evaluating bexagliflozin and velagliflozin, some enrolled cats were fed diabetic prescription diets.[28,29] The task force recommends continuing the cat's usual diet for the first 2 wk of SGLT2 inhibitor treatment, and if the cat is doing well, then slowly introduce a low-carbohydrate diet.

Monitoring

Treatment goals for cats receiving SGLT2 inhibitors mirror those for patients receiving insulin, and monitoring is similarly focused on assessing glycemic control, body weight, and overall well-being. Because clinical hypoglycemia is rare, glucose curves and/or continuous glucose monitoring is usually unnecessary. However, carefully monitor for ketosis in cats on an SGLT2 inhibitor, particularly during the first 2 wk of treatment (Table 6.1), as DKA is most common during this period. It is substantially more important during this period to monitor blood BHB than BG.

In general, the blood BHB concentration should decrease from pretreatment values in most cats after starting an SGLT2 inhibitor. The bexagliflozin label suggests insulin is indicated if BHB increases from pretreatment values without providing specific BHB cutoffs, although clinicians have anecdotally applied previously reported values exceeding 2.4 mmol/L as a cutoff for DKA diagnosis (see Table 6.1).

However, anecdotal experience with SGLT2 inhibitors suggests there may be off-label exceptions which allow for continued treatment in the face of a mild increase in BHB from baseline. Some task force members tolerate mild increases in BHB (<20% from baseline) during the first 3 days of therapy if the cat is clinically well, eating, and can be regularly monitored with a daily BHB assessment (see Table 6.1). Additionally, some task force members initiate SGLT2 inhibitor therapy in cats whose BHB is >3.6 mmol/L at diagnosis (see above, Patient Selection, and Figure 6.1) and therefore tolerate a recheck visit BHB above 2.4 mmol/L as long as levels are declining compared with the previous assessment. Continued use of an SGLT2 inhibitor in the presence of clinical signs of illness, persistently increasing BHB concentrations after the first 3 days of therapy, or a lack of appropriate BHB monitoring puts the patient at marked risk for DKA.

Response to Therapy

In most diabetic cats, BG improves within hours of administering an SGLT2 inhibitor, and serum fructosamine concentrations are routinely within the reference range after 8 wk.[28,29,30] Despite persistent glucosuria, PU/PD also improves in most cats. Peripheral neuropathy improved in >75% of affected cats treated with velagliflozin.[28] Current evidence suggests assessing overall clinical response after 1 mo, and if the cat is still hyperglycemic with clinical signs of DM, discontinue the drug and provide insulin therapy. The likelihood of diabetes remission in cats receiving an SGLT2 inhibitor is currently unknown, but remission is likely possible when mitigating factors are addressed and resolved (see Section 9, Diabetic Remission).

Side Effects and Adverse Events

Approximately 38-50% of cats have changes in stool consistency within the first 2 wk of SGLT2 inhibitor administration.[28,29] This is likely due to mild cross-inhibition of sodium-glucose transporter 1 in the small intestine, which transports luminal glucose into enterocytes, with inhibition resulting in osmotic diarrhea. As such, antibiotic therapy is not indicated. In most cats, the effect is modest and self-limiting and may be mitigated by a 25% dose reduction for several days or by switching to a low-carbohydrate or high-fiber diet in the experience of task force members. Other symptomatic therapies, such as pectin or kaolin, may also be helpful. Persistent or treatment-resistant diarrhea may be an indication to stop therapy and transition to insulin. Vomiting is also commonly reported but tends to be sporadic. If the cat is eating well and stable, both bexagliflozin and velagliflozin can be safely redosed if the cat vomits within 30 min of dosing.

Modest increases in serum total calcium have been reported in a small number of cats.[28] The task force recommends monitoring ionized calcium concentrations in cats with a history of hypercalcemia, as SGLT2 inhibitor–induced changes in renal sodium handling and acid-base status may impact calcium homeostasis.[40]

The most serious complication with any diabetic cat, whether on insulin or an SGLT2 inhibitor, is DKA.[28,29,30] While typical DKA can occur, SGLT2-inhibitor-treated cats more commonly develop DKA without hyperglycemia called euglycemic DKA (EDKA).

TABLE 6.1

Recommended Monitoring Schedule for Cats Receiving SGLT2 Inhibitors*

Day	Test	Comment
2–3	**Review history**	Investigate poor appetite, vomiting, lethargy: Switch to insulin
	Physical examination	Monitor attitude, body weight, hydration (See note a: 1-4 below)
	Evaluate for ketosis[a]	Blood BHB >2.4 mmol/L (25 mg/dL): Switch to insulin
		1.0–2.4 mmol/L (10.4–25 mg/dL): Recheck in 2–3 days, sooner if ill (See note a: 1–4 below)
		Plasma acetoacetate (using plasma on urine dipstick) ≥1+: Switch to insulin
		Urine dipstick ≥Trace: Switch to insulin
7	**Review history and physical examination**[b]	See above; review presence of clinical signs of DM[b]
	Evaluate for ketosis[c]	See above[c]
	Check BG	Spot check is sufficient
14	**Review history and physical examination**	See above
	Evaluate for ketosis	See above
	Check BG	Expect to see BG <13.9 mmol/L (<250 mg/dL) OK to continue SGTL2 inhibitor if cat otherwise doing well despite hyperglycemia
30	**Review history and physical examination**	See above Excessive weight loss (>8% from baseline): Switch to insulin
	Evaluate for ketosis	See above
	Check BG	Expect to see BG <13.9 mmol/L (<250 mg/dL)
		BG >13.9 mmol/L (>250 mg/dL) with ongoing signs of DM: Switch to insulin
	Fructosamine	Expect normalization or significant improvement from baseline
		Not improved by >50 µmol/L from baseline and ongoing signs of DM: Switch to insulin
Every 3 mo	**As for Day 30**	See above

BG, blood glucose; BHB, beta-hydroxybutyrate; DKA, diabetic ketoacidosis; DM, diabetes mellitus

*Reprinted from Cook AK, Behrend E. SGLT2 inhibitor use in the management of feline diabetes mellitus. *J Vet Pharmacol Ther* 2025;48 Suppl 1(Suppl 1):19–30.

Task Force Recommendations

a 1–4

1. Blood BHB has increased but the cat is eating/drinking normally: ***Proceed with caution and recheck daily.***
   Blood BHB is unchanged but <2.4 mmol/L (25 mg/dL): Recheck in 2 or 3 days, sooner if ill.
   Blood BHB has decreased, and values are <1.0–2.4 mmol/L (10.4–25 mg/dL): Proceed to next recheck, sooner if ill.
2. Some cats show a mild BHB increase at their 2- or 3-day recheck but remain clinically stable. Drug discontinuation is not uniformly warranted, but BHB should be monitored every 1–2 days to ensure BHB eventually declines over the subsequent 2–5 days.
3. If a cat's BHB was >2.4 mmol/L before starting an SGLT2 inhibitor, the BHB at day 2–3 may be improved yet remain above the 2.4 mmol/L cutoff. In this circumstance, SGLT2 inhibitor therapy can be continued so long as the cat remains clinically stable and daily BHB monitoring shows continued improvement.
4. Unintentional weight loss of >5% from baseline at this visit is associated with an increased risk of DKA by day 14.**

b Mild weight loss (<5%) may occur during the first week of therapy. However, significant unintentional weight loss after the first week is often an early indicator of a developing problem, such as possible DKA.

c Blood BHB has increased, is unchanged, or remains >2.4 mmol/L (25 mg/dL): Switch to insulin.
Blood BHB is normal or has further decreased to values <1.0–2.4 mmol/L (10.4–25 mg/dL): Proceed to next recheck, sooner if ill.

**(See Behrend EN, Ward CR, Chukwu V, Cook AK, Kroh C, Lathan P, May J, Schermerhorn T, Scott-Moncrieff JC, Voth R. Velagliflozin, a once-daily, liquid, oral SGLT2 inhibitor, is effective as a stand-alone therapy for feline diabetes mellitus: the SENSATION study. *J Am Vet Med Assoc* 2024;262(10):1343–53.)

If EDKA or DKA occurs, it usually develops within the first 2 wk of therapy. EDKA is diagnosed by identifying abnormalities expected in DKA (fluid, electrolyte, and acid-base derangements) in cats who remain euglycemic (i.e., BG <250 mg/dL). Reported incidence of EDKA in cats who have been treated with an SGLT2 inhibitor is the same (5–7%) as the incidence of DKA in cats treated with insulin.[28,29,30] Cats previously treated with insulin appear to be predisposed.[28] Affected cats are often hyporexic and lethargic; dehydration is variable but may be severe. Blood BHB is typically >2.4 mmol/L and acetoacetate will be detectable in urine in many, but not all, cases. Failure to promptly recognize and address this condition, especially in cats with unknown medical or medication histories, will result in significant progressive morbidity (see Figure 12.1).

Possible Risk Factors for DKA[a]

- Weight loss >5% from baseline to days 2–3
- Unintentional weight loss after day 7
- Progressive cholesterol or triglyceride elevation
- 10-fold increase in the triglyceride concentration

a. Behrend EN, Ward CR, Chukwu V, Cook AK, Kroh C, Lathan P, May J, Schermerhorn T, Scott-Moncrieff JC, Voth R. Velagliflozin, a once-daily, liquid, oral SGLT2 inhibitor, is effective as a stand-alone therapy for feline diabetes mellitus: the SENSATION study. *J Am Vet Med Assoc* 2024;262(10):1343–53.

Switching to Insulin

In nonresponder cats (i.e., BG >250 mg/dL), the SGLT2 inhibitor can be discontinued and insulin started the following day. If the cat is not hyperglycemic, it may take several days for the physiological effects of the SGLT2 inhibitor to abate and for BG to rise; in nonketotic cats, withhold insulin until hyperglycemia is documented.

Section 7: Insulin Treatment and Monitoring

Insulin Treatment in Cats

Top 3 Takeaways

1. Diabetic remission is a reasonable goal in feline patients.
2. Successful treatment reduces clinical signs without hypoglycemia.
3. The starting insulin dose is typically 1 unit per cat every 12 hr.

Exogenous insulin administration is the traditional approach to managing diabetic cats. The goals of insulin treatment are the same as with other treatment options: improved glycemic control, mitigation of clinical signs, and improved quality of life for the cat and the clients. Tight glycemic control is not as readily achievable in feline patients as it is in humans.

Insulin Selection

A number of insulins are available for treating DM, and some are more effective than others in feline patients (Table 7.1). The most common choices for cats remain glargine (U-100) (approved for use in people) and protamine zinc recombinant human insulin (PZI) (approved for use in cats and dogs). Both have an acceptable duration of action in cats, provide more consistent glycemic control, and have been commonly associated with inducing diabetic remission. Lente insulin (porcine insulin zinc suspension) is approved for and often used in cats; however, it is not routinely recommended by task force members as a first-choice insulin due to having a shorter duration of action as compared to other starting insulin options. Neutral protamine Hagedorn (NPH) insulin is not considered an acceptable choice for cats owing to a very short (<8 hr) duration of effect.

The basal insulin glargine U-300 is not currently widely used as a standard first choice option although it has been proven effective at controlling hyperglycemia, reducing daily glycemic variability, and achieving diabetic remission in cats.[41] It is more concentrated but less potent than glargine U-100 and therefore should be considered as a separate insulin type and not simply the equivalent of 3 times that of glargine U-100. Because of slowed absorption resulting from the reduced surface area of the injected depot, glargine U-300 exerts a prolonged duration of action possibly allowing for *q* 24 hr administration in some cats.[42] Task force members with experience using "peakless" insulin formulations, such as glargine U-300 and basal insulin degludec, report that many treated cats demonstrate a flat time-action profile more like basal insulin secretion and have used these products for treatment of newly diagnosed diabetics or as an option for difficult-to-regulate cats (see Table 7.1).

A potentially promising ultra-long-acting insulin preparation is currently being developed.[43] A weekly injection would tremendously relieve caregiver burden and stress and would be a welcome addition to current tools for managing feline DM. Additionally, studies are being done to evaluate the viability of incretin hormones such as glucagon-like peptide-1 (GLP-1) for use in cats to increase pancreatic insulin secretion.[44]

Insulin Administration

Insulin is administered with either specific insulin syringes or insulin pens. Insulin syringes must match the concentration of insulin to be given; that is, use U-100 syringes with U-100 insulin and use U-40 syringes with U-40 insulin. Insulin syringes with a total volume no larger than 0.3 mL make dose visualization easier. Avoid ultra-short needles (<8mm), as it may be difficult to ensure proper administration through thick fur.

Glargine U-300 requires administration using the manufacturer-provided prefilled insulin pen that dials in increments of 1 unit.

TABLE 7.1
Insulin Products for Cats

Insulin Product	Product Description	Brand Name (Manufacturer)	Veterinary FDA Approval Status	Peak Action (Nadir) and Duration of Effect	Starting Dose	Concentration
Intermediate-Acting Insulin						
Lente	Porcine insulin zinc suspension	**Vetsulin** (Merck Animal Health)	Approved	Nadir 2–8 hr. Duration 8–14 hr.[a]	1–2 U per cat *q* 12 hr.[b]	U-40
	Comments: • Injection pens (in either 0.5-U or 1-U increments) are available for cats. • Bottle must be shaken to resuspend insulin crystals prior to use.					
Long-Acting Insulin						
Glargine U-100	Recombinant DNA origin human insulin	**Lantus** (Sanofi) **Basaglar** (Lilly) **Semglee** (Viatris & Biocon Biologics) **Glargine ɣfgn** (Viatris & Biocon Biologics) **Rezvoglar** (Lilly)	Not approved	Nadir 12–14 hr. Duration 12–24 hr.	1–2 U per cat *q* 12 hr.	U-100
	Comments: Commonly used in cats; use only U-100 (U-300 available; see below).					
PZI	Recombinant DNA origin human insulin	**ProZinc** (Boehringer Ingelheim Animal Health)	Approved	Nadir 5–7 hr. Duration 8–24 hr.[c]	1–2 U per cat *q* 12 hr.	U-40
	Comments: Commonly used in cats.					
Basal Insulin						
Degludec	Recombinant DNA origin human insulin	**Tresiba** (Novo Nordisk)	Not approved	Peakless Duration 10.35 +/- 3 hr.[d]	1 U per cat *q* 12 hr.[e]	U-100, U-200
	Comments: • Duration in cats suggests use as a *q* 12 hr insulin. • Does not need to be given with a meal.					
Glargine U-300	Recombinant DNA origin human insulin	**Toujeo** (Sanofi)	Not approved	Peakless Duration 14.5 +/- 2.3 hr.[d]	0.5 U/kg *q* 12–24 hr.[f] Or 2 U per cat *q* 24 hr.[e]	U-300
	Comments: • Use lean body weight to calculate U/kg doses. • Does not need to be given with a meal. • Requires administration using the manufacturer-provided prefilled insulin pen in increments of 1 unit.					

BG, blood glucose; PZI, protamine zinc insulin; U, units.

a. Martin GJ, Rand JS. Pharmacokinetic and pharmacodynamics study of caninsulin in cats with diabetes mellitus. Internal Study Report. 2000.

b. Caney SM. Management of cats on Lente insulin: tips and traps. *Vet Clin North Am Small Anim Pract* 2013;43(2):267–82.

c. Nelson RW, Henley K, Cole C, et al. Field safety and efficacy of protamine zinc recombinant human insulin for treatment of diabetes mellitus in cats. *J Vet Intern Med* 2009;23(4):787–93.

d. Gilor C, Culp W, Ghandi S, et al. Comparison of pharmacodynamics and pharmacokinetics of insulin degludec and insulin glargine 300 U/mL in healthy cats. *Domest Anim Endocrinol* 2019;69:19–29.

e. Gilor C, Fleeman LM. One hundred years of insulin: Is it time for smart? *J Small Anim Pract* 2022;63(9):645–60.

f. Linari G, Fleeman L, Gilor C, et al. Insulin glargine 300 U/ml for the treatment of feline diabetes mellitus. *J Feline Med Surg* 2022;24(2):168–76.

An appropriate needle (ideal needle length 10-12 mm) must be used with insulin pens, and the needle must be primed before administering insulin to ensure proper dosing (see the manufacturer provided recommendations). Insulin pens also have a variety of dosing options that range from 1/2-unit increments to 2-unit increments, which may not be suitable for small dosing changes. Clinicians should review manufacturer instructions for the insulin pen being used to identify the recommended injection times (often around 10 seconds), which is the amount of time the needle should remain in the patient's skin after deploying the injection to ensure the entire dose is delivered to the cat.

Insulin Dosing

Dosing common insulins for cats is not based on units per kilogram, except for glargine U-300 (considered a basal insulin). In overweight or obese cats, all weight-based insulin dosing should be calculated using the cat's estimated ideal body weight.

For glargine U-100 or PZI, start most cats on 1 unit/**cat** every 12 hr.

Basal insulin glargine U-300 is dosed at a starting dose of 0.5 units/kg every 12–24 hr.[41]

See also Section 8, Dietary Management, for information on meal timing related to insulin administration.

Monitoring Cats Receiving Insulin

Top 3 Takeaways

1. Monitor the cat, not just the numbers.
2. In-clinic blood glucose curves are not recommended.
3. Most cats will be regulated on less than 4 units of insulin twice daily.

DM is a serious, chronic disease with considerable consequences if the patient is not monitored and managed appropriately. Monitoring is more frequent in the period between starting insulin and achieving glycemic control, but long-term monitoring is essential. In cats achieving remission, approximately 25% were reported to occur within the first 2-3 months following diagnosis, while over 50% occurred within 6 months.[53,55] Monitoring during the first 3-6 months is especially critical to ensure the safety and success of insulin treatment.[2]

Monitoring can be divided into initial and long-term categories. Treatment success is not measured solely by laboratory values but also by improvement and resolution of clinical signs. With good regulation, PU, PD, and PP will drastically improve, and initially, weight gain or cessation of unintentional weight loss are positive indicators.

Initial Monitoring: Glargine U-100 or PZI

Perform the first glycemic check at 5–7 days after initiating treatment with glargine U-100 or PZI. Note clients' observations of clinical signs and weigh the cat at every visit. If clinical signs have not improved or the cat has not maintained or gained weight, an increased insulin dose is likely needed. Clients should closely monitor their cat for clinical signs of hypoglycemia after starting insulin and if observed, seek veterinary assistance urgently (see Section 15, Figure 15.1). If the patient is hyporexic, vomiting, or generally unwell, assess for ketosis with blood BHB or urine ketone measurement.

Ideally, place a CGM[45] at the first recheck at 5–7 days, especially if the insulin dose will be increased. The initial regulation period is a critical time for the cat to potentially experience remission or develop hypoglycemic episodes, which makes the CGM an important tool. Hypoglycemia reported by a human-calibrated CGM may not accurately reflect the cat's true BG, therefore correlate any low BG readings on CGM with a veterinary-calibrated PBGM and clinical signs. It is important to note that occasionally cats will achieve excellent clinical control but have reported BG readings on CGM that are consistently higher (250–350 mg/dL) than the typical targeted range (80–300 mg/dL), highlighting the importance of considering clinical response in therapeutic decision making and not just BG values.

Continue rechecks every 5–7 days. At each recheck, confirm presence or absence of clinical signs, monitor weight, and evaluate glycemic control. The insulin dose can be adjusted every 5–7 days if complete information is available to support safely increasing the dose. If the client is unable to provide accurate and thorough home observations, consider more conservative dose increases and extend rechecks to every 10-14 days. Clients may choose to use urine glucose monitoring for additional information. A negative urine glucose, however, may mean either perfect regulation or a period of hypoglycemia. Fructosamine measurement can be a helpful addition to clinical impression and blood glucose monitoring, but it has limitations (see Section 3, Diagnosing DM in Cats and Section 14, Other Methods for Monitoring Glycemic Data).

In-clinic blood glucose curves are no longer recommended for routine monitoring of diabetic cats. Furthermore, in-home blood glucose curves for cats may also be influenced by stress hyperglycemia, making interpretation challenging (see Section 13, Glucose Monitoring). The use of a CGM, although not specifically calibrated for cats, provides significantly more information than the traditional blood glucose curve. They are simple to place on cats, and even if they do not stay in place for the full 14 days, they provide more complete information than a traditional 8 hr in-hospital or 10–12 hr in-home blood glucose curve.

> In-clinic blood glucose curves are no longer recommended for routine diabetic monitoring in cats.

If a cat is not regulated with 4 units or less given twice daily, additional evaluation is recommended before further increasing the dose. Proper insulin handling and administration must be evaluated,

as well as considering other disease processes causing IR (see Section 10, Troubleshooting in Diabetic Cats).

Initial Monitoring: Glargine U-300

Initial monitoring of glargine U-300 involves placement of a CGM at the time insulin is started because dosing decisions can be made more quickly than with nonbasal insulins. After starting, the dose can be increased every 1–3 days until an appropriate nadir (80-120 mg/dL) has been achieved. When initiated at once-daily administration, if an appropriate nadir is reached within 2-3 days but BG remains above 300 mg/dL for more than 12 hr per day, a transition to twice-daily administration using the same dose should be considered.[41]

Long-Term Monitoring

Once the correct insulin dose is identified, long-term monitoring is relatively straightforward. Recheck at 4–6 wk after establishing the correct dose, and evaluate the client's impressions, the cat's overall clinical signs, and available data such as home blood and urine glucose checks and fructosamine level. If there is any question about the cat's glycemic control status, including concerns about hypoglycemia, place a CGM. In cats with diabetic remission potential, brief check-ins every 3 months may assist with early detection of downward trends in the BG. Perform routine full rechecks every 6–12 months like those for any cat with a chronic disease, and include a full physical examination and history, CBC, chemistry profile, TT4, urinalysis, and fructosamine measurement.

Section 8: Dietary Management

Top 3 Takeaways

1. Cats may benefit from a low-carbohydrate, high-protein diet.
2. Meal feeding is not essential but preferred.
3. Overweight or obese cats benefit from healthy weight loss.

Dietary Therapy Goals and Management

In cats diagnosed with DM, dietary therapy is typically considered a complement to insulin or SGLT2 inhibitor use. Occasionally cats will successfully go into remission with a diet change, but this is not to be expected. However, diet modification and achieving an ideal body weight may be helpful in reducing DM risk in non-diabetic obese cats or subclinical hyperglycemic cats. Consider a diabetic patient's individual needs when making a nutritional recommendation.

Dietary therapy aims to optimize body weight with appropriate macronutrient levels and calorie and portion control. Treatment goals include weight loss in obese patients and stopping DM-associated weight loss. Dietary management of DM involves the following:

- Calculate daily caloric intake based on optimized body weight and an accurate diet history.
- Monitor body weight (using the same scale for consistency) at least once or twice monthly as therapy is instituted; a healthy rate of loss for an obese cat is 0.5–2% of body weight per week (see the *AAHA Nutrition and Weight Management Guidelines* at aaha.org for additional resources).
- Monitor body and muscle condition scores to help direct adjustments in dietary therapy.
- Manage protein and carbohydrate intake to minimize postprandial hyperglycemia. Protein normalizes fat metabolism and provides a consistent energy source. Arginine stimulates insulin secretion.
- Prioritize a patient's reliable food intake from a complete and balanced diet over modifying specific nutrients.
- Adjust dietary recommendations if cats have concurrent diseases (e.g., chronic kidney disease, pancreatitis, intestinal disease). In these situations, the task force generally recommends selecting a diet based on which comorbidity is most likely to impact the patient's survival, e.g., selecting a renal diet rather than a diabetic diet in a cat with both DM and advanced stage proteinuric renal disease. Consultation with a veterinary nutritionist can be helpful in formulating nutritional plans that work for multiple comorbid conditions.

It is ideal to use meal feeding with intermediate-acting insulins that peak within a few hours of injection; however, this is not essential in cats and graze eating over the day is acceptable. With glargine U-300, strict meal feeding is not required because the frequency of injections may be decreased and risk of hypoglycemia associated with missed meals is low.[43] The timing of meals can also be adjusted if the pet is eating a low–glycemic index diet.[46]

- Feeding portioned meals has several advantages for the dietary management of diabetic cats:
  - It is easier to monitor intake and appetite.
  - Portion control is facilitated.
- Free-choice feeding is acceptable if a cat's eating habits cannot be changed. (The task force recommends the daily ration be divided into multiple meals. Timed feeders may help in this scenario.)[47]
- Canned foods are preferred over dry foods. Canned foods provide:
  - Lower carbohydrate levels.
  - Ease of portion control.
  - Lower caloric density; cats can eat a higher volume of canned food and obtain the same caloric intake as smaller volumes of dry food.
  - Additional water intake.

Commercially available therapeutic diets designed for diabetic cats are often calorie dense. For obese cats (BCS >7/9), feeding a diet with moderate carbohydrate content (15-25% metabolizable energy [ME]) and lower calories, such as a therapeutic diet designed for weight loss, may be considered.[46]

The ideal diet for most diabetic cats includes:[9]

- High protein content (>40–45% ME, >10 g/100 kcal) and reduced carbohydrate content (<12–15% ME, <3 g/100 kcal).[47]
- Canned food or a mix of canned and dry.[9]
- Carbohydrate intake should be limited because carbohydrates may contribute to hyperglycemia and glucose toxicity. The task force recommends a diet carbohydrate content of ~12% ME, recognizing that there are a variety of expert opinions on this topic.[47,48]
- In diabetic cats, remission rates between 15 and 100% have been reported when cats were given a combination of a high-protein/low-carbohydrate diet and insulin.[49,50]
- High-fiber diets are not typically recommended for cats with DM.

Pet food labels do not consistently include carbohydrates in the guaranteed analysis, although The American Association of Feed Control Officials Pet Food Label Modernization regulations require carbohydrates (see www.aafco.org/pflm/). If not listed, the carbohydrate content of a diet can be calculated by subtracting the listed percentages of protein, fat, fiber, moisture, and ash from 100. If ash content is also not listed, use an estimate of 2-3% for canned diets and 5-8% for dry diets. Then, online tools can be used to convert nutrient information to ME. Balance.it has a free guaranteed analysis to ME content of nutrients converter (balance.it/convert), and Tufts University also has a nutrient converter (sites.tufts.edu/petfoodology/2017/08/07/nutrient_converter/).

Section 9: Diabetic Remission

Top 3 Takeaways

1. Diabetic remission is almost exclusively a feline phenomenon, thus supporting the insulin-resistant model for this species.
2. Remission requires restoration of beta-cell function and relies on reversal of IR and glucose toxicity.
3. Cats receiving exogenous insulin that undergo unrecognized remission are vulnerable to life-threatening insulin-induced hypoglycemia.

Diabetic remission (i.e, euglycemia maintained for >4 wk without exogenous insulin or oral hypoglycemic agents) routinely occurs in diabetic cats. This transition reflects recovery of beta-cell function and relies on the reversal of IR and glucose toxicity.[2] However, diabetic cats undergoing remission are not cured, because pancreatic insulin reserve is permanently limited and relapse is common.[51]

Approximately 25% of cats achieving remission did so in the 2-3 months following diagnosis, while a majority of cats achieved remission within 6 months.[53,55] Reported incidences vary and appear to be influenced by patient characteristics and management strategies; however, the task force supports using an average remission rate of approximately 30% in the United States.[2] Cats with reversible causes of IR, such as obesity or recent glucocorticoid administration, are more likely to undergo remission, assuming that adiposity is addressed or insulin-antagonizing medications are withdrawn or both.[55] Promptly address other causes of IR such as dental disease, rather than postponing treatment until BG is adequately regulated. Canned high protein diets may also support remission by mitigating sarcopenia and boosting secretion of GLP-1, an incretin with a trophic effect on beta cells.[52,53] Cats with a history of DKA[54] and/or peripheral neuropathy may undergo remission, with a 2024 study reporting similar rates of remission between cats with historic DKA (9.8%) and those with neuropathy (8.5%) at diagnosis.[55] Cats with hypersomatotropism (acromegaly) are not expected to undergo remission without definitive treatment for the underlying condition.[56]

For cats receiving insulin, diabetic remission is supported by effective glycemic control and indicated by a progressive decrease in insulin requirements or evidence of hypoglycemia.[2] Although some studies suggest that insulin type plays a key role, carefully monitoring and adjusting the treatment protocol to achieve good glycemic control within 6 months of DM diagnosis is probably more impactful than the product administered.

Remission onset is readily apparent if BG is routinely monitored, but remission may be overlooked in unmonitored cats until there are obvious signs of hypoglycemia. Urine glucose monitoring is less sensitive, but zero glucosuria for >48 hr suggests either excellent glycemic control or sustained hypoglycemia. Similarly, consider remission if serum fructosamine concentrations are within or below the reference range.

The incidence of remission for cats receiving an SGLT2 inhibitor has not been evaluated at this time. As these drugs cause persistent glucosuria irrespective of BG concentration and insulin secretion, the drug must be withheld to identify remission. If clients have cost concerns or want to assess if the SGLT2 drug is required long term, it is reasonable to check for remission after at least 90 days of therapy. Closely monitor BG with a CGM or 1–2 glucometer checks per day for at least a week; values >250 mg/dL with concurrent ongoing clinical signs indicate the need for continued treatment.[21] Alternatively, clients can monitor urine at home, bearing in mind that it may take several days for the glucosuric effects of the drug to wear off and even short periods of hyperglycemia impact beta cell viability and drive apoptosis.[5,6] Cats that undergo remission but subsequently relapse often lose enough beta cells to ultimately require exogenous insulin permanently. Achieving a second remission is less common, with reported rates ranging between 0-22%.[57,58]

Although further studies are needed to evaluate strategies for maintaining diabetic remission, diligent weight management and continued use of a canned low-carbohydrate diet are recommended for all cats.[53] Additionally, relapses in cats previously treated with insulin may possibly be prevented by long-term use of an SGLT2 inhibitor (an extra-label use), although more research is needed. Physical examination with continued monitoring of clinical signs, weight, and appropriate laboratory evaluation every 6 mo may allow early detection of possible diabetic relapse.

Section 10: Troubleshooting in Diabetic Cats

Top 3 Takeaways

1. Teach clients how to recognize potential complications.
2. Increasing insulin dose requirements may signal other underlying diseases.
3. Consult a specialist as needed.

Managing diabetic cats is not always straightforward. The approach to troubleshooting problems with diabetic management differs between patients who receive SGLT2 inhibitors and those treated with insulin.

When using a CGM to monitor either SGLT2 inhibitor or insulin use, if persistent moderate hyperglycemia is seen in a cat who is otherwise not showing clinical signs and maintaining or gaining weight, therapy adjustment may not be necessary. Task force members have frequently managed clinically well cats with glucose concentrations persistently >250 mg/dL as determined by CGM.

Troubleshooting SGLT2 Inhibitor Treatment

Clinical hypoglycemia is not a concern with SGLT2 inhibitor treatment, and unresponsive hyperglycemia is uncommon. If hyperglycemia persists, ensure that the cat is receiving the prescribed dose. If clients are mixing the drug with food, they should avoid mixing the dose with a full meal as cats may be under-dosed if not all food is consumed. If hyperglycemia remains despite accurate dosing and administration, discontinue the SGLT2 inhibitor and transition to insulin. Persistent biochemical changes such as hypercalcemia or severe hyperlipidemia may also require discontinuing the SGLT2 inhibitor and transitioning to insulin. Although perineal mycotic infections are routinely reported in human patients treated with SGLT2 inhibitors, these infections have not been described in feline patients.

One of the most common complications with SGLT2 inhibitors is diarrhea. This can be managed with symptomatic care or a 3- to 5-day 25-50% reduction in dose, as it tends to be transient in most cases. In some instances, it may help to discontinue the SGLT2 inhibitor for 2–3 days and allow the diarrhea to improve, then restart treatment at half the dose and gradually increase it to the prescribed dose. Changing to another SGLT2 inhibitor may be helpful in some cats. For persistent diarrhea, antibiotics are not indicated, and the patient may require transition to insulin.

Troubleshooting Insulin Treatment (See Also Figure 15.2)

Problematic patients who are receiving insulin usually fall into two categories: cats who become hypoglycemic and cats who exhibit persistent hyperglycemia.

Always confirm that insulin is being handled and administered correctly. Check the dose on the syringe and injection routine with the client and ensure that doses are not skipped or accidentally administered more than once. Credentialed technicians can perform initial consultations to gather this information and provide additional client education (see Box, Technician Initial Consultations).

Hypoglycemia may occur with excessive insulin administration, waxing and waning IR conditions, or with unrecognized diabetic remission, and can be life threatening (Figure 15.1, Managing Hypoglycemia). It is important for caregivers, including hospital staff, to know the clinical signs of and risks for hypoglycemia (see Section 11, Client Education). If a cat becomes hypoglycemic, investigate insulin administration, appetite or vomiting, and general health over the previous days to weeks. Diet changes, intestinal disease, and pancreatitis are just a few reasons a cat may eat less and become at risk for hypoglycemia if the same dose of insulin is administered.

Persistent hyperglycemia despite increasing doses of insulin may be due to IR, but proper insulin care and administration should always be confirmed first. Once confirmed, consider any concurrently administered medications. Discontinue insulin-resistance-causing medication(s) if possible, and if still uncontrolled 2 wk after discontinuation, increase insulin dose.

Multiple diseases and conditions can complicate diabetic regulation with insulin by inducing IR, including dental disease, bacterial infections, pancreatitis, inflammatory bowel disease, and hypersomatotropism (acromegaly). Second-level diagnostics, including gastrointestinal testing (fPLI, trypsin-like immunoreactivity, cobalamin, folate), abdominal ultrasound, and hormonal testing, may be appropriate.[59,60] Note that unregulated hyperthyroidism may cause a decrease in insulin-like growth factor (IGF-1),[61] and IGF-1 may be increased in obese cats.[62] IGF-1 testing should be done at least 4–6 wk after starting insulin in newly diabetic cats, as they have significantly lower IGF-1 levels before starting insulin administration.[63] Resolution of concurrent diseases may eliminate the need for an increased insulin dose and, in some cases, may reduce or eliminate the need for insulin administration altogether.

Credentialed Technician Consultations for Troubleshooting Insulin Therapy

- Ask about current food (type, amount, timing), any dietary changes, and any new medications, supplements, or clinical signs suggestive of insulin resistance.
- Ask the client how they store and prepare the insulin (i.e., shaking versus rolling).
- Ensure that the syringes match the insulin concentration (U-100 versus U-40).
- If using an insulin pen, ask the client whether they prime needles before each use.
- Assess how long the insulin vial has been in use since being opened or uncapped; consider replacement if in use more than 4 mo.
- Using sterile saline, have the client demonstrate how they administer injections to their cat.
- Have the client keep a log that family members initial when they administer the insulin to ensure doses are not skipped or doubled.

If no underlying disease is identified and the patient is not regulated, consider changing to another type of insulin. When changing insulins, it is safest to initiate the new type at a standard starting dose, such as 1 unit/**cat** twice daily for glargine U-100 or PZI. Consult with a specialist if the patient still cannot be regulated. Diabetic ketoacidosis is a serious and potentially fatal complication of diabetes, whether on insulin or SGLT2 inhibitors (see Section 12, Diabetic Ketoacidosis).

Section 11: Client Education

Top 3 Takeaways

1. Help clients recognize that their lifestyle may need adjustments to meet their diabetic cat's needs.
2. Confirm that clients know certain insulins are given by insulin pen only.
3. Ensure that clients understand that SGLT2 inhibitors are not insulin.

Be transparent, supportive, and empathetic with clients when discussing the commitment needed to manage their pet's DM and emphasize that successful control is achievable but sometimes takes weeks or months. Give clients adequate access to veterinary team members trained to answer their questions and troubleshoot common problems. Provide written material for reference when the veterinary team is unavailable. Offer content (e.g., online, handouts) that answers frequently asked questions, describes what to watch for at home, and explains how to respond to changes in their cat's condition, and direct clients to reliable online information. For help generating written instructions, see the Diabetic Pet Discharge Template at aaha.org/diabetes-management-cats.

Explain that DM remission can occur in cats who receive insulin or an SGLT2 inhibitor. Emphasize that although achieving remission is a great goal, it is not the main focus as they monitor and care for their cats at home. Describe that remission typically happens when the cause of insulin resistance resolves (e.g., weight loss in an obese cat, diet modifications, stopping corticosteroids) and often occurs in the first 3-6 months after starting treatment.

Key Client Education Points for Clients with Diabetic Cats

SGLT2 Inhibitor Monitoring and Administration

1. Explain that SGLT2 inhibitors are not insulin. Familiarize the client with safe and effective use of an SGLT2 inhibitor, including expected benefits, possible complications (including EDKA), and required monitoring and follow-up. Inform the client about any specific concerns about the use of an SGLT2 inhibitor in their cat.
2. Advise clients to closely monitor cats during the first 2 wk of therapy because DKA/EDKA is more likely to occur within this time. Educate clients about signs of DKA/EDKA.[64]
   a. Emphasize that the cat needs veterinary evaluation if the client notes any decrease in appetite or if the cat is not feeling well in general.
3. Instruct clients to tell the veterinary team that their cat has diabetes and is receiving an SGLT2 inhibitor. This is especially important in the emergency setting where a complete medical record may not be available.
4. Discuss how and when to dose the drug and explain what to do if a dose is missed, if the cat is uninterested in food and misses a meal, or if the cat vomits before or after administration.
   a. If the client misses an SGLT2 inhibitor dose, instruct the client to administer the dose as soon as remembered if relatively close to their normal administration time, otherwise pick up dosing again at the next scheduled treatment time the following day.
   b. If the cat vomits after dosing, instruct the client to redose if vomiting occurs within 30 min of administration. If it occurs after 30 min, instruct the client that it is not necessary to redose.
   c. If vomiting persists, clients should be instructed to contact the veterinary clinic.
   d. If the cat is on an SGLT2 inhibitor and is uninterested in food for more than 24 hr or seems unwell, ketosis may be a concern. Check BHB and seek veterinary assistance.

Insulin Effects, Handling, Storage, and Administration

1. Explain to clients how insulin works and its effects on BG.
2. Discuss what to do if the cat does not eat a full meal or vomits before or after insulin administration. See Frequently Asked Questions at aaha.org/diabetes-management-cats for more information.
3. Teach clients about proper handling and storage of the specific type of prescribed insulin, including the following points as appropriate:
   a. Gently roll but do not shake the vial when using glargine U-100, PZI, glargine U-300, or insulin degludec.
   b. If using porcine insulin zinc suspension (Vetsulin), shake the vial to obtain a homogeneous, uniformly milky suspension.
   c. Do not freeze insulin or expose it to heat. Avoid leaving insulin in environments prone to temperature extremes (e.g., a parked car) and wherever prolonged exposure to direct sunlight or freezing temperatures may occur.
   d. Refrigerate insulin to maintain a consistent environmental temperature and allow extended use of each vial. When insulin is refrigerated and handled carefully, the task force is comfortable with clients continuing to use insulin beyond the manufacturer-recommended in-use duration (28–56 days for most insulin types). Preservative-containing insulin vials in use for 6 mo were not shown to be at increased risk of bacterial contamination.[65] If there are any questions about insulin efficacy or a cat's DM clinical signs recur despite fully compliant insulin therapy, the task force recommends replacing the insulin vial.
   e. Clients can wipe the vial stopper with alcohol before inserting the syringe needle, but this was not associated with improved prevention of bacterial contamination over 6 mo of vial use.[65]
   f. If the insulin ever appears flocculent, discolored, or exhibits consistency changes, it should be replaced immediately.
4. Explain the types of insulin syringes and which one to use.
   a. Always use a U-40 insulin syringe with U-40 insulin and a U-100 insulin syringe with U-100 insulin.
   b. 0.3- and 0.5-mL insulin syringes or insulin pens best facilitate accurate dosing, especially in cats receiving <5 units per dose.[66] (Veterinarians need to evaluate whether the needles in the insulin pens are long enough for each patient [i.e., 10-12 mm].)
   c. Syringes with 0.5-unit increment hashmarks or commercially available syringe magnifiers are also available to allow more accurate dosing than visual estimation using a standard syringe.
   d. Syringes are for single use.
   e. Do not use "short" needles. Use standard 29-gauge, half-inch needles.
5. Explain insulin pen use.
   a. Some insulins, such as glargine U-300 and degludec U-200, must be administered with an insulin pen.

   b. Insulin pen cartridges contain mixing beads and are typically held extended and waved up and down to mix the insulin before use.
   c. Use a new needle for each injection and prime the insulin pen needle before administration.
   d. Check the manufacturer-recommended injection time to ensure full dose is administered.
   e. Dose adjustments vary based on the type of insulin pen and range from 1/2-U to 2-U increments.
6. Demonstrate proper insulin dose measurement and administration technique.
   a. Use sterile saline to allow the client to practice giving injections until they feel comfortable.
7. Teach clients to recognize hypoglycemia and take action if it occurs.
   a. Signs include lethargy, sleepiness, strange behaviors, abnormal gait, weakness, tremors, and seizures.
   b. If the cat is conscious, clients should feed a high-carbohydrate meal (e.g., rice, bread, pasta, add corn syrup to regular diet).
   c. If the cat is poorly responsive or has tremors, clients should be prepared to rub 1 teaspoon of corn syrup onto the cat's gums using a cotton-tipped applicator or syringe (some experts use a dose of up to 0.25 mL/kg). The client should never be instructed to place their fingers into a hypoglycemic patient's mouth.
   d. Advise the client of the risk of aspiration in an obtunded animal. Feed the cat if the cat responds within 5 min. Take the pet to a veterinarian.
   e. Empower clients to decrease or skip an insulin dose and seek urgent veterinary assistance if signs of hypoglycemia are noted, but warn them to never increase the insulin dose or frequency of administration without clear instructions from their veterinarian.

Lifestyle Change Expectations

1. Review the schedule commitment required for administering the recommended treatment.
   a. Insulin is often given twice daily.
      i. Newer insulins may allow less frequent injections for some patients.
   b. SGLT2 inhibitors are given once daily.
2. Explain that insulin needs change over time, which may require more frequent veterinary visits.
3. Discuss home monitoring aids and their role in assisting with monitoring, and that these do not replace the need for in-hospital veterinary evaluations.
4. Discuss client experience and impacts on quality of life (e.g., caregiver attachment, fatigue, caregiver grief when pet passes).

Home Monitoring Options

1. CGMs are useful tools for clients and veterinary professionals. These allow 24 hr continuous monitoring and can give the health care team more detailed information on glucose control. Although they are labeled for 15-day use in humans, they rarely last this long in cats. However, even 2–3 days' worth of data is useful.
2. Clients may prefer to use a glucometer. Use only a veterinary-calibrated PBGM, such as the AlphaTrak 3.
3. Cats on insulin who may be approaching remission can be monitored for glucosuria using glucose strips or glucose-detecting litter (e.g., Royal Canin Glucodetect by BluCare (https://blucarelab.com/products/).
4. In cats, one of the parameters reported to be a useful and practical indicator of clinical DM control is the amount of water consumed over 24 hr.[67] Microchip-linked water monitors, like Felaqua Connect (surepetcare.com/en-us/felaqua-connect) and others, can be useful at-home tools for clients to document water consumption.
5. Clients are often happy with the level of clinical DM control, despite not having laboratory evidence of tight glycemic control, emphasizing that the long-term goal of DM treatment is to eliminate clinical signs.[67]

Additional client resources are available in the *AAHA Diabetes Management Guidelines* resource center at aaha.org/diabetes-management-cats.

Section 12: Diabetic Ketoacidosis in Cats

Top 3 Takeaways

1. Insulin is required to treat DKA, even with euglycemic DKA (EDKA), an uncommon complication of SGLT2 inhibitor therapy in cats.
2. Consider using a glargine U-100 protocol for some cats instead of regular insulin.
3. Complete normalization of BG control is not required before discharge following DKA treatment.

DKA is a life-threatening complication of DM. Although DKA is more commonly seen in naive diabetic patients,[68] it may occur in treated diabetics. Concurrent diseases (e.g., pancreatitis, urinary tract or other infections, hypercortisolism, and renal disease) often precipitate DKA. Insulin deficiency leads to reduced glucose transport into cells and increased release of free fatty acids, resulting in increased hepatic ketone production, acidosis, electrolyte imbalances, and dehydration.

Diagnosis of DKA relies on identifying compatible clinical signs in sick diabetic patients and confirming ketosis and acidosis. If acid/base status measurement is not available, treat sick, ketotic diabetic patients as DKA patients. Clinically well diabetic cats occasionally have ketonuria, so in the absence of consistent biochemical abnormalities and clinical signs of DKA (e.g., poor appetite, vomiting), do not treat them as DKA patients.

Measure ketones with a point-of-care handheld ketone meter (these measure BHB) or with standard urine test strips (these measure acetoacetate). Both may be helpful, but BHB more accurately identifies earlier stages of ketoacidosis.[69] Clinical laboratories also measure BHB if a point-of-care ketone meter is not an option, however, rapid identification of ketone elevation is important. Because of the affordability and ease of point-of-care ketone meters, the task force advises having a handheld ketone meter available in the clinic.

DKA treatment involves rehydration, correcting electrolyte abnormalities, insulin administration, and treating any underlying disease.

DKA and EDKA: Treatment for Severely Compromised Patients

Refer to a 24 hr facility

DKA: Primary Care Treatment for Less Critical Patients

Consider referral if your clinic's capabilities do not allow for optimum nursing care and hospitalization. Start supportive care if transfer to referral center is not immediately available.

- Start IV fluids to correct dehydration over 6–12 hr (12–24 hr for patients prone to fluid overload) and meet maintenance fluid requirements. Balanced crystalloids (e.g., lactated Ringer's solution, Plasmalyte, or Normosol R) are ideal.
- Address electrolyte disturbances. Add potassium chloride (KCl) and/or potassium phosphate (KPhos) to fluids.* Address hypokalemia as a priority and consider that most DKA patients have a total body potassium deficiency. Potassium levels should ideally be >3.0-3.5 mEq/L before starting insulin. Initially monitor electrolytes every 4-6 hours, especially if high KCl or KPhos infusion rates are required.
- Use a PBGM to monitor BG. Can consider placing a CGM and then initially confirming accuracy as compared with a PBGM. If the CGM appears inaccurate, a PBGM should ideally be used to guide treatment adjustments.
- A regular insulin protocol can be initiated starting at 0.1 U/kg IM then repeated every 1–2 hr with dose adjustments made based on the serial BG monitoring.
- A glargine U-100 protocol can be used as an alternative to regular insulin.[a]
  - Administer 1 U glargine U-100 IV and monitor glucose trends hourly via PBGM or CGM.
  - Administer additional 0.5–1 U glargine U-100 IM every 2–3 hr until BG is 150–250 mg/dL, and then give subcutaneous (SQ) glargine U-100 at 1–2 U every 12 hr.
- For either insulin protocol, add dextrose to fluids (2.5-5%) to maintain BG between 150-250mg/dL.[b]
- Nursing care! Warmth, food, and love.[c]
- Give antibiotics as needed for concurrent bacterial cystitis or other infection.
- Hospitalize until the patient is stable, rehydrated, and eating well.
- Monitor BHB every 12–24 hr until the patient is stable.
- Transition to long-term diabetic management when the patient is stable, rehydrated, and eating well.

FIGURE 12.1
Diabetic Ketoacidosis Protocol for Cats

(Continued on next page)

EDKA: Primary Care Treatment for Less Critical Patients

Consider referral if your clinic's capabilities do not allow for optimum nursing care and hospitalization. Start supportive care if transfer to referral center is not immediately available.

- Discontinue SGLT2 inhibitor.
  - Be aware that the BG-lowering effect of the SGLT2 inhibitor can persist for prolonged periods (multiple days) in cats with comorbid disease, such as hepatic dysfunction or lipidosis.
- Start IV fluids with at least 5% dextrose added at an appropriate rate to correct dehydration. Balanced crystalloids (e.g., lactated Ringer's solution, Plasmalyte, or Normosol R) are ideal.
  - If hypoglycemic (BG <150 mg/dL) at presentation, a 0.25- to 0.5-mL/kg bolus of 50% dextrose diluted 1:4 with 0.9% saline can be given intravenously.
- Add KCl or KPhos as needed to fluids and initially monitor electrolytes at least every 4-6 hours.*
- Use a PBGM or CGM to monitor glucose.
- Initiate insulin therapy within 4 hr once the BG is consistently >150 mg/dL on dextrose supplementation and potassium is >3.0 mEq/L. (See regular insulin or glargine U-100 protocols described above under DKA treatment). If the initial dextrose support is inadequate to increase BG to 150 mg/dL within 4 hr, increase the dextrose concentration to 7.5% or higher.
- Give 0.25–0.3 g of dextrose/kg/hr for every 0.1 U/kg/hr of insulin. Insulin MUST be given continuously IV or repeatedly IM, and it may be necessary to increase dextrose to more than 5% to allow for this.
- Nursing care! Warmth, food, and love.[c]
- Give antibiotics as needed for concurrent bacterial cystitis or other infection.
- Hospitalize until the patient is stable, rehydrated, and eating well.
- Monitor BHB every 8–12 hr until the patient is stable.
- Transition to long-acting insulin for diabetic management; do not restart an SGLT2 inhibitor.

BG, blood glucose; BHB, beta-hydroxybutyrate; CGM, continuous glucose monitor; DKA, diabetic ketoacidosis; EDKA, euglycemic diabetic ketoacidosis; IV, intravenous; KCl, potassium chloride; KPhos, potassium phosphate; PBGM, portable blood glucose monitor

a. Zeugswetter FK, Luckschander-Zeller N, Karlovits S, et al. Glargine versus regular insulin protocol in feline diabetic ketoacidosis. *J Vet Emerg Crit Care* 2021;31:459–68.

b. Gallagher BR, Mahony OM, Rozanski EA, Buob S, Freeman LM. A pilot study comparing a protocol using intermittent administration of glargine and regular insulin to a continuous rate infusion of regular insulin in cats with naturally occurring diabetic ketoacidosis. *J Vet Emerg Crit Care* (San Antonio). 2015;25(2):234-239.

c. Carney HC, Little S, Brownlee-Tomasso D, et al. AAFP and ISFM Feline-Friendly Nursing Care Guidelines. *J Feline Med Surg* 2012;14(5):337–49.

*See the *AAHA Fluid Therapy Guidelines* at aaha.org/fluid-therapy for instructions on supplementing fluids.

FIGURE 12.1, CONTINUED

Diabetic Ketoacidosis Protocol for Cats

Pay particular attention to the phosphorus concentration in cats owing to their sensitivity to hypophosphatemia-induced hemolysis. See Figure 12.1 for DKA treatment protocols.

Insulin is used primarily to eliminate ketosis but must be given in conjunction with fluid therapy and other supportive treatments. Fluid therapy alone often provides significant glucose, electrolyte, and acid-base correction in the absence of insulin, but insulin must be started within 4–6 hr of hospital admission, in most cases.

In cats that develop EDKA while being treated with SGLT2 inhibitors, BG often remains below 250 mg/dL despite ketoacidosis. The BG-lowering effect of an SGLT2 inhibitor may persist for days following discontinuation in cats with significant hepatic disease, such as hepatic lipidosis.[36,37] Despite their euglycemia, these cats require insulin administration to inhibit ketone production, resolve DKA, and help normalize metabolism.

DKA and EDKA treatments are nearly identical, except EDKA patients need immediate dextrose administration until the BG is >150 mg/dL in order to safely start insulin.

The severity of illness varies in cats with ketoacidosis. Patients typically present with nonspecific signs such as lethargy, dehydration, weakness, hyporexia, vomiting, and weight loss. They may have a history of recent PU/PD/PP.[70] Patients who present with severe compromise require referral for 24 hr critical care, but some patients with less severe clinical signs can be treated by the primary care veterinarian. Although regular insulin administration (given IV, by continuous rate infusion, or intramuscularly [IM]) has been the mainstay of care for cats with DKA for decades, some cats can be successfully managed with various glargine protocols (see Figure 12.1).[70,71]

How to Formulate Dextrose-Containing Fluids[a]

Amount of 50% Dextrose Solution Added to 1L Bag of Isotonic Crystalloids*	Final Dextrose Concentration
25 ml	1.25%
50 ml	2.5%
100 ml	5%
150 ml	7.5%

*Remove an equivalent volume of the isotonic crystalloid fluid from the bag before adding 50% dextrose solution.

a. Modified from Table 14, *AAHA Fluid Therapy Guidelines*. Available at www.aaha.org/resources/2024-aaha-fluid-therapy-guidelines-for-dogs-and-cats/.

General Monitoring Considerations

Monitoring diabetic pets can be challenging. The algorithm in Figure 13.1 provides a quick reference for three types of DM patients receiving insulin or an SGLT2 inhibitor—newly diagnosed, previously diagnosed, and previously diagnosed but currently unregulated. Monitoring options include performing BGCs, placing a CGM, measuring fructosamine, and assessing clinical signs and weight. Occasionally, monitoring urinary glucose may be warranted, such as screening for hypoglycemia, but it is not a recommended routine monitoring tool. Results from different monitoring approaches may conflict.

Section 13: Glucose Monitoring

Top 3 Takeaways:

1. Glucose monitoring includes blood glucose curves (BGC) and continuous glucose monitoring (CGM) and identifies clinically undetectable hypoglycemia (thus the insulin dose can be decreased before clinical signs occur).
2. Anytime DM signs recur, glucose monitoring is required to identify the root cause (low dose, short duration of action) and direct how to safely adjust (increase or decrease) an insulin dose or change insulin type.
3. Situations when glucose monitoring should be performed include:
   a. At 5–14 days after starting insulin or following any dose change;
   b. Any time clinical signs recur in a previously controlled patient; and
   c. When hypoglycemia is suspected.

Blood Glucose Curves

A BGC is typically performed by measuring BG using venous or capillary blood before (baseline, time 0) and then every 2 hr after feeding

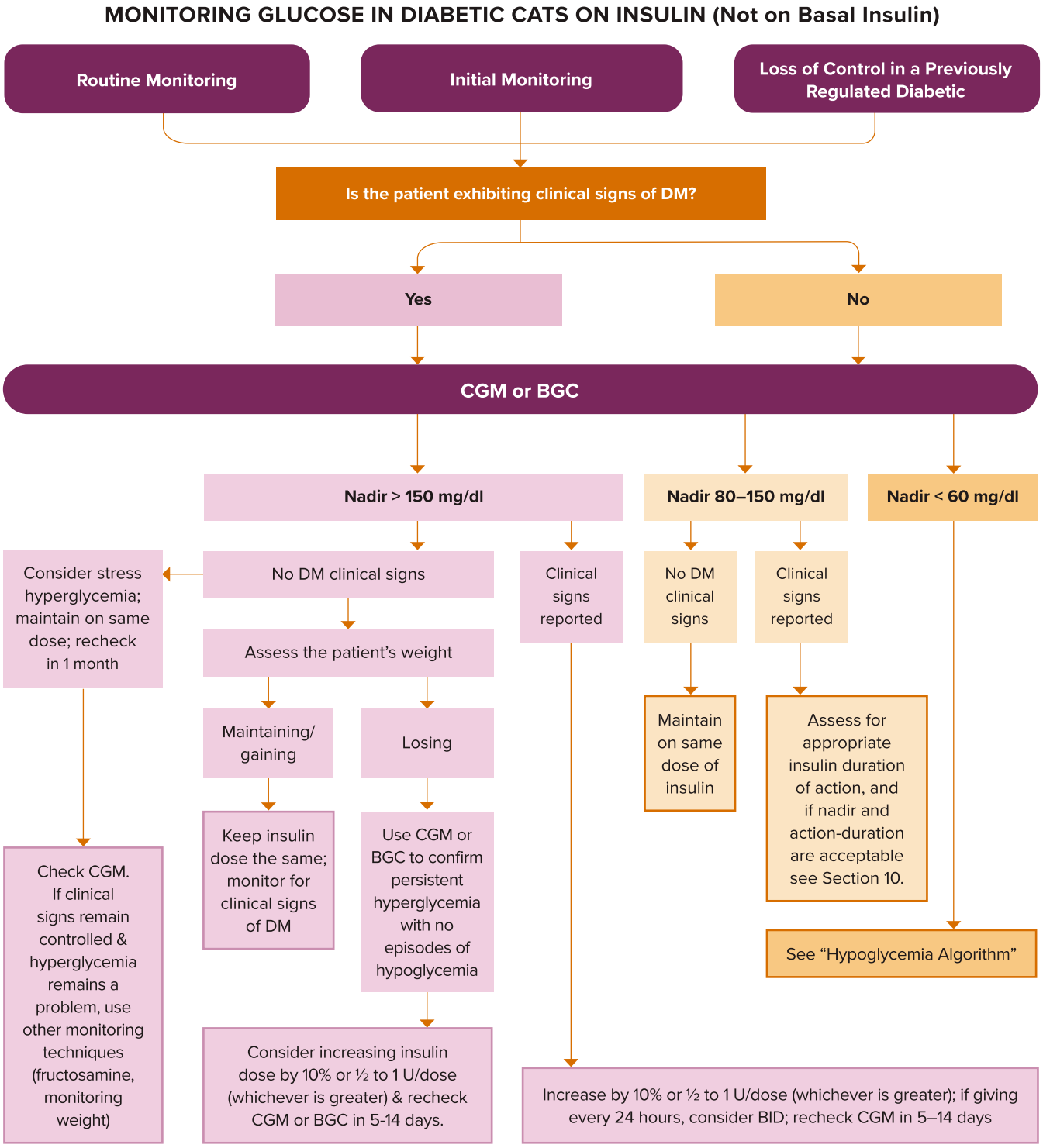

FIGURE 13.1

Monitoring Glucose in Diabetic Cats on Insulin (Not on Basal Insulin)

BID, twice daily; BGC, blood glucose curve; CGM, continuous glucose monitor; DM, diabetes mellitus; U, unit

a normal-sized meal and administering the patient's full insulin dose, for up to 10-12 hr.

A BGC should identify the lowest BG (i.e., the nadir) obtained, the duration of insulin action observed, and the range of BG fluctuation during the dosing interval. The ideal nadir is a BG of 80–150 mg/dL. As most insulin types are administered twice daily, an ideal duration of insulin effect is as close to 12 hr as possible. The BG readings should ideally range between 80 and 300 mg/dL during the BGC as long as the BG remains 200-250 mg/dL for most of the dosing interval assessed. Identifying these aspects of a BGC allows logical changes to be made to the patient's dosing regimen as needed.

A glucometer calibrated for use in veterinary patients may be the most practical and accurate method to serially monitor the BG.[72,73,74] Although glucometers designed for use in people are readily accessible to pet caregivers, the task force does not recommend their use owing to lack of veterinary-specific calibration, which can lead to inaccurate result reporting.

The first aim in regulating a diabetic is to achieve an acceptable nadir. If an acceptable nadir is not achieved, consider increasing the insulin dosage (Figure 13.1). An acceptable nadir with good clinical control may not be obtained if the insulin has a short duration of activity. Avoid prolonged (i.e., 1–2 hours) periods of hypoglycemia (BG <60 mg/dL) and consider reducing the insulin dose if noted or anytime a patient exhibits clinical signs of hypoglycemia. Once an acceptable nadir is achieved, duration of action—roughly defined as the amount of time BG is controlled (ideally 80-250 mg/dL)—can be determined. If either insufficient or excessive duration of insulin action is contributing to uncontrolled BG, change the frequency of insulin administration or, more commonly, transition to a new insulin type.

The Somogyi phenomenon, also called hypoglycemia-induced hyperglycemia, refers to hypoglycemia followed by marked hyperglycemia. It results from a physiological response when an insulin dose causes BG to be <60 mg/dL or when BG concentrations decrease rapidly over a short period of time. In either case, counter-regulatory hormones (e.g., cortisol, epinephrine, and glucagon) are released to increase BG. Rebound hyperglycemia usually occurs rapidly and can be followed by a period of sustained IR. If a Somogyi phenomenon is observed, decrease the insulin dose. Once the nadir is >60 mg/dL, counter-regulatory hormones will no longer interfere, and the true insulin effect will become apparent.[75]

Glucose curves are not perfect, so always interpret them in light of clinical signs and changes in body weight. Responses seen on a BGC vary from day to day and can be affected by deviation from the patient's normal routine.[76,77] Stress hyperglycemia can falsely elevate BG results and complicate BGC interpretation. See the *AAHA Diabetes Management Guidelines* resource center at aaha.org for examples of interpreting various glucose curves.

Transitioning to a new insulin type can occur several ways, and it is prudent to first review the time-action profile details of the new insulin to guide starting dose determination. The new insulin can be initiated at the specific recommended starting dose, keeping in mind that dose or administration frequency may differ between insulin types (such as switching from Vetsulin to PZI). When transitioning from a non-basal insulin to glargine U-300, initiating at either the recommended starting dose or at the same dose used with the previous insulin have been reported.[a] During transitions, monitor BG closely and consult with a specialist as needed.

a. Linari G, Fleeman L, Gilor C, Giacomelli L, Fracassi F. Insulin glargine 300 U/ml for the treatment of feline diabetes mellitus. *J Feline Med Surg*. 2022 Feb;24(2):168-176.

In-Hospital Blood Glucose Curves

In-hospital blood glucose curves are no longer recommended for routine diabetic monitoring in cats.

At-Home Blood Glucose Curves

Obtaining a BGC at home was the mainstay of feline diabetic monitoring for years prior to the introduction of CGMs, and this monitoring tool continues to be a helpful option in some cats. Not all clients are suited to the task of obtaining a home BGC. Clients frequently encounter problems such as needing more than one puncture to obtain a sufficient sample, inability to restrain a pet without help, and the pet's resistance to blood sampling.[79] Cats are susceptible to stress hyperglycemia at home for a BGC and the blood glucose values may reflect that.

Capillary blood is most suitable.[78] Common blood collection sites are the lateral ear or non–weight-bearing or accessory foot pads. If using lancing devices designed for pricking human fingertips, choose one with a variable needle depth often ranging from 1.0-5.0 mm. Cats may require a 1.0-1.8mm lancing depth when sampling from the ear or paw pad. While some task force members report patients exhibit less pain responses when using lancets, a hypodermic needle can also be used for sampling.[79] To ensure result accuracy, the lancing device must produce a droplet of blood sufficient for BG determination without requiring excessive manipulation of the pricked site, such as repeatedly squeezing the area to increase droplet size.

Even home BGCs can vary from day to day and must always be interpreted considering clinical signs and trends in the patient's

body weight.[80] Refer to the *AAHA Diabetes Management Guidelines* resource center at aaha.org/diabetes-management-cats for more detailed information and resources for clients on at-home monitoring using BGCs.

Continuous Glucose Monitoring Systems

Standard BGCs have limitations, such as large day-to-day variation in insulin responses and the possibility of missing hypoglycemia during the night. CGMs record interstitial glucose readings continuously over multiple days, which can help identify problems and allow more comprehensive assessments of BG control. CGM sensors are easily placed—even in less cooperative patients—and are generally as affordable as a BGC. A CGM also provides more physiological information for interpretation as glycemic activity is monitored in the patient's home environment and captures all aspects of their daily routine, such as meals, treats, and exercise.

The FreeStyle Libre (FSL) is a CGM system that reports an average interstitial glucose concentration every 15 min for up to 15 days. Successful use of the FSL has been reported in cats.[81,82,83] A 2019 study also reported its use in hospitalized patients with diabetic ketoacidosis.[84] Although not calibrated for veterinary patients, CGMs are typically used to follow BG trends over time and appear to be relatively accurate.[85] However, there can be discrepancies between glucose results reported by the FSL and AlphaTrak in some patients, with FSL accuracy in reporting low glucose readings often warranting further confirmation.[81] Training clients to confirm low FSL readings with a veterinary-calibrated PBGM, particularly when clinical signs of hypoglycemia are not evident, is recommended before making adjustments to therapy. A "Notes" feature in the FSL system allows clients to document timing of meals, insulin, exercise, or unexpected events (such as vomiting) to aid the veterinarian's assessment.

Inform clients that the sensors do not always function or remain attached to the patient for the full 15 days, but the information gained from even a few days of reporting is usually more helpful than a standard BGC. Reinforcing the FSL sensor adhesive pad with adhesive wipes or tissue glue and/or using a commercial sensor cover, T-shirt, or stockinette may help prevent inadvertent sensor removal.

Clients with real-time access to their pet's glycemic information can become noncompliant. For example, they may feel compelled to alter prescribed therapies based on glucose readings independent of veterinary guidance or seek frequent veterinary consultation by calling with every slightly abnormal reading. Additionally, clients can become preoccupied with the need to always know their pet's glycemic status. These clients may want a CGM placed on the patient continuously, even when it is not medically necessary. Educating clients and setting proper expectations regarding CGM use can help mitigate these concerns.

Section 14: Other Methods for Monitoring Glycemic Status

Top 3 Takeaways

1. Routine urine glucose measurement is not typically recommended for directing therapeutic decision-making because of low accuracy.
2. Fructosamine trends tend to be more useful than isolated values.
3. Control of clinical signs is an essential goal of diabetes treatment, and the presence or absence of clinical signs is often a more useful marker of clinical DM control than any glycemic data obtained.

Urine Glucose Measurements

UG concentration is only a reflection of the average BG over the time interval since the bladder was last voided. Therefore, routine UG measurement is not typically recommended.

Patients that have consistently negative UG should be screened for hypoglycemia. This finding may indicate tight BG regulation, excessive insulin dosages, or the onset of possible diabetic remission. However, a negative UG reading only means that BG was below the renal threshold (i.e., BG could have been 150 mg/dL or 40 mg/dL). The only way to know is to measure BG.[86]

Glycosylated Proteins

Serial measurement of fructosamine over time is more useful than spot determinations to evaluate trends in glycemic control. Declining fructosamine values indicate the average BG is decreasing over time, whereas increasing values indicate the opposite. A fructosamine concentration below the reference range is highly suggestive of chronic hypoglycemia, which should be verified with a BGC or a CGM assessment. Additionally, this scenario may indicate that a feline patient is entering diabetic remission.

Clinicians should consider the limitations of fructosamine as a marker of average BG over time. Short but clinically relevant periods of hypo- or hyperglycemia may not be identified and reduce the clinical utility of the reported result. For example, well-controlled diabetics may appear to have elevated fructosamine concentrations, or conversely, an uncontrolled diabetic may have normal concentrations.[87] Fructosamine may be elevated in sick, hyperglycemic but nondiabetic cats.[87]

Hemoglobin A1C (i.e., glycated hemoglobin) is commonly used to monitor diabetes in humans and has been described in veterinary medicine as a marker of mean BG over the preceding 2–3 mo.[20,88,89,90] A dried blood spot mail-in test card is commercially available for use in cats but has not yet been validated in diabetic cats.

Home Monitoring of Clinical Signs

Client perception of clinical signs in combination with serial monitoring of body weight is crucial to effective DM monitoring. Encourage clients to keep a daily log documenting their pet's appetite, thirst,

urinary habits (e.g., increased, normal, decreased), feeding (e.g., diet type, amount), and insulin dose administered, which can be brought in for review during each in-clinic recheck examination. When the patient has no clinical signs and the body weight is steady or increasing, DM is likely well controlled. Because clinical signs are subjective or possibly difficult to fully appreciate (such as water intake in cats), the use of automated devices monitoring food or water intake may improve objectivity as opposed to solely relying on client observations (see Section 11, Client Education).

Section 15: Algorithms for Managing Hypoglycemia and Troubleshooting in Cats

The following algorithms were originally published in the *2018 AAHA Diabetes Management Guidelines* and updated for these guidelines. These algorithms can assist with managing hypoglycemic patients and troubleshooting patients on high doses of insulin (excluding those on basal insulin).

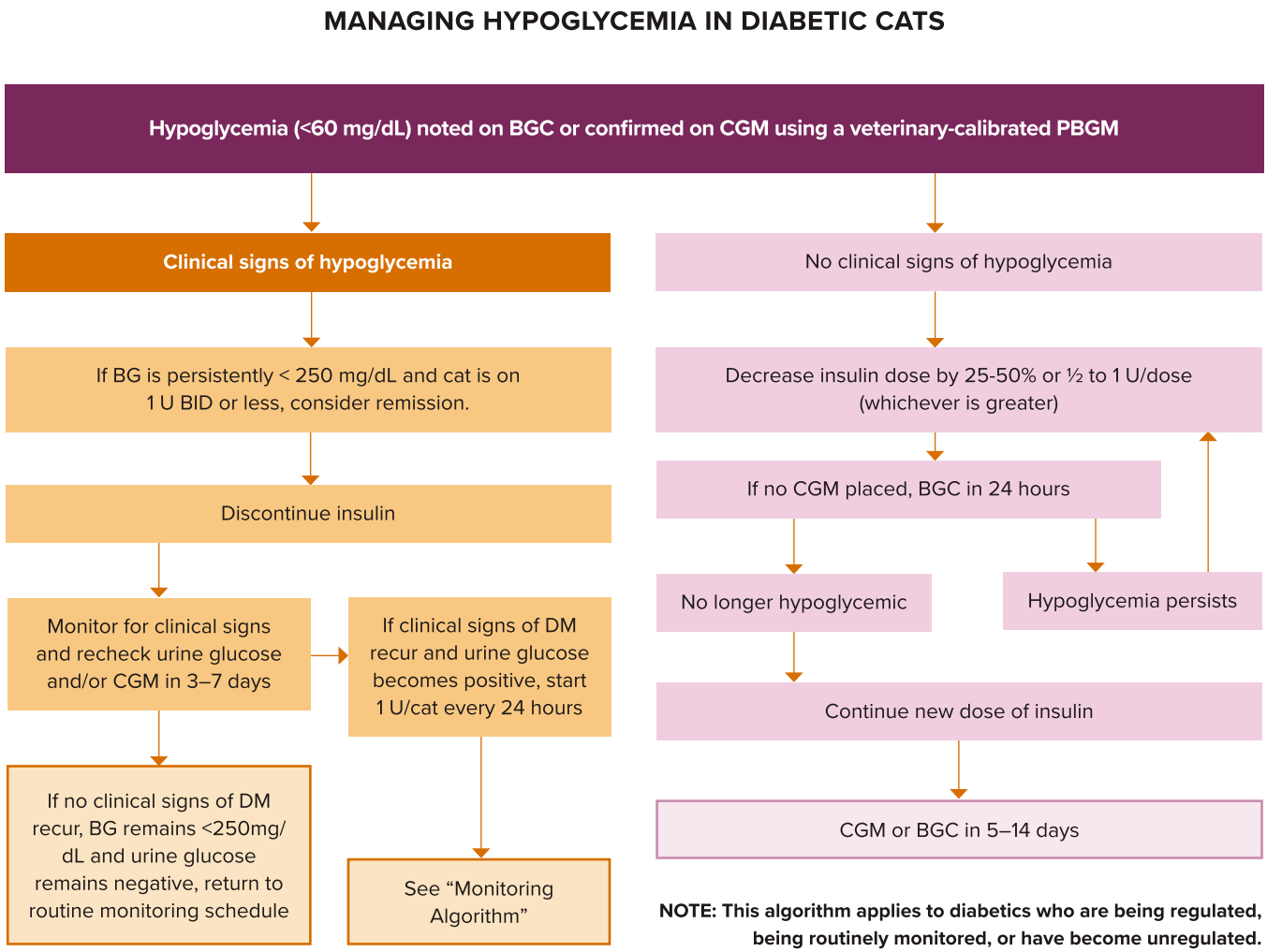

FIGURE 15.1

Managing Hypoglycemia in Diabetic Cats

BID, twice daily; BG, blood glucose; BCC, blood glucose curve; CGM, continuous glucose monitor; U, unit

TROUBLESHOOTING DIABETIC CATS RECEIVING HIGH DOSES OF INSULIN

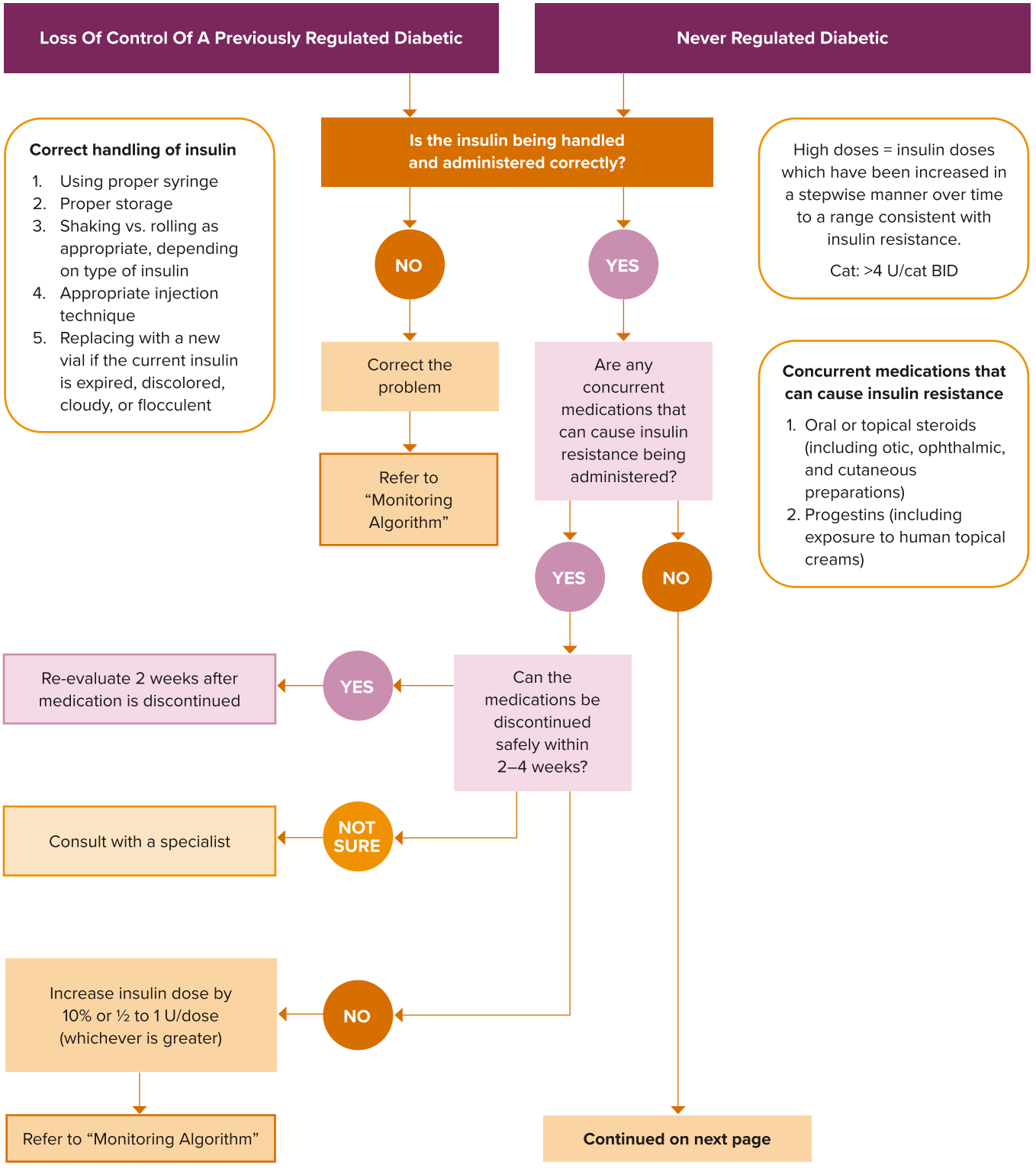

FIGURE 15.2

Troubleshooting Diabetic Cats Receiving High Doses of Insulin

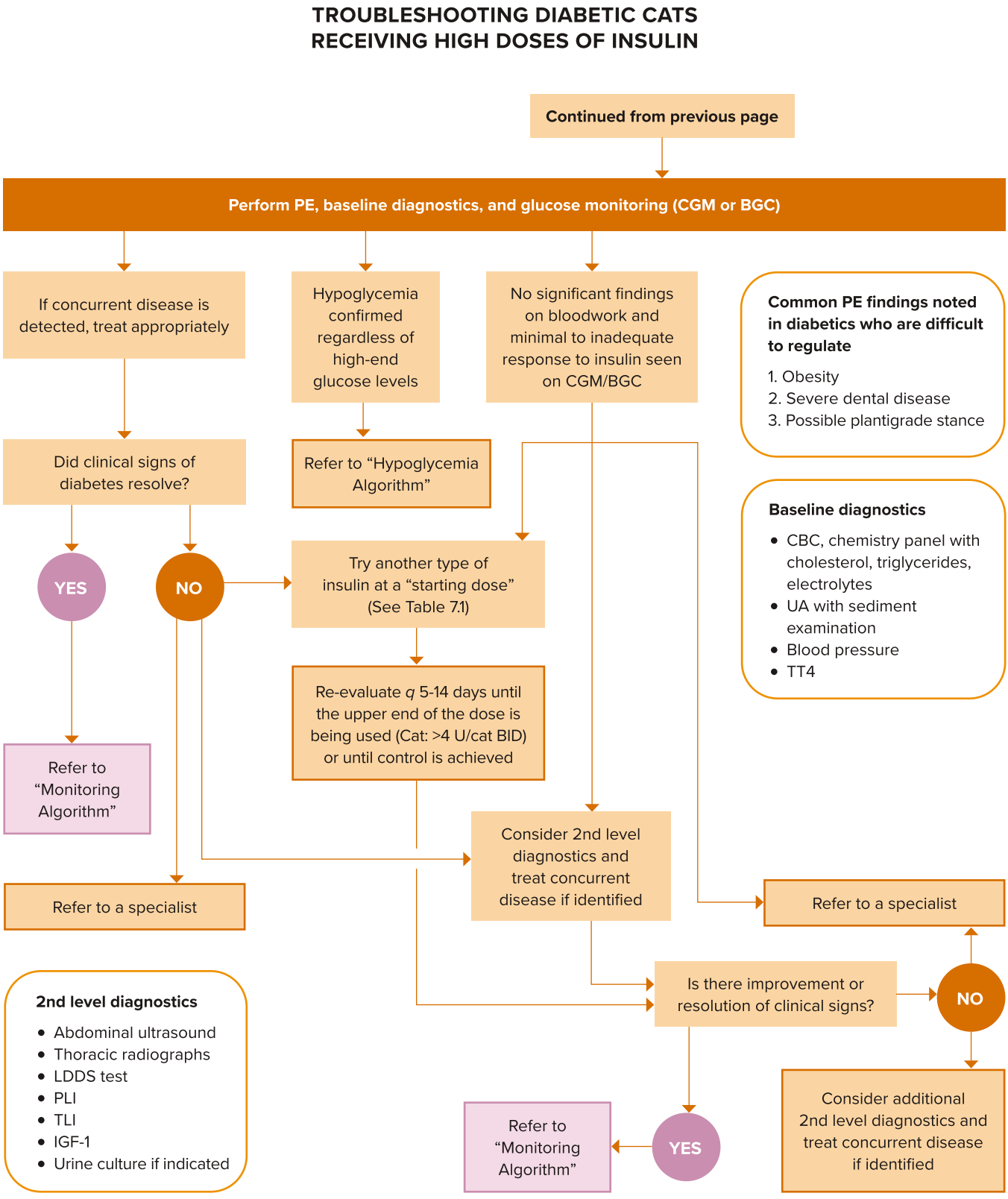

FIGURE 15.2, CONTINUED

Troubleshooting Diabetic Cats Receiving High Doses of Insulin

BGC, blood glucose curve; CBC, complete blood count; CGM, continuous glucose monitor; PE, physical examination; U, unit; UA, urinalysis

Conclusion

Diabetic cats can have a good quality of life with few or no clinical signs, facilitated by clients' and veterinary teams' commitment to attentive patient care and monitoring, dietary and schedule adjustments, and diligent follow-up evaluations. A rewarding outcome for diabetic pets starts with realistic but positive and honest conversations between clients and veterinary teams about expectations relating to treatment, patient monitoring, communication, goals, and the commitments required from those involved in the patient's care. Cats who develop diabetes can live comfortably with their condition for the rest of their lives, and some cats may experience disease remission.

Understanding appropriate patient selection for noninsulin therapies and the differences between insulin formulations and their effects is crucial. Diligent patient observation both at home and via intermittent evaluations in-clinic are essential to gauge therapeutic response, indicate when changes to treatment plans or additional diagnostic tests are needed, and detect or avoid complications associated with the disease or inadequate treatment. Enhancing patients' and clients' quality of life relies on resolving clinical signs through adequate, and not necessarily perfect, glycemic control.

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