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Diagnosis of prediabetes in cats: glucose concentration cut points for impaired fasting glucose and impaired glucose tolerance

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ABSTRACT

Diabetes is typically diagnosed in cats once clinical signs are evident. Diagnostic criteria for prediabetes in cats have not been defined. The objective of the study was to establish methodology and cut points for fasting and 2-h blood glucose concentrations in healthy client-owned senior cats (≥8 yr) using ear/paw samples and a portable glucose meter calibrated for feline blood. Of the 78 cats, 27 were ideal (body condition score [BCS] 4 or 5 of 9), 31 overweight (BCS 6 or 7), and 20 obese (BCS 8 or 9); 19 were Burmese and 59 non-Burmese. After an 18–24-h fast and an ear/paw blood glucose measurement using a portable glucose meter, glucose (0.5 g/kg bodyweight) was administered intravenous and blood glucose measured at 2 min and 2 h. Cut points for fasting and 2-h glucose concentrations were defined as the upper limits of 95% reference intervals using cats with BCS 4 or 5. The upper cut point for fasting glucose was 6.5 mmol/L. Of the overweight and obese cats, 1 (BCS 7) was above this cut point indicating evidence of impaired fasting glucose. The cut point for 2-h glucose was 9.8 mmol/L. A total of 7 cats (4 with BCS 8 or 9 including 1 Burmese; 3 with BCS 6 or 7, non-Burmese) were above this cut point and thus had evidence of impaired glucose tolerance. In conclusion, the methodology and cutpoints for diagnosis of prediabetes are defined for use in healthy cats 8 yr and older with a range of BCSs.

1. Introduction

In cats, 0.2% to 1% [1–3] are reported to be diabetic compared with 4 [4] to 10% [4,5] of humans. Humans with blood glucose concentrations above normal but below diabetic for fasting or at 2 h in a glucose tolerance test are classed as having impaired fasting glucose or impaired glucose tolerance respectively. They are considered prediabetic and develop diabetes at a rate of 5%–10% per yr [6,7]. It is estimated that more than 50% of humans in the United States of America with diabetes are undiagnosed [8], and the number with undiagnosed prediabetes is 3 to 4 times greater than with undiagnosed diabetes [8]. There are no corresponding data for cats in the veterinary literature. As in humans, there is a genetic predisposition for feline diabetes. Burmese cats from the United Kingdom and Oceania are approximately 4 times more likely to develop diabetes than other breed [9], with one in 50 affected [2].

Diagnostic criteria for subclinical and prediabetes in cats have not been defined, and cats are not typically diagnosed

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until clinical diabetes is evident. In obese cats, mild fasting or postprandial hyperglycemia is reported to be the only early sign of diabetes, before onset of classical signs of diabetes such as polyuria [10]. Reported upper limits for normal fasting blood glucose in cats vary from 6.1 mmol/L [11] to 9 mmol/L [12–14]; this variability is due at least in part to a lack of standardization of the test protocol.

Intravenous (IV) glucose tolerance tests are used to assess glucose tolerance in cats [15]. The 'gold standard' test requires multiple samples and interpretation can be difficult because of the complex calculations required to generate the necessary statistics such as glucose half-life, glucose clearance time, and area under the curve. Veterinarians need screening tests for impaired fasting glucose and impaired glucose tolerance that are inexpensive, noninvasive, and easy to perform and interpret in a clinical setting. A standardized IV glucose tolerance test would need a standardized glucose dose rate, fasting period, sampling times, and an established reference range applicable to all cats, lean, overweight, and obese.

Numerous portable blood glucose meters calibrated for human blood are used for glucose monitoring in cats [16–18]. Although precise, they are less accurate, typically measuring 0.5 to 2.2 mmol/L lower than a serum chemistry analyzer [19]. A meter validated for feline blood, requiring a 0.3-μL blood sample is now commercially available [20], facilitating successful blood sampling from the ear or foot pad and more accurate measurements. A simplified protocol for IV glucose tolerance testing in cats using this glucose meter has been reported using a glucose dose of 1 g/kg [7], but from a practitioner's perspective, the volume to be infused can be problematic. A glucose dose of 0.5 g/kg is typically used in cats for assessing glucose tolerance, whereas 1 g/kg is used for assessing maximal insulin secretory capacity.

Administering an IV glucose dose to overweight and obese cats based on bodyweight spuriously affects some measures of glucose tolerance [21]. This is presumed to occur because blood volume does not increase linearly with the increase in body weight due to obesity [22]. As a result, peak (2-min) glucose concentration is higher in obese cats, which subsequently increases 2-h glucose concentration when glucose is dosed on bodyweight [21]. This can be overcome by adjusting either the glucose dose or measured 2-h blood glucose concentration based on body condition score (BCS), so that one reference interval can be used for lean, overweight, and obese cats. To the authors' knowledge, these adjustments have not been applied to cats in the age group at risk of diabetes (≥8 yr).

The aims of this study were to establish methodology and cut points for fasting and 2-h blood glucose concentration in healthy client-owned senior cats of varying body condition using ear/paw samples and a portable glucose meter calibrated for feline blood, to compare these between Burmese and non-Burmese cats, to apply adjustment equations to 2-h blood glucose concentrations in overweight and obese cats.

2. Materials and methods

2.1. Study overview

The protocol for these studies and the care and handling of these animals were approved by the Animal Experimentation Ethics Committee of the University of Queensland approval number SVS/040/10/NC/ABBOTT. In 78 client-owned cats, fasting blood glucose was measured from a paw or ear sample using a portable glucose meter and then an IV glucose tolerance test was performed using a glucose dose of 0.5 g/kg. This was repeated in 8 of these cats 23 to 57 d later to determine variability over time. An IV glucose tolerance test using the same protocol but a glucose dose rate of 1 g/kg was also subsequently performed in 11 of the 78 cats.

2.2. Animals

Clinically healthy client-owned cats ≥8 yr (n = 90) were recruited though veterinary clinics, advertisements, and radio interviews between May 2011 and November 2012. Cats were tested at the University of Queensland Small Animal Clinic and a private specialist cat clinic. All cats included in the study appeared clinically healthy during the examination. The cats were not on any medications except routine flea and worming control. Exclusions were based on hematological and biochemical panels, BCS of ≤3 of a 9-point scale [23] and behavior of the cats. Exclusions (n = 12) were for stress/aggressive behavior (n = 3), suspected pancreatitis based on increased feline pancreatic specific lipase (fPLI) of >3.5 μg/L in line with the general interpretive guidelines of our reference laboratory (n = 2), hyperthyroidism (n = 3), ongoing health issues (n = 2), pancreatic cancer (n = 1), and BCS ≤3 of 9 (n = 1). Remaining cats (n = 78) were classified as non-Burmese (n = 59) or Burmese (n = 19). Body condition scores of the cats (out of 9) [23] included in the study were all assessed by one person (M.R.J.) and were 4 (8 cats), 5 (19 cats), 6 (14 cats), 7 (17 cats), 8 (14 cats), and 9 (6 cats). Data were collected on diets of the study cats and consisted of a variety of supermarket, premium, and home-cooked dry and tinned food.

2.3. Protocol

Cats were admitted to the hospital the day before the glucose tolerance tests and all cats stayed overnight. On admission, a 5-mL venous blood sample was collected for a routine health screen performed by a commercial veterinary diagnostic laboratory (Idexx Laboratories, Brisbane, Australia). The following morning, after food was withheld for 18 to 24 h, a jugular venous blood sample (4 mL) was collected for hormone assays and then a 22-gauge catheter (Surflo 22G ×1″ intravenous catheter, Terumo Europe, Belgium) was placed in the cephalic vein and flushed (2 mL 0.9% sodium chloride [Baxter]). To allow for resolution of stress hyperglycemia, fasting blood glucose was measured 3 h after catheter placement [24]. A portable glucose meter calibrated for feline blood (Abbott Alpha Trak) was used and the sample obtained from the paw or ear. Glucose (undiluted 50% glucose injection BP [British Pharmacopoeia]; Astra Pharmaceutical; 0.5 g/kg) was then administered IV over 30 s via the catheter. A timer was started halfway through the infusion and blood samples were taken at 2 min, 2 h, and then hourly until glucose returned to below our laboratory's upper limit of normal fasting glucose concentration of 6.5 mmol/L [25]. On completion, the catheter was removed, cats were fed and discharged.