

Welcome
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you're here!

 **MEDVET**
CONFERENCE

Diabetic Monitoring: CGMs, Fructosamine and Hemoglobin A1C

Liz Lee, DVM, Residency Trained in Small Animal Internal Medicine

MedVet Northern Utah

MedVet Salt Lake City

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Learning Objectives

- Understanding the difference between continuous glucose monitors, fructosamine and hemoglobin A1C
- Recognizing clinical situations for which a CGM, fructosamine and hemoglobin A1C may be best utilized
- Understanding the limitations of varying diabetic monitoring tools

Outline

- Review of traditional diabetic monitoring tools
- Fructosamine
- Hemoglobin A1C
- Continuous glucose monitors, emphasis on Freestyle Libre

Traditional Diabetic Monitoring Tools

Clinical Signs

- The MOST IMPORTANT
- History
 - Open ended questions
 - Sliding scales for PU/PD or polyphagia
- PE
 - Weight



Spot BG

- Only relevant if low



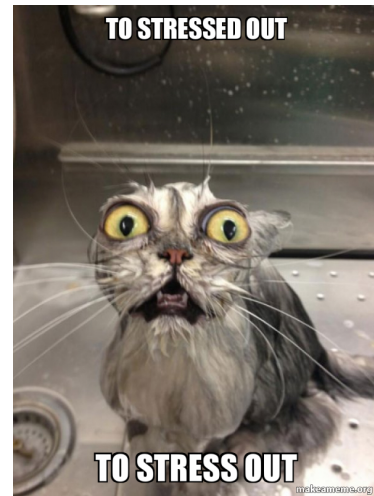
In Hospital BG curves

- Utility

- Assessment of overall trend
 - Nadir
 - Duration of action
- Monitoring of hypoglycemic events

- Cons

- Stress hyperglycemia
- Unfamiliar environment
- Patient compliance
- Staff time



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DOI: 10.1111/jvim.15930

STANDARD ARTICLE



Journal of Veterinary Internal Medicine

Open Access

ACVIM

American College of
Veterinary Internal Medicine

Comparison between a flash glucose monitoring system and a portable blood glucose meter for monitoring dogs with diabetes mellitus

Francesca Del Baldo¹ | Claudia Canton¹ | Silvia Testa¹ | Harry Swales²  |
Ignazio Drudi³ | Stefania Golinelli¹ | Federico Fracassi¹ 

Case Study

- BG curves collected q2hr in hospital compared to CGM of same patient
- No significant difference between therapeutic recommendations based on different data sets
- In hospital BG curves did not capture day to day variation or all nadirs

In Hospital BG curves

Greatest utility with hospitalized sick patients

- DKA
- After iatrogenic hypoglycemia



At Home BG curves

- Pros

- Normal environment and routine
- Can track day to day variation

- Cons

- Owner dependent
- Multiple blood draws
- May still miss nadir

Urine Dipsticks

- Glucosuria is expected in DM
 - Exception feline entering remission
- Affected by hydration status
- Renal threshold is likely variable between individuals

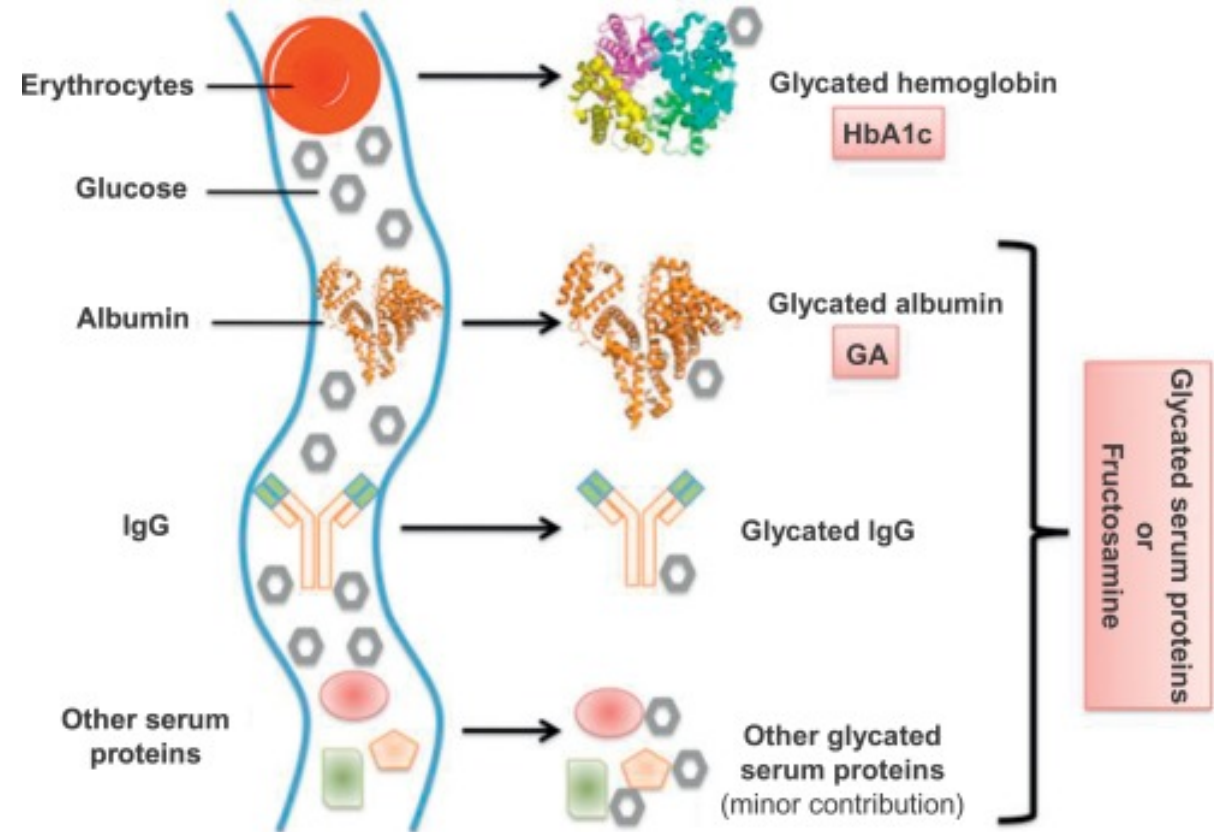


Urine Dipsticks

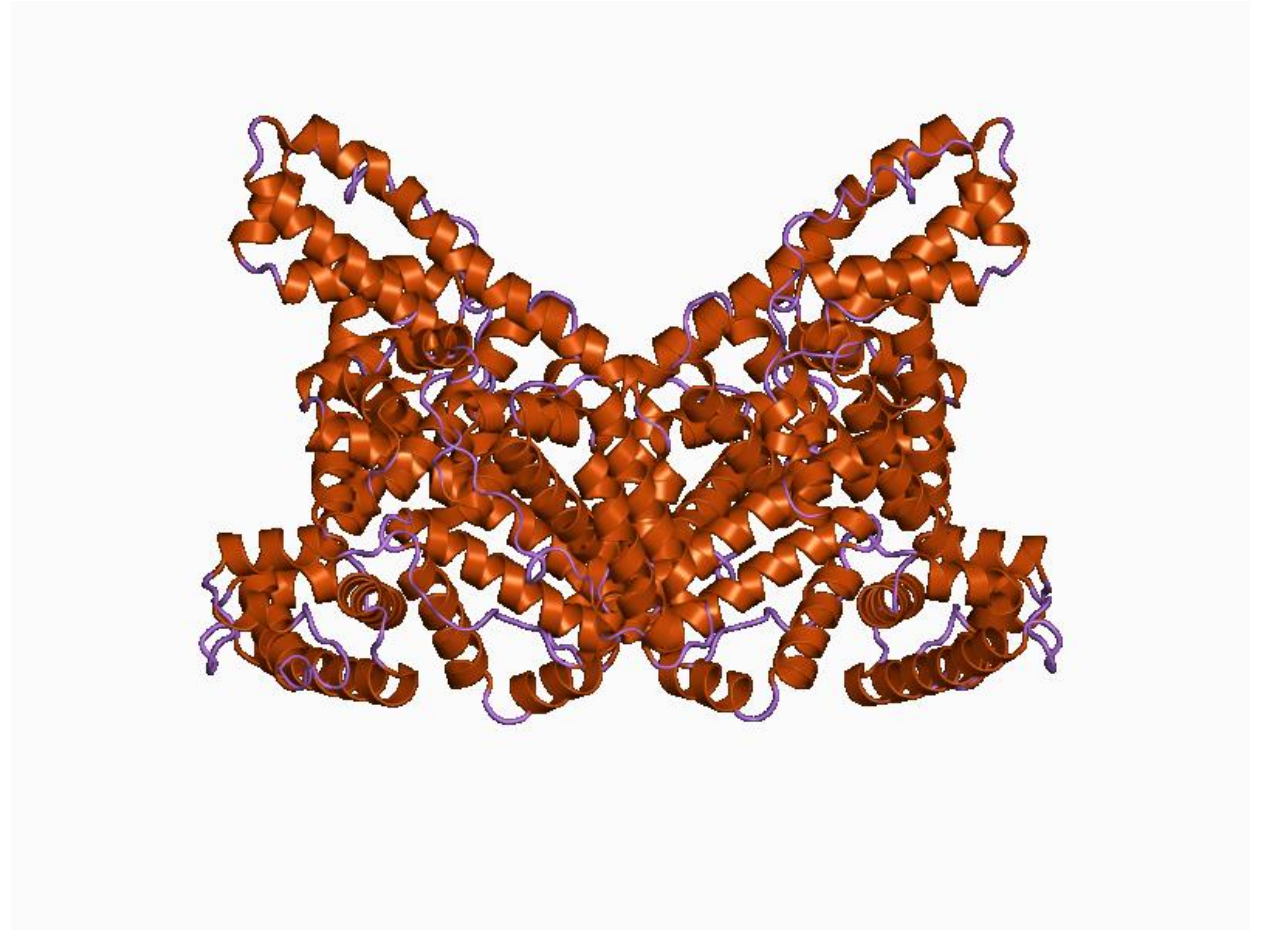
Utility

- Assessing for persistent ketonuria**
 - Only detect acetoacetic acid
- Assessing for lack of glucosuria in suspected overcontrolled patients
- Not meant to dictate changing insulin dosing
- Provides homework for owners

Glycated Proteins



Fructosamine



Fructosamine

- Glycosylated protein
 - Irreversibly binds plasma protein
- Influenced by
 - Severity of hyperglycemia
 - Duration of hyperglycemia
- Long term reflection of glycemic control
 - Cats 1-2 weeks
 - Dogs 2-3 weeks
- Widely available through diagnostic labs

Fructosamine

Affected by

- Protein turnover
 - Enteropathies
 - PLN
 - Hyperthyroidism
 - Azotemia
 - Hyperlipidemia
- Produced in the liver
 - All may cause falsely low results

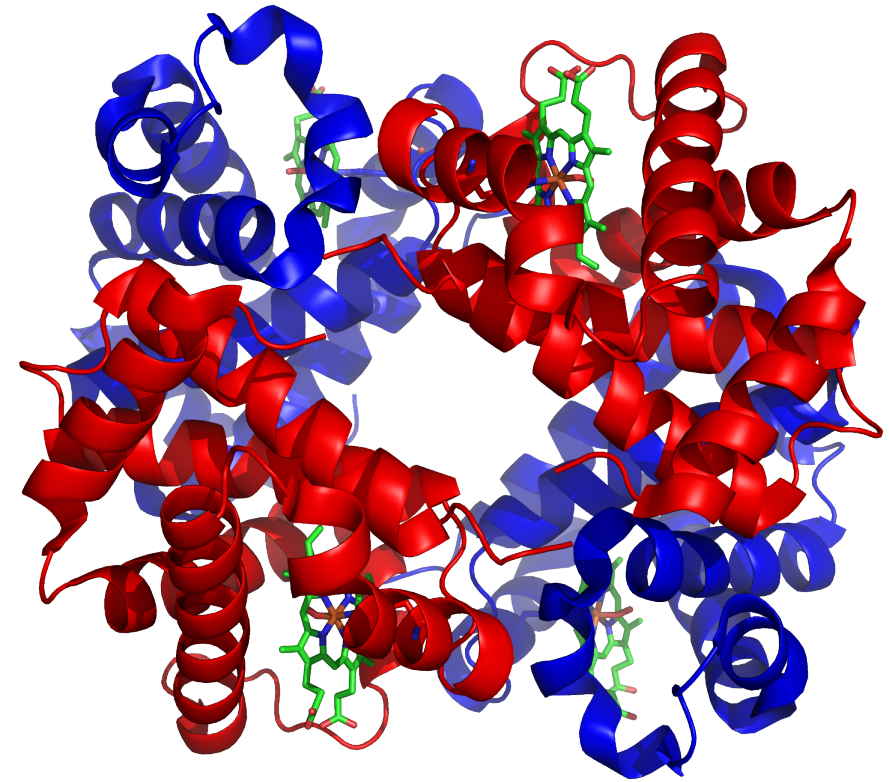
Fructosamine: Clinical Indications

- Ruling out stress hyperglycemia
- Routine monitoring of DM control
 - Recommend using same lab for comparisons
- Non-diabetics
 - 200-360 mmol/L

Control	Over	Good	Fair	Poor
Dog	<300	350-425	425-500	>500
Cat	<300*	350-450	451-550	>550

*diabetic remission

Hemoglobin A1C



Hemoglobin A1C



- Glycosylated protein
 - Irreversibly binds hemoglobin
- Influenced by
 - Severity of hyperglycemia
 - Duration of hyperglycemia
- Well correlated with fructosamine
- Long term reflection of glycemic control based on RBC life
 - Cats 70 days (~2 mo)
 - Dogs 110 days (~ 3 mo)

Hemoglobin A1C

- Not influenced by protein turnover
- Anemia may lead to falsely low results
- Not as widely available
 - Baycom Diagnostics - \$99 suggested client price

Hemoglobin A1C: Clinical Indications

- Concurrent enteropathy or disease with high protein turnover
- Routine monitoring
- Extended RBC half life compared to plasma protein may not be as clinically useful for subacute changes

		A1c (HbA1c) Levels			
		Average Normal	Normal	Transitional	DIABETES
 Feline	1.8	0 to 4	4 to 6	6 to 12	12 to 30
 Canine	3.3	0 to 4	4 to 6	6 to 12	12 to 30

A1c levels are reflective of the average glucose levels for the last 70 days in Felines and the last 110 days in Canines.

Baycom diagnostics

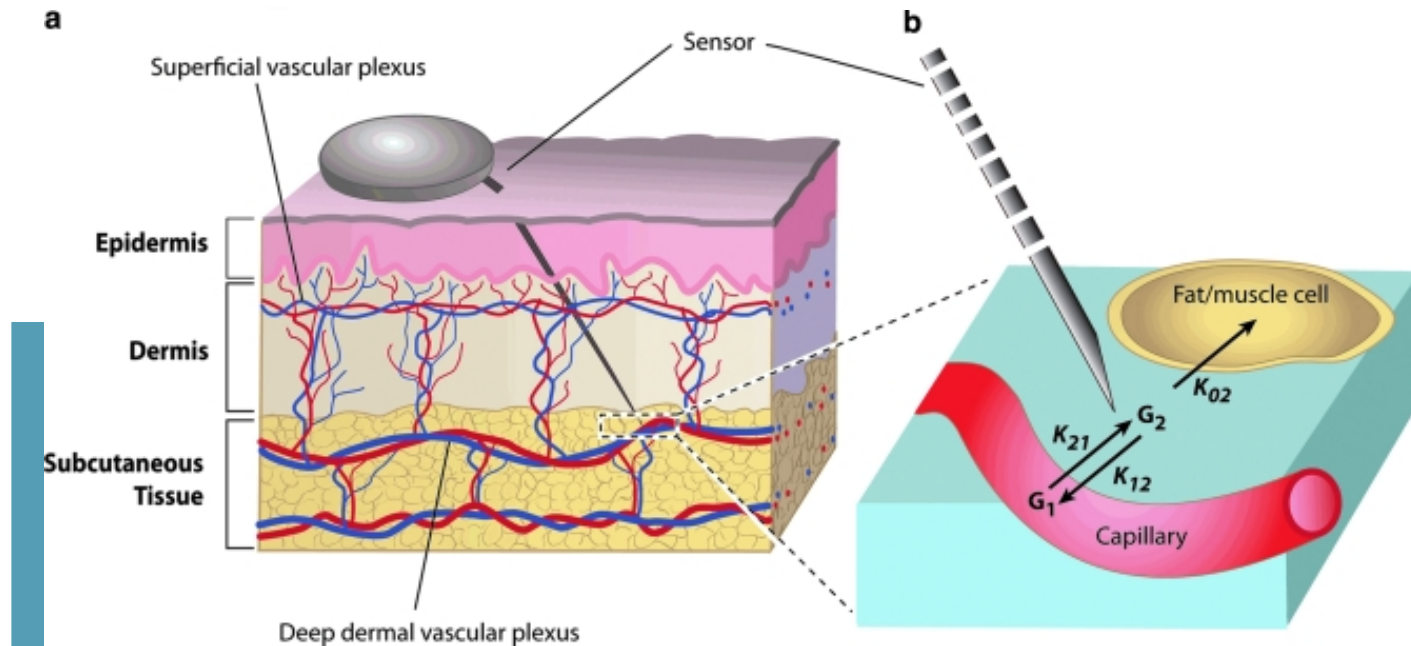
Glycosylated Proteins

- Always interpret in conjunction with clinical signs
- A high value only indicates inadequate glycemic control, but does not tell you why
- If high investigate an underlying cause

Continuous Glucose Monitors (CGM)

CGM

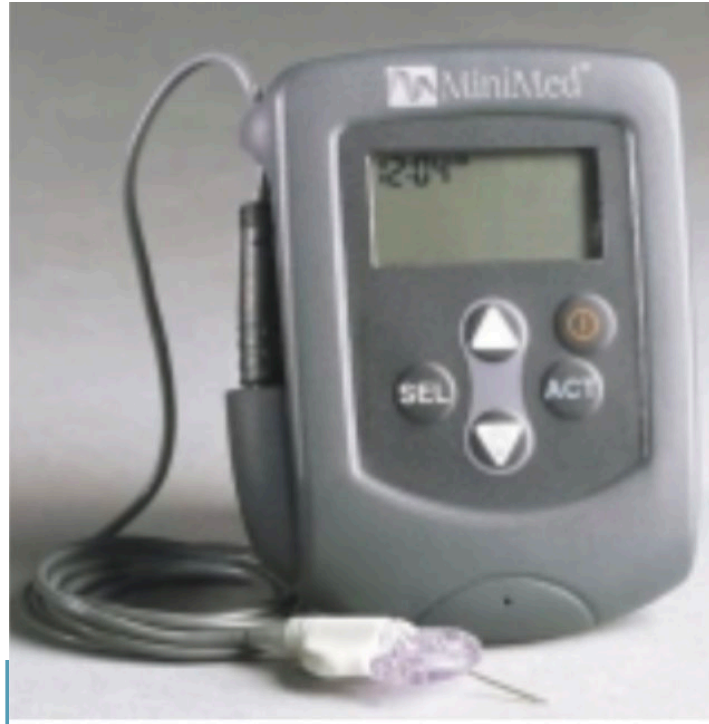
- Measurement of interstitial glucose through probe within interstitial space
- Obtains more frequent measurements (minutes)



<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2903977/>

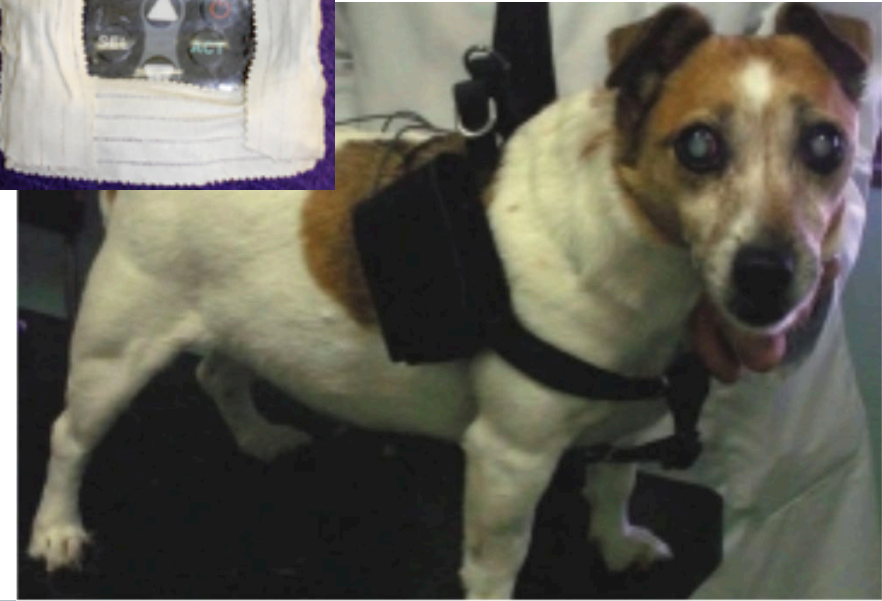
CGM

- 2003 first devices used in veterinary patients
- Measurements every 5 min
- Consisted of probe with separate recording device
- Calibration with spot BGs required after placement
- Data not available immediately



CGM

- 2003 first devices used in veterinary patients
- Measurements every 5 min
- Consisted of probe with separate recording device
- Calibration with spot BGs required after placement
- Data not available immediately



CGM: Freestyle Libre

- Freestyle Libre
 - Flash Glucose Monitoring System (FGMS)
- Measurements every min for 14 days
- Must be scanned every 8 hours
- No need for calibration
- Smaller footprint and easier application



CGM: Freestyle Libre

- Day to day variation
- Circadian fluctuations
- Post prandial hyperglycemia
- Client and practice friendly user interface
 - Separate sensor
 - iPhone and Android apps





Search Patients



MedVet Utah

1 Filter

MedVet Utah

8 Columns

2 weeks

0/5

Last Name	First Name	Date of Birth	Last Available Data	Average Glucose...	Average Scans/Views pe...	% In Target	LibreView User Status
Brown	Kazu	4/5/2014	a day ago	416	5	0	Connected
Cionni	Candy	1/1/2009	12/14/2020	434	5	0	Connected
Coon	Moqui	12/1/2009	10/16/2020	435	3	0	Connected
Dalton	Isis	9/1/2006	11/3/2020	261	6	21	Connected
Danner	Angel	4/15/2008	12/6/2020	408	4	1	Connected
Ellerbeck	Guenhwyvar	9/1/2009	1/22/2021	316	14	7	Connected
Fournier	Nola	12/29/2013	1/1/2021	385	2	0	Connected
Kenney	Frank	3/2/2008	12/30/2020	328	21	14	Connected
Lowe	Madison	9/1/2015	9/19/2020	217	9	48	Connected
Lowe	Madison	6/15/2005	No Uploads				Connected
Mangum	Weasley	8/7/2013	10/29/2020	385	5	4	Connected
Maximus	Charles	2/12/1995	1/11/2021	281	3	19	Connected
Mayers	Scooter	12/15/2006	9/30/2020	199	27	57	Connected
McNally	Roxy	4/11/2011	12/2/2020	351	8	7	Connected
Morales	Sammy	3/24/2000	10/14/2020	98	1	78	Connected
Parkanzky	Max	7/11/1988	No Uploads				Pending Resend
Preston	Parker	12/6/2008	10/19/2020	186	4	41	Connected
Sargaleis	Alex	6/6/2010	a day ago	412	5	2	Connected

Download Current View

AGP Report

Glucose Pattern Insights

Monthly Summary

Daily Log

Snapshot

Mealtime Patterns

Weekly Summary

Reader Details

Daily Patterns




1 of 1



Cooper Risso

MRN: _____

UC Davis VMTH SA Internal Medicine

PAGE: 1 / 1

DOB: 01/29/2009

DEVICE: FreeStyle Libre

PHONE: 530-752-1393

GENERATED: 02/07/2021

AGP Report

January 24, 2021 - February 6, 2021 (14 Days)

LibreView

GLUCOSE STATISTICS AND TARGETS

January 24, 2021 - February 6, 2021 **14 Days**
% Time CGM is Active 92%

Ranges And Targets For	Type 1 or Type 2 Diabetes
Glucose Ranges	Targets % of Readings (Time/Day)
Target Range 70-180 mg/dL	Greater than 70% (16h 48min)
Below 70 mg/dL	Less than 4% (58min)
Below 54 mg/dL	Less than 1% (14min)
Above 180 mg/dL	Less than 25% (6h)
Above 250 mg/dL	Less than 5% (1h 12min)
Each 5% increase in time in range (70-180 mg/dL) is clinically beneficial.	

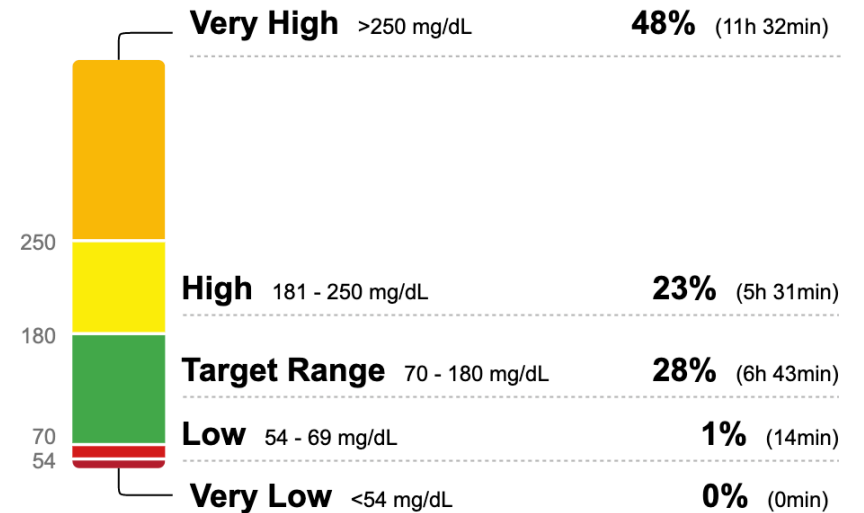
Average Glucose 251 mg/dL

Glucose Management Indicator (GMI) 9.3%

Glucose Variability 40.2%

Defined as percent coefficient of variation (%CV); target ≤36%

TIME IN RANGES



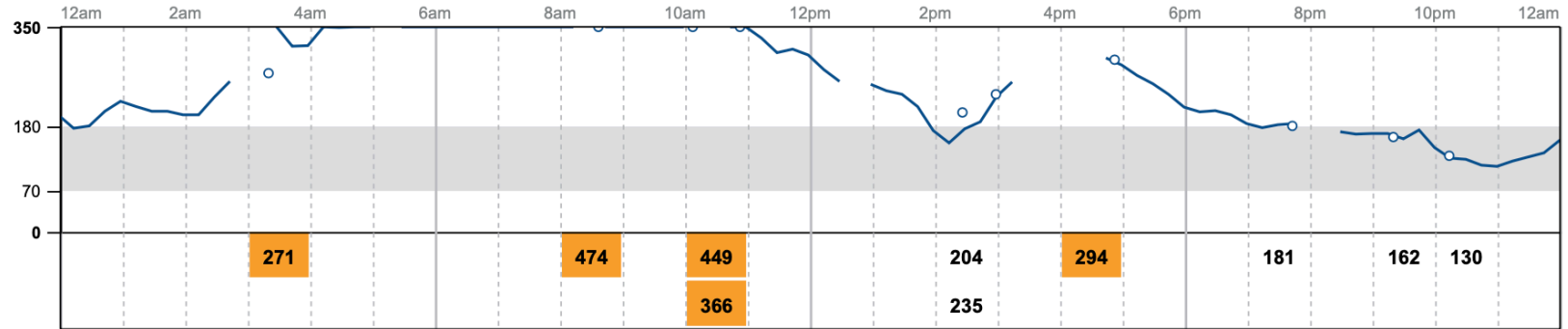
AMBULATORY GLUCOSE PROFILE (AGP)

Daily Log

January 24, 2021 - February 6, 2021 (14 Days)

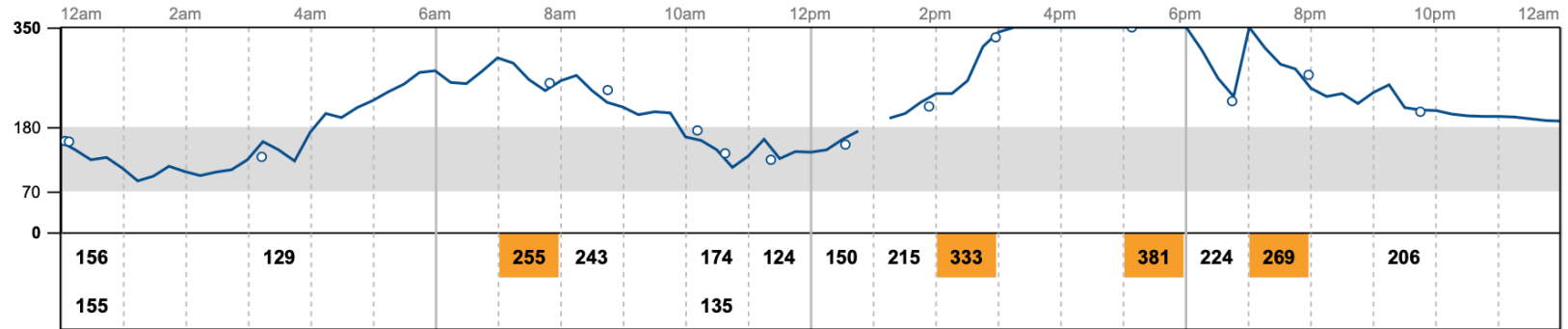
SUN Jan 24

Glucose mg/dL



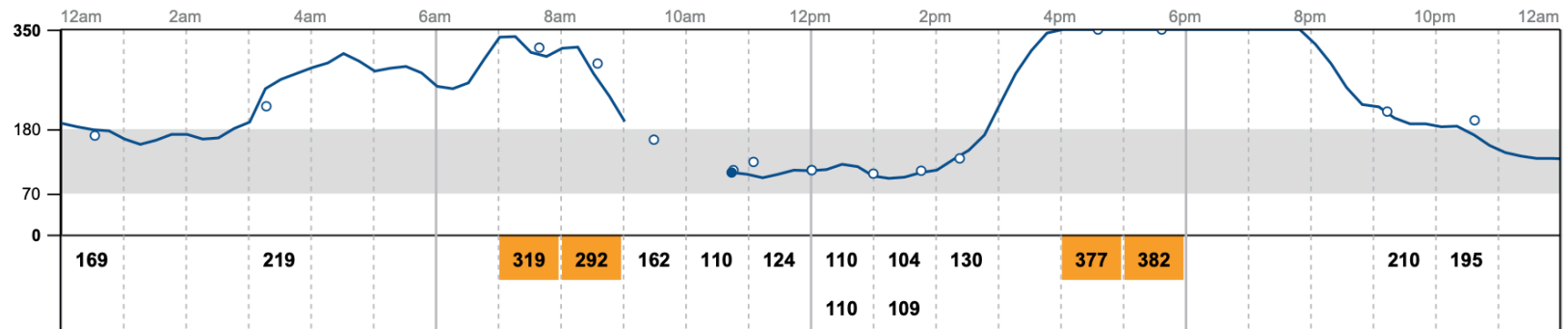
MON Jan 25

Glucose mg/dL



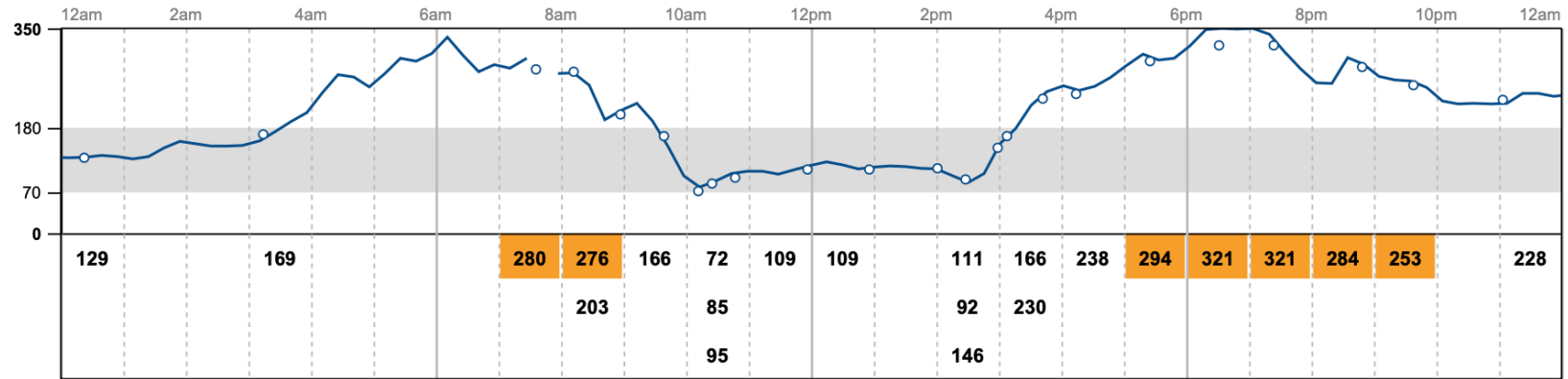
TUE Jan 26

Glucose mg/dL



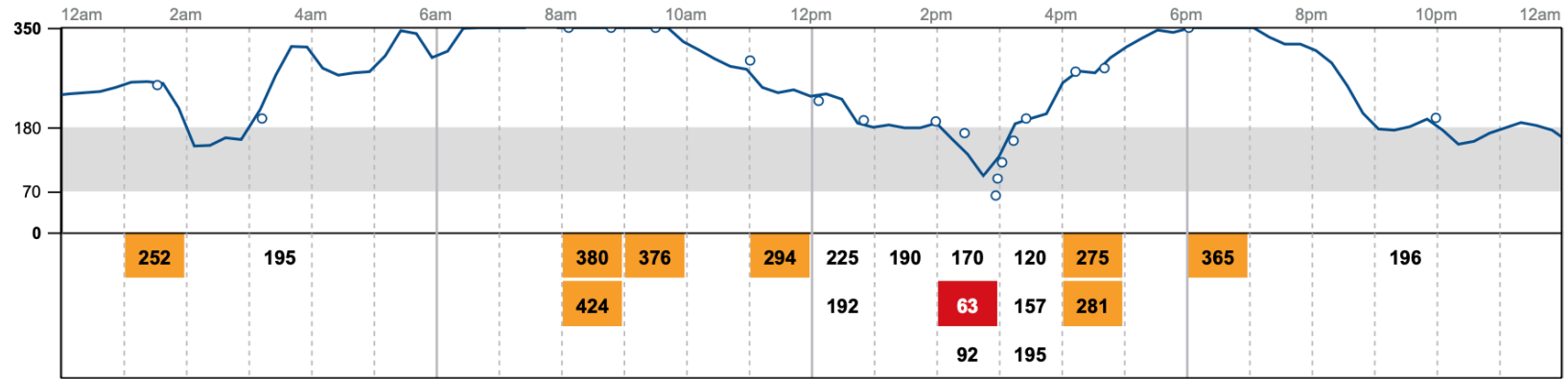
WED Jan 27

Glucose mg/dL



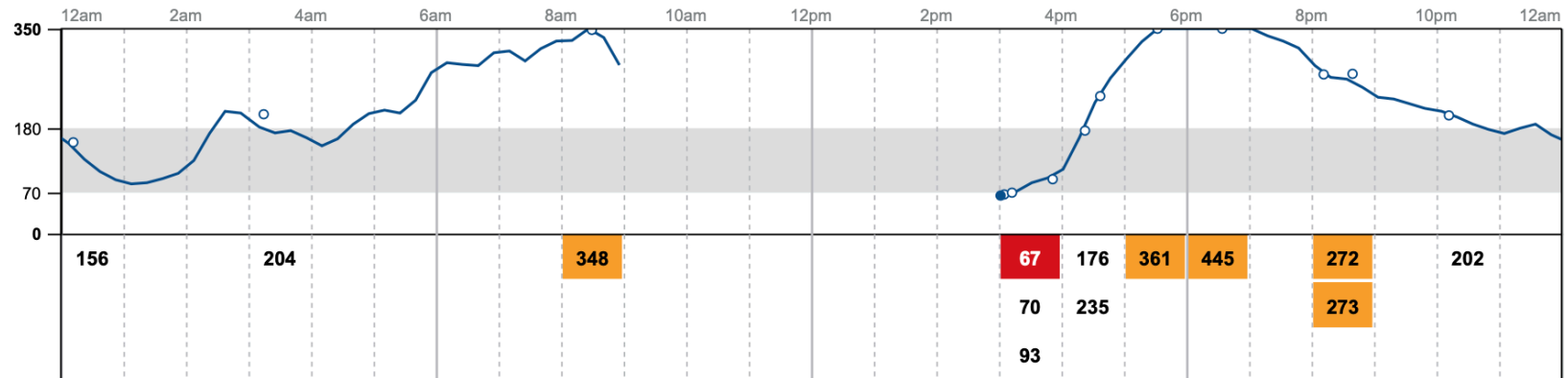
THU Jan 28

Glucose mg/dL



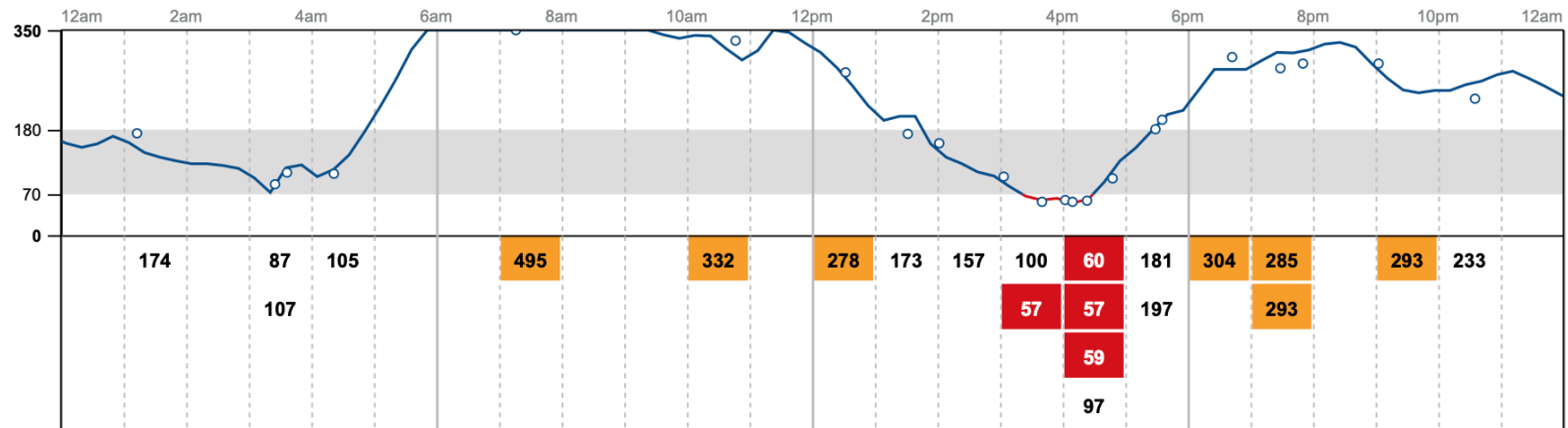
FRI Jan 29

Glucose mg/dL



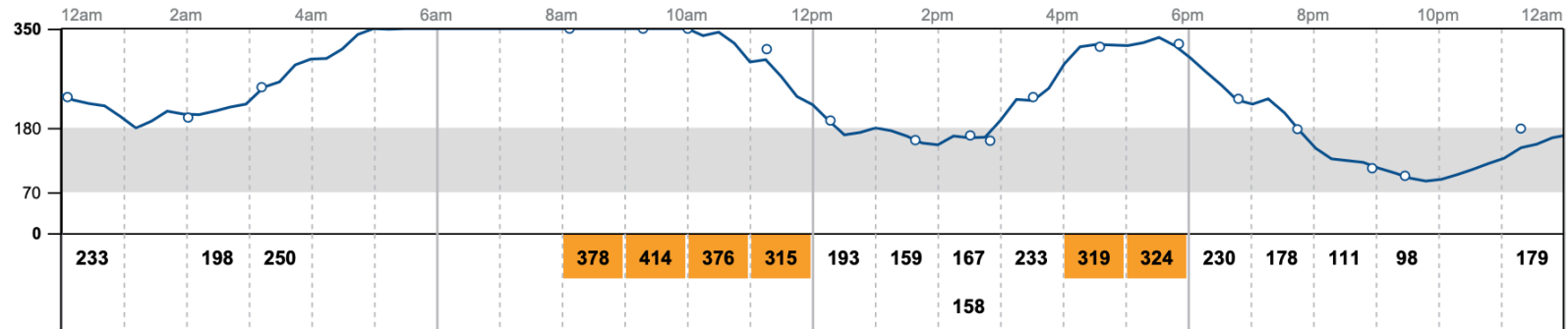
SAT Jan 30

Glucose mg/dL



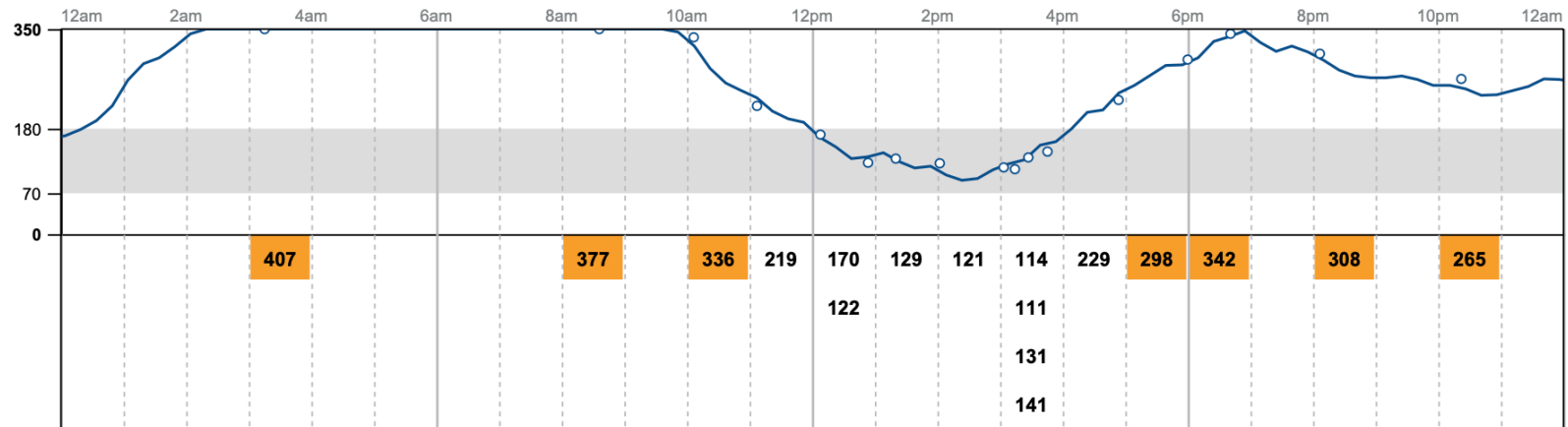
SUN Jan 31

Glucose mg/dL



MON Feb 1

Glucose mg/dL



CGM: Limitations

- Comorbidities associated with large fluid shifts
 - DKA??
- Sensor detachment/failure
- Adhesion site erythema
- Accuracy decreases at low and high readings
- Owner comfort

Shoelson et al JFMS 2020, Malerba et al JVIM 2020, Corradini et al JVIM 2016, DeIbaldo et al JVIM 2020

CGM: DKA

Original Study

Journal of Veterinary Emergency and Critical Care 20(3) 2010, pp 303–312
doi: 10.1111/j.1476-4431.2010.00538.x

Accuracy of a continuous glucose monitoring system in dogs and cats with diabetic ketoacidosis

Erica L. Reineke, VMD, DACVECC; Daniel J. Fletcher, DVM, PhD, DACVECC; Lesley G. King, MVB, DACVIM, DACVECC and Kenneth J. Drobatz, DVM, MSCE, DACVIM, DACVECC

- 13 dogs, 11 cats
- Covariants assessed
 - Hydration, BCS
 - Calibration frequency 8 vs 12 hours
 - Severity of ketosis

Received: 24 October 2018 | Accepted: 23 October 2019
DOI: 10.1111/jvim.15657

STANDARD ARTICLE

Journal of Veterinary Internal Medicine 
Open Access American College of Veterinary Internal Medicine

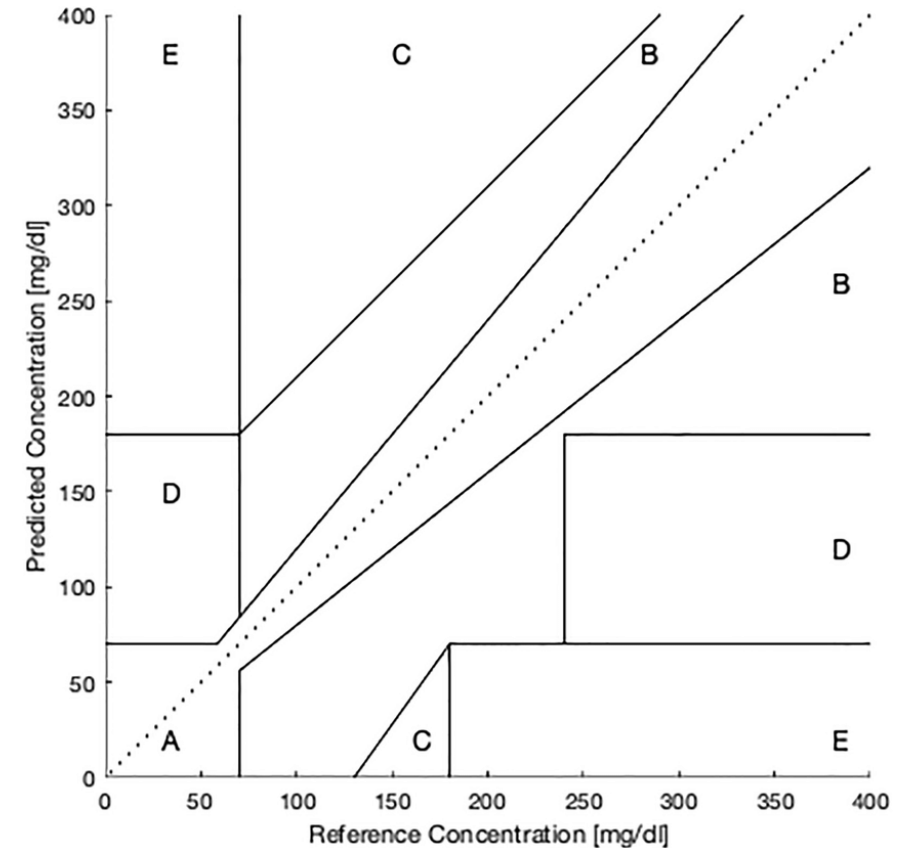
Accuracy of a flash glucose monitoring system in dogs with diabetic ketoacidosis

Eleonora Malerba¹ | Chiara Cattani¹ | Francesca Del Baldo¹ | Gaia Carotenuto¹ | Sara Corradini¹ | Stefania Golinelli¹ | Ignazio Drudi² | Federico Fracassi¹ 

- 14 dogs
- Covariants assessed
 - BCS
 - Low (BG <100), High (BG >100)
 - Resolution of DKA

CGM: DKA – Error Grid Analysis

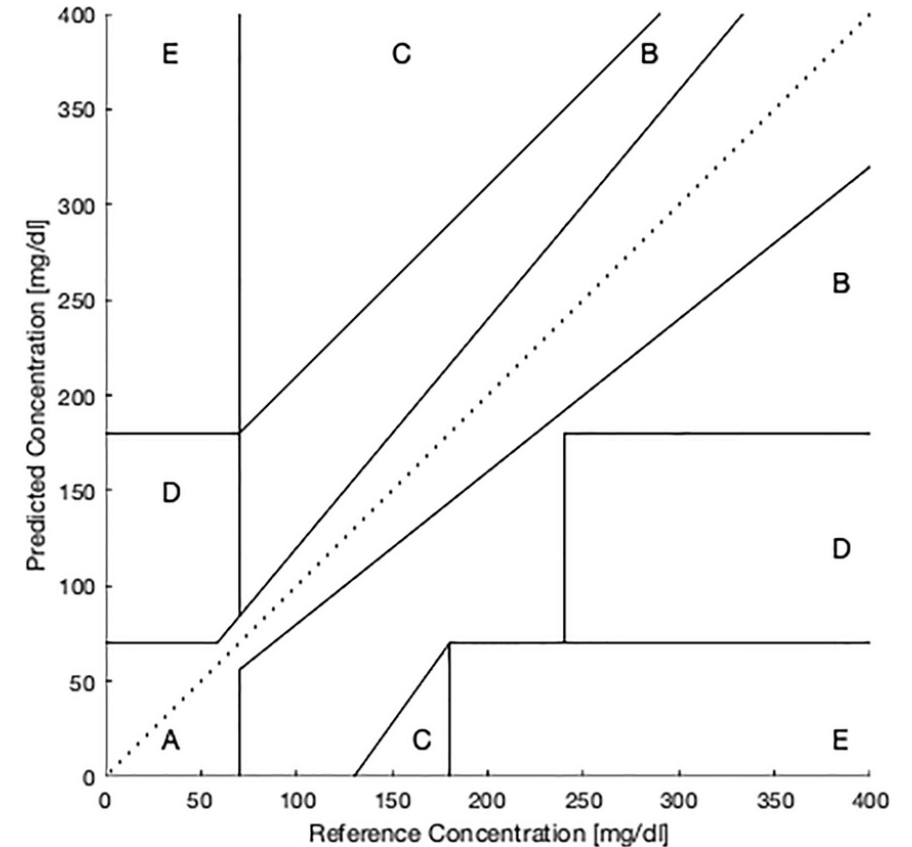
- Categorization of BG measurement errors in relation to clinical risk for diabetes mellitus
- 99% of points should be in Zone A/B



<https://doi.org/10.1371/journal.pone.0225613.g006>

CGM: DKA – Error Grid Analysis

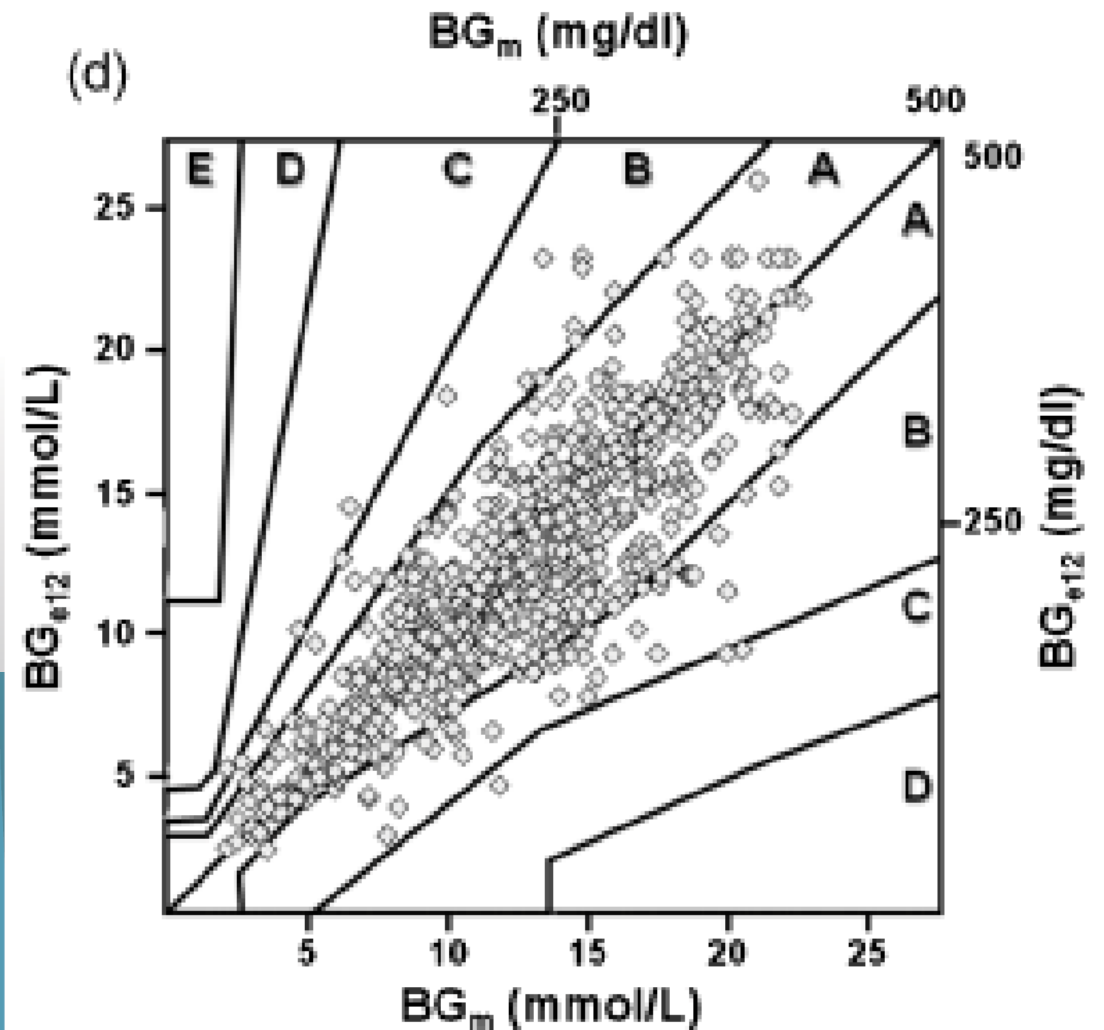
- Zone A: within 20% variability
- Zone B: $> 20\%$ no change in alteration treatment
- Zone C: overcorrection of an acceptable glucose value
- Zone D: no correction when treatment should be administered
- Zone E: erroneous treatment



<https://doi.org/10.1371/journal.pone.0225613.g006>

CGM: DKA

- Clinical accuracy
 - 96.7-100% in Zones A/B
- No statistical significance BCS, severity ketosis, resolution DKA
- Weak association hydration status
- High interpatient variability

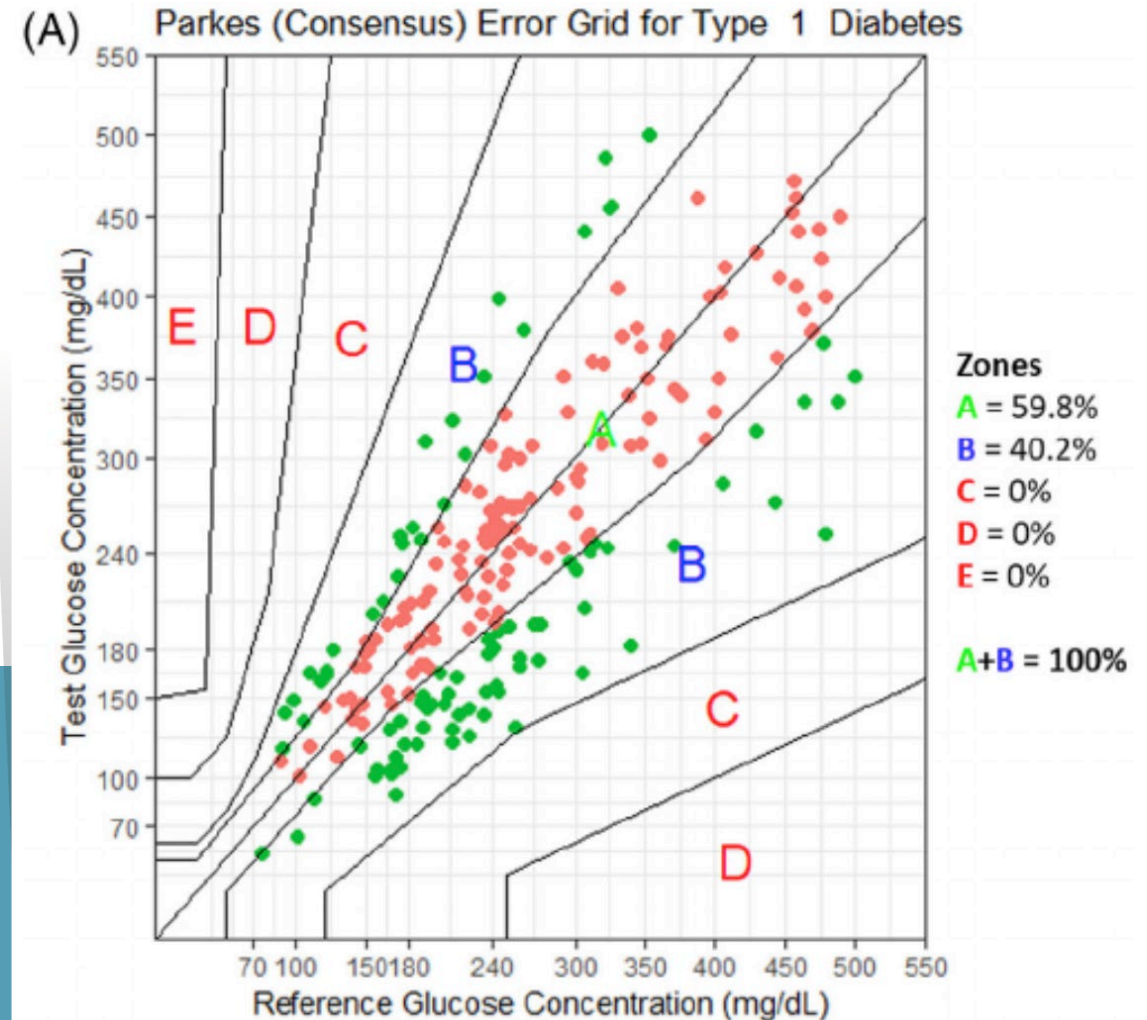


MEDVET

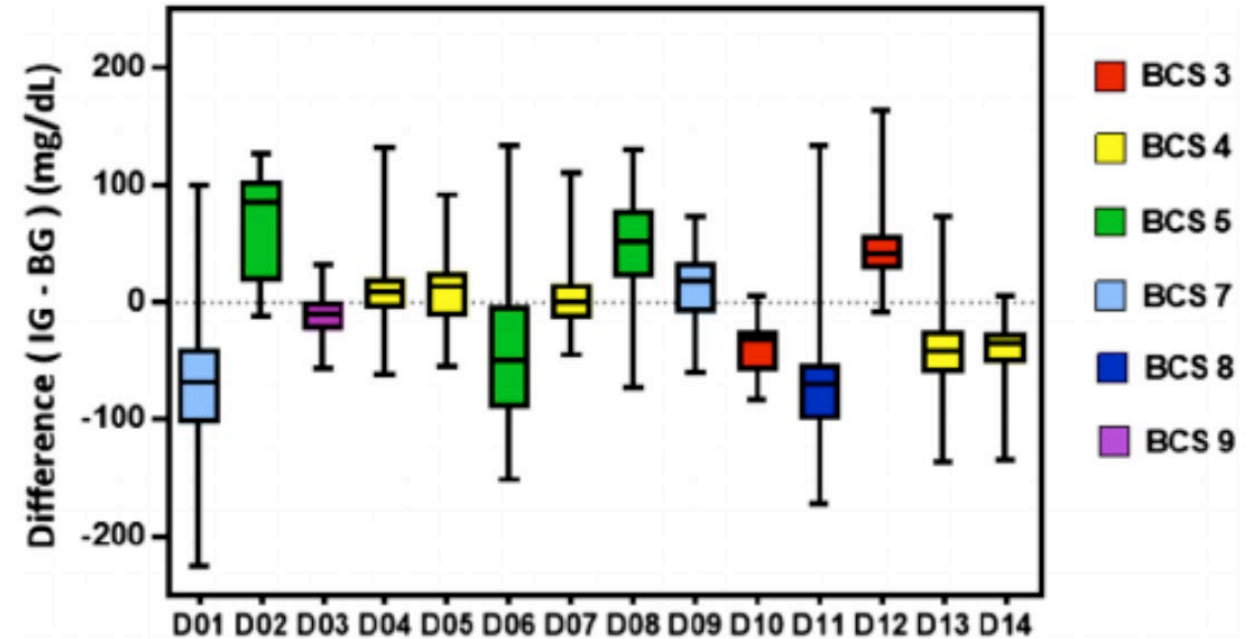
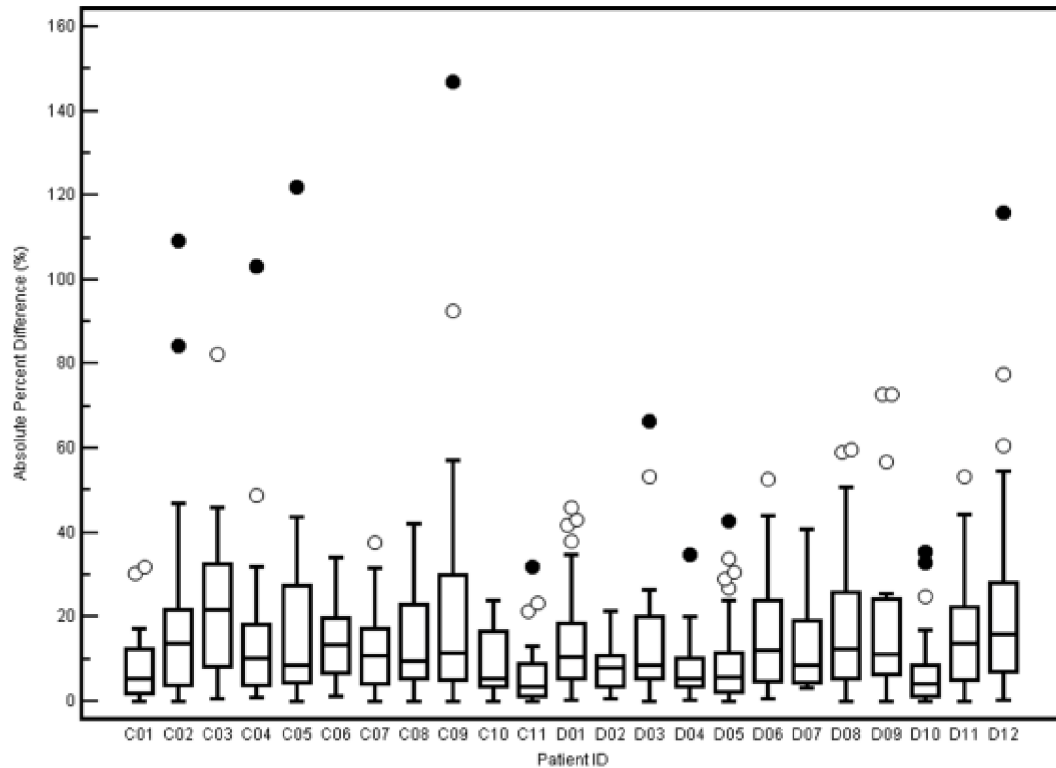
CONFERENCE

CGM: DKA

- Clinical accuracy
 - 96.7-100% in Zones A/B
- No statistical significance BCS, severity ketosis, resolution DKA
- Weak association hydration status
- High interpatient variability



CGM: DKA – Interpatient Variability



Reinke et al JVECCS 2010, Malerba et al JVIM 2020

CGM: Freestyle Libre - DKA

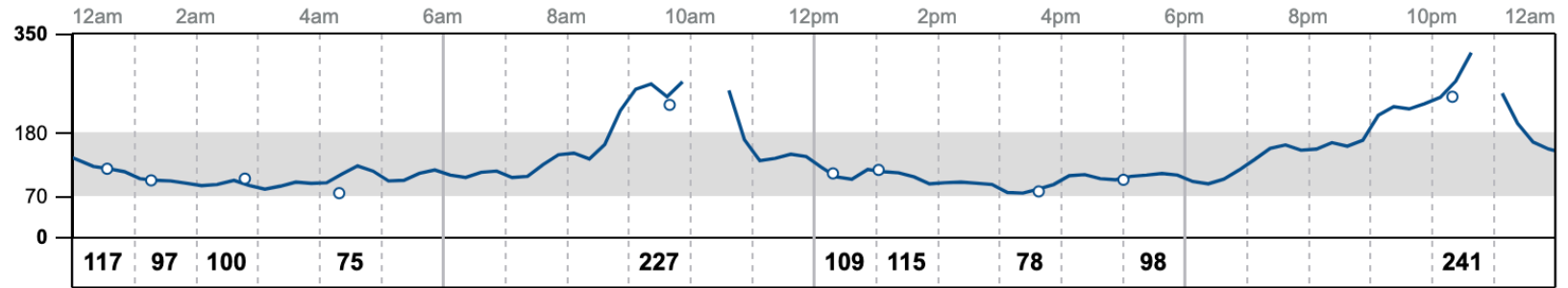
- When to consider:
 - Small or anemic patients
 - Fractious or inability to get central line
 - Hydrated
 - After resolution of ketosis and prior to discharge
- Variable between individuals
- If questionable double check BG

CGM: Case Example

- 11yo MC Min Pin presenting for evaluation of DM and HAC control
- Well controlled diabetic for past 3 years on NPH 9 units q12h
- Diagnosed with HAC and started Trilostane 3 mo prior
- Still PU/PD
- Overall, more lethargic

THU Sep 17

Glucose mg/dL

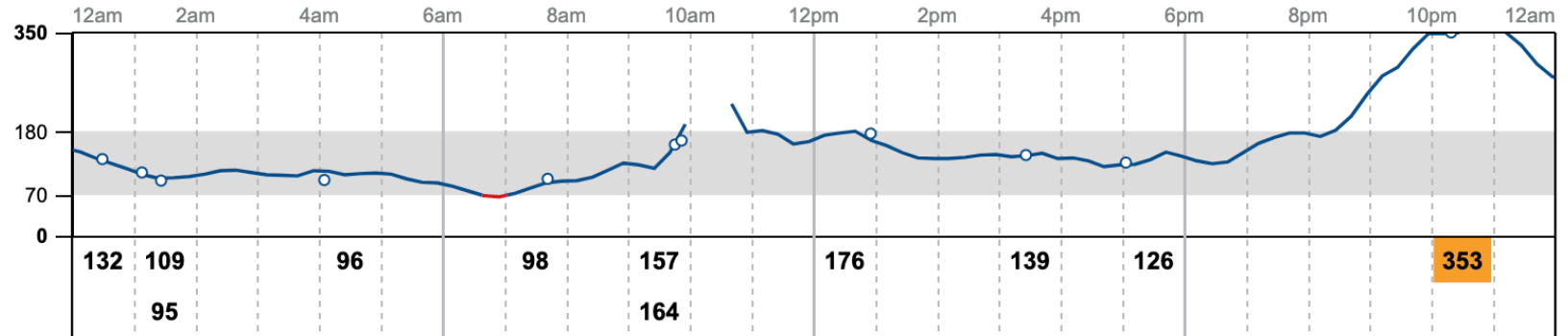


Notes Scooter ate his prescription dog food (hills multi benefit)for the second time at 945 am before I gave him his insulin. ◀

Scooter is eating his prescription diet food ◀

FRI Sep 18

Glucose mg/dL



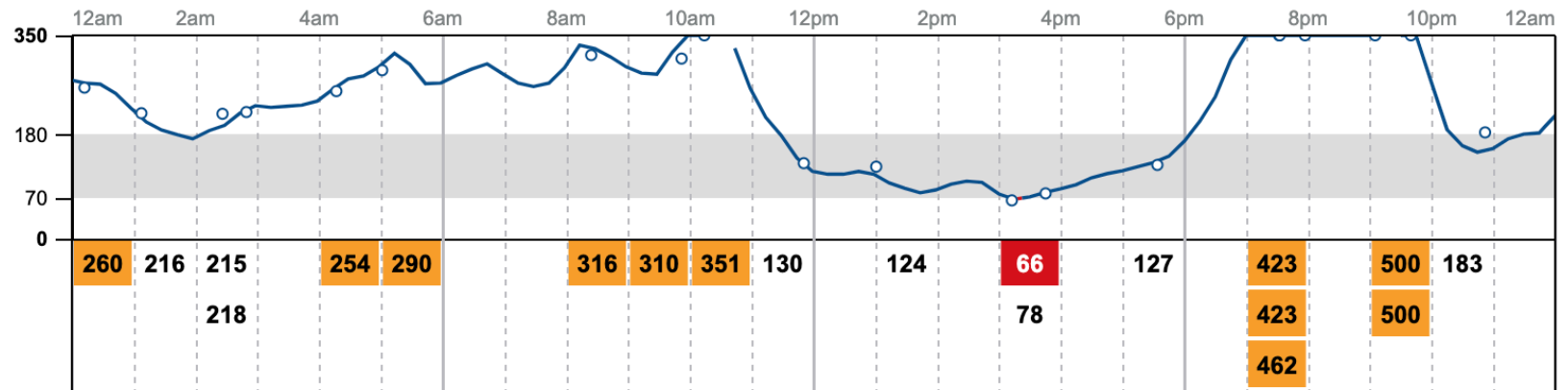
Notes

▶ Scooter is eating his prescription dog food

He's eating his prescription food ◀

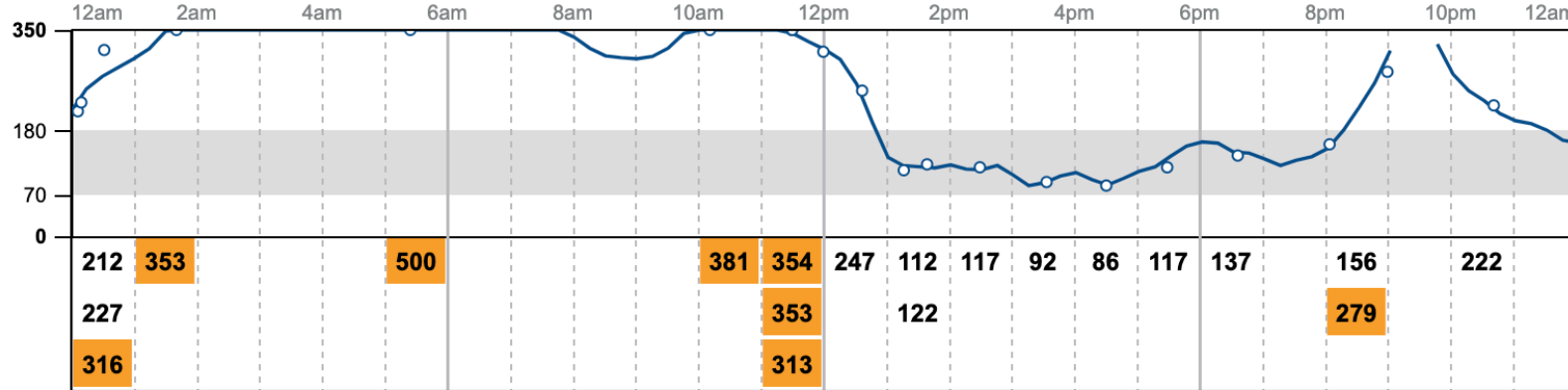
SAT Sep 19

Glucose mg/dL



SUN Sep 20

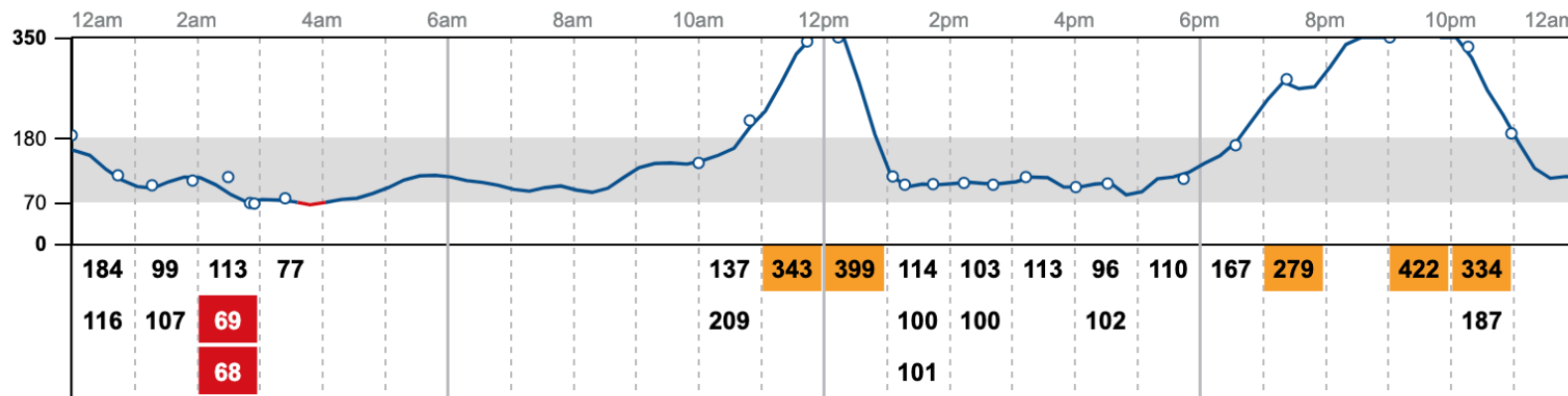
Glucose mg/dL



Notes: Are these good for him? His levels don't seem to go down at night as during the day.

MON Sep 21

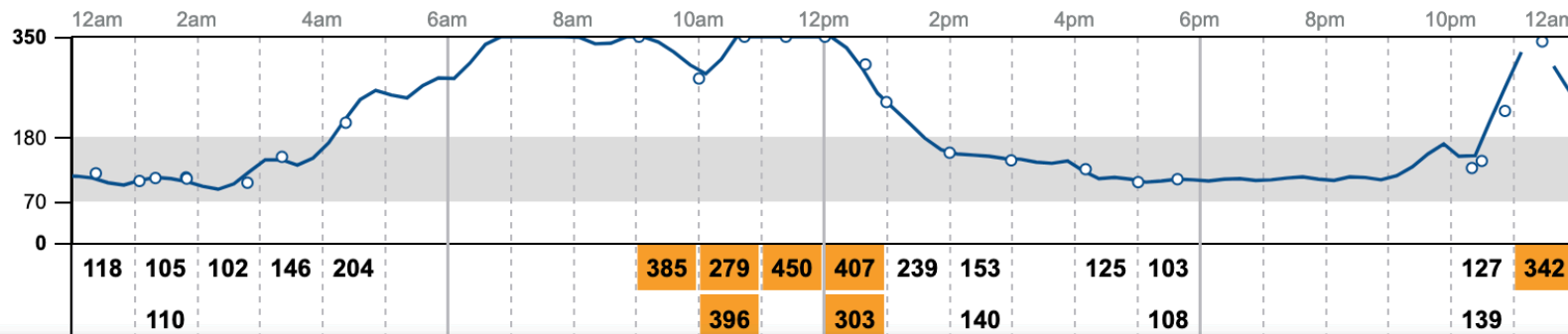
Glucose mg/dL



Notes: He does not seem to be as finicky at night. I give him his 10 mg trilostane in the morning and the 5 mg at night.

TUE Sep 22

Glucose mg/dL

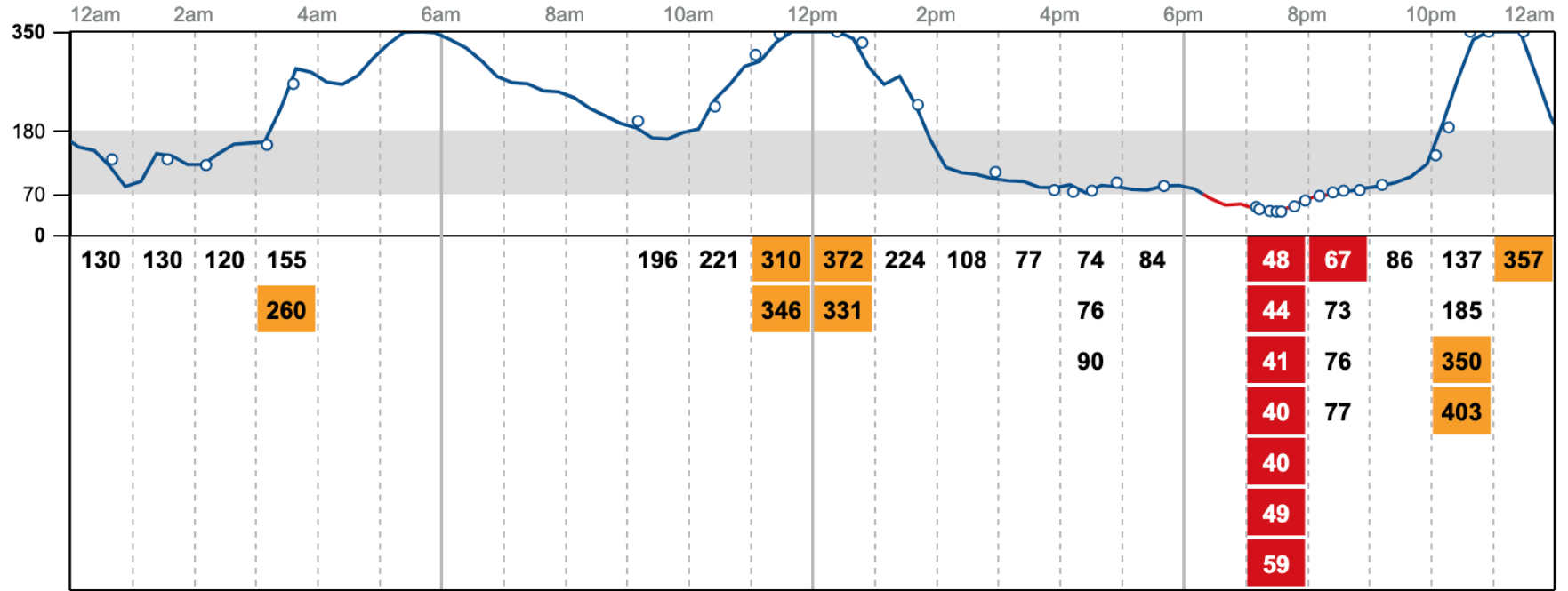


CGM: Case Example

- Based off CGM data would you recommend any change to insulin dosing?
- What might be causing PU/PD?

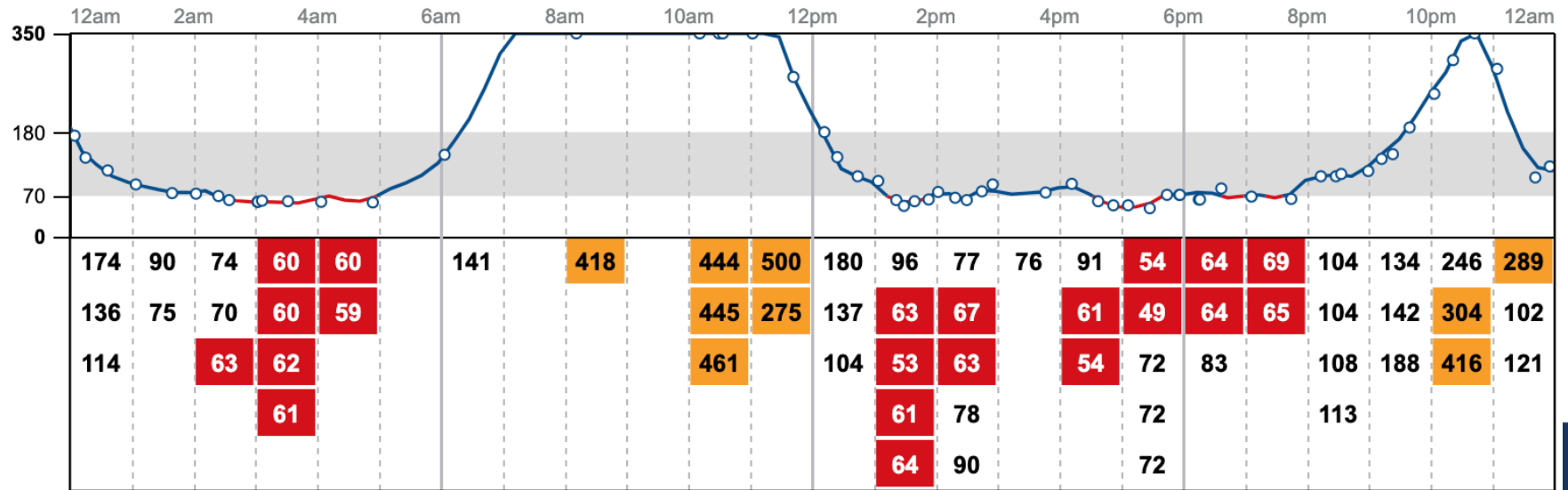
MON Sep 28

Glucose mg/dL



TUE Sep 29

Glucose mg/dL



CGM: Case Example

- Multiple instances of marked hypoglycemia one week later
- Based on CGM data would you recommend a change to insulin?
- Cause of newfound hypoglycemia?

CGM: Case Example

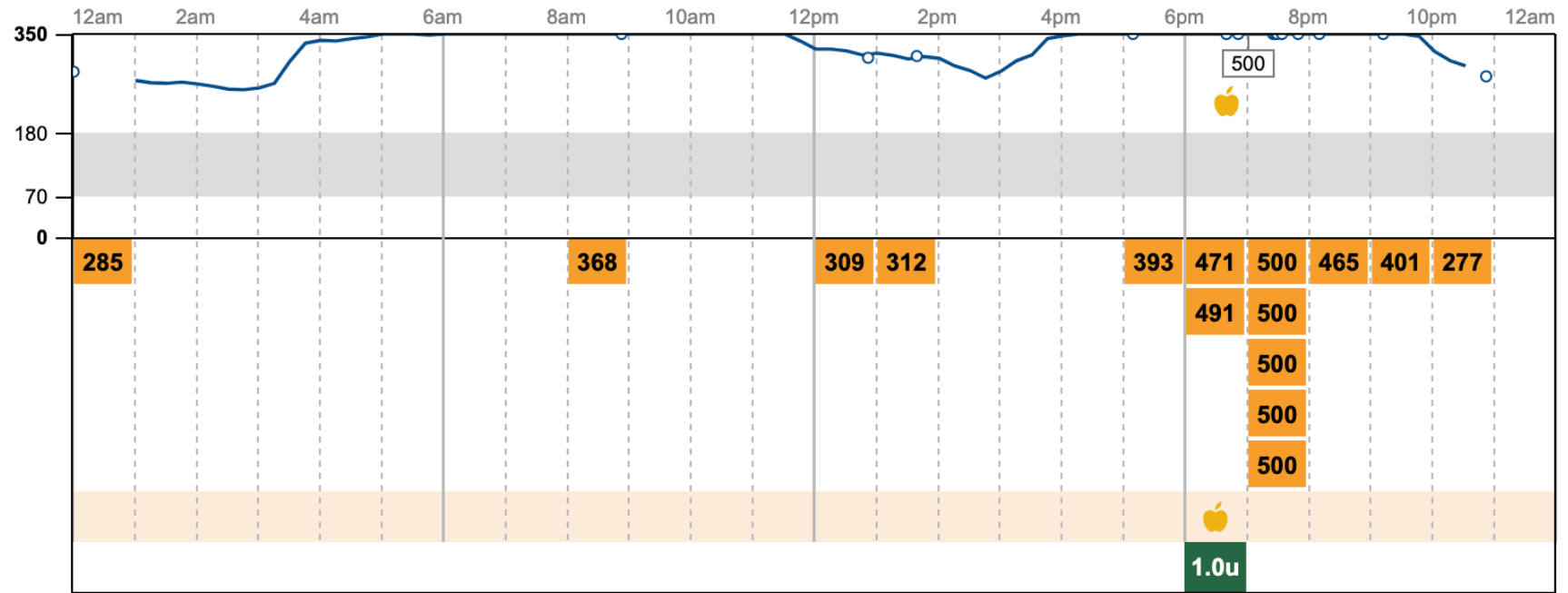
- 12-year-old FS DSH diagnosed with diabetes mellitus 1.5 years prior and went into remission 1 year after starting Purina DM diet
 - Had one instance of iatrogenic hypoglycemia
- Relapsed 6 months after discontinuation of insulin
- PE: BCS 3/9, dehydrated
- Rx glargine 1 unit q12h

SAT Jan 9

Glucose mg/dL

Carbs grams

Long-Acting Insulin

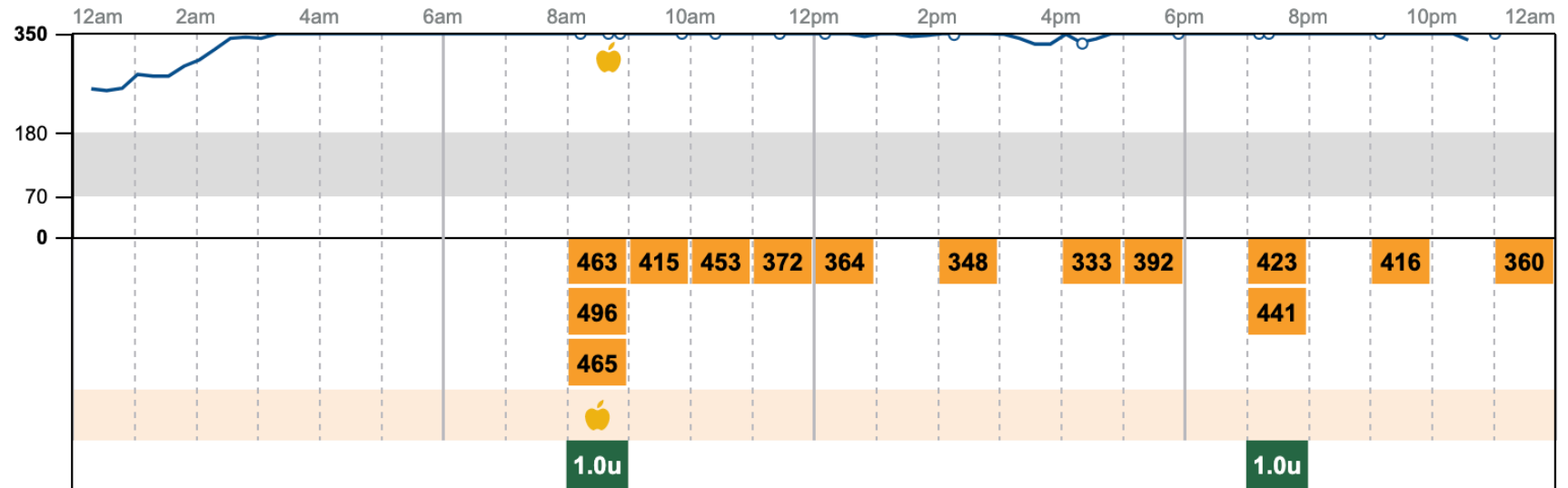


SUN Jan 10


Glucose mg/dL


Carbs grams

Long-Acting Insulin

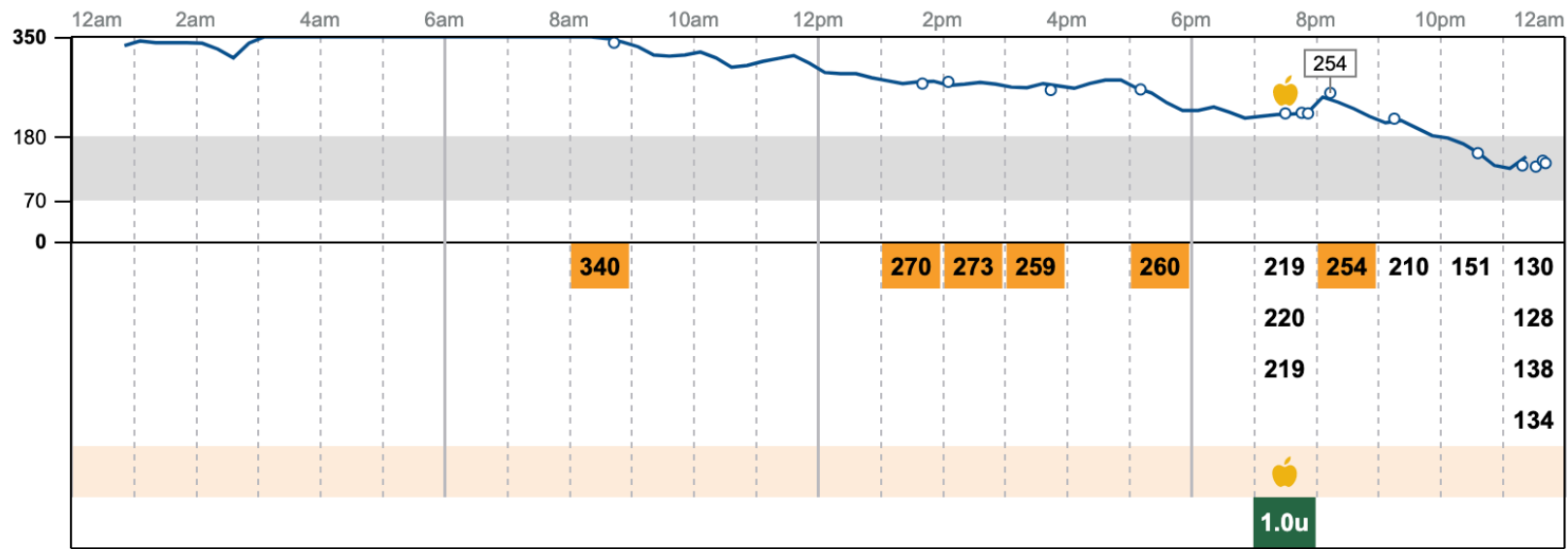


MON Jan 11


 Glucose mg/dL

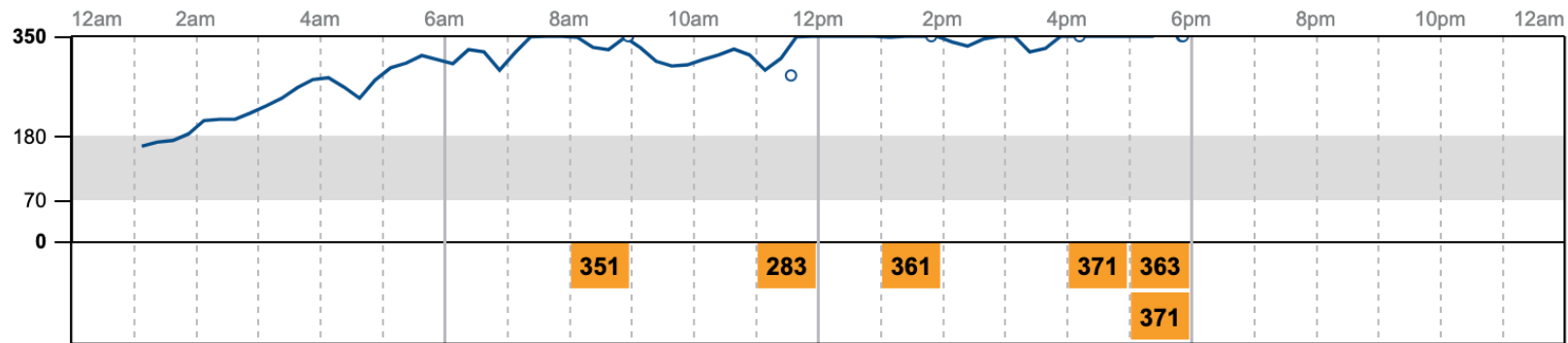
 Carbs grams

 Long-Acting Insulin




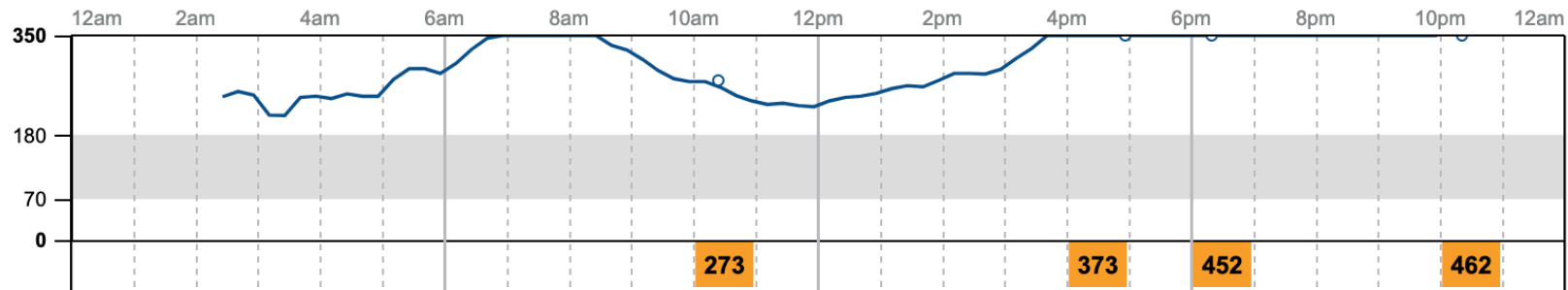
TUE Jan 12

 Glucose mg/dL



WED Jan 13

 Glucose mg/dL

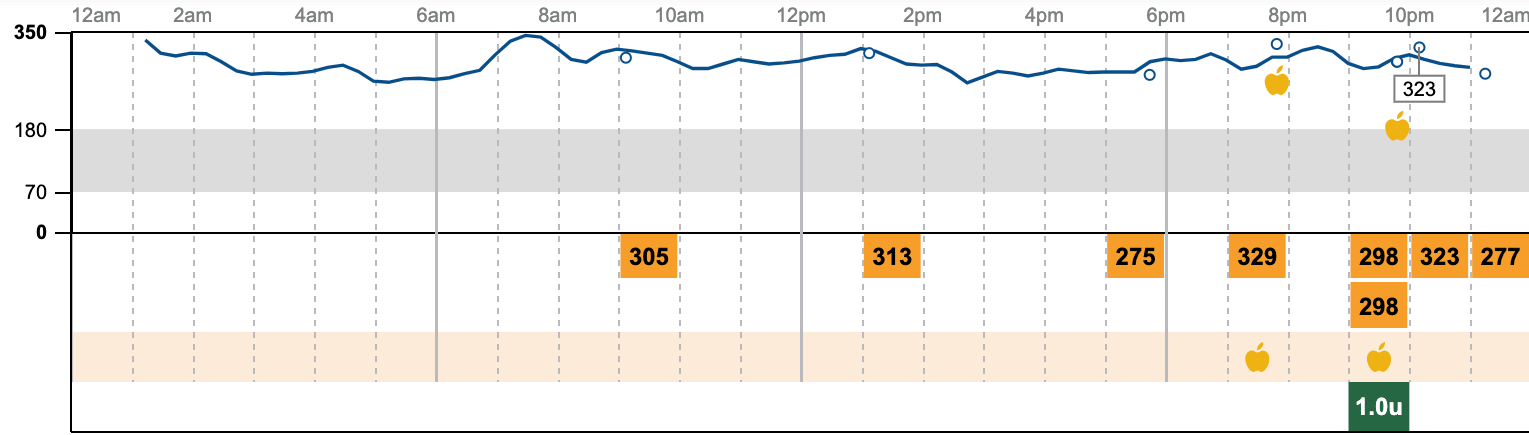


THU Jan 14

Glucose mg/dL

Carbs grams

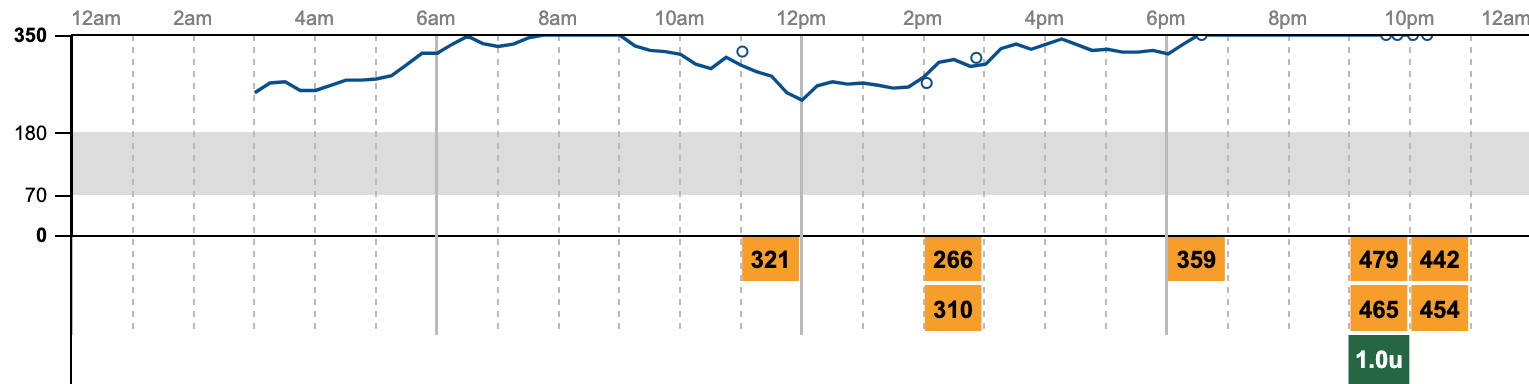
Long-Acting Insulin



FRI Jan 15

Glucose mg/dL

Long-Acting Insulin

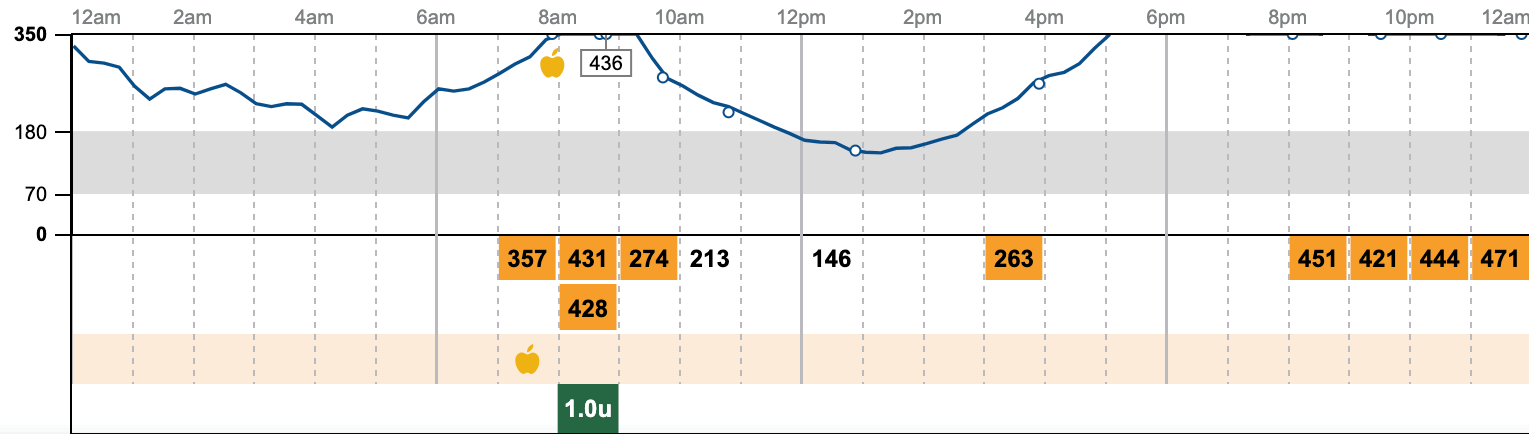


SAT Jan 16

Glucose mg/dL

Carbs grams

Long-Acting Insulin



CGM: Case Example

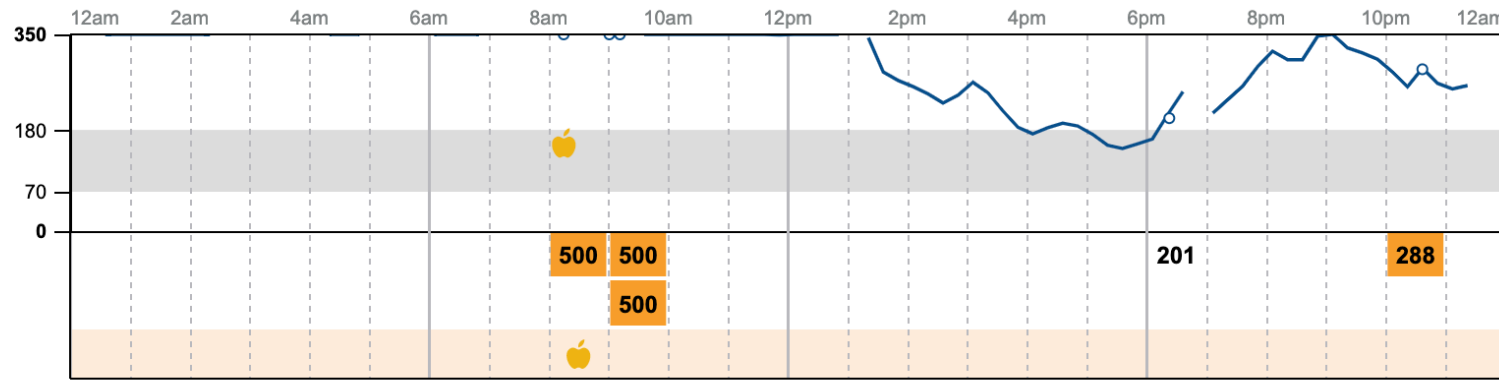
- Persistently PU/PD, slightly less polyphagic at home, but otherwise bright
- Elected to increase insulin to 2 units q12h

SUN Jan 17

Glucose mg/dL

Carbs grams

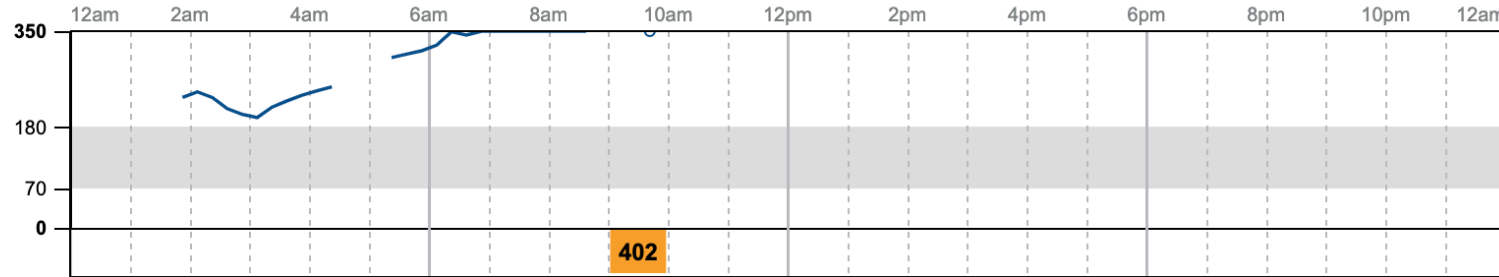
Notes



► She did eat some dog food and then vomited.

MON Jan 18

Glucose mg/dL

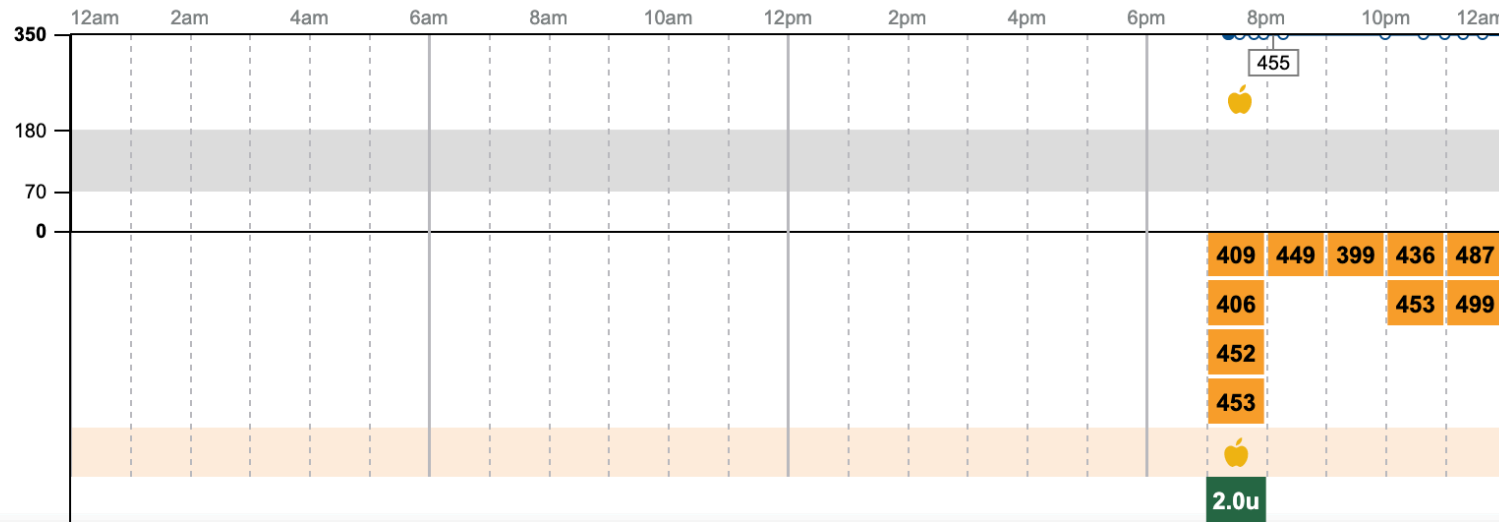


TUE Jan 19

Glucose mg/dL

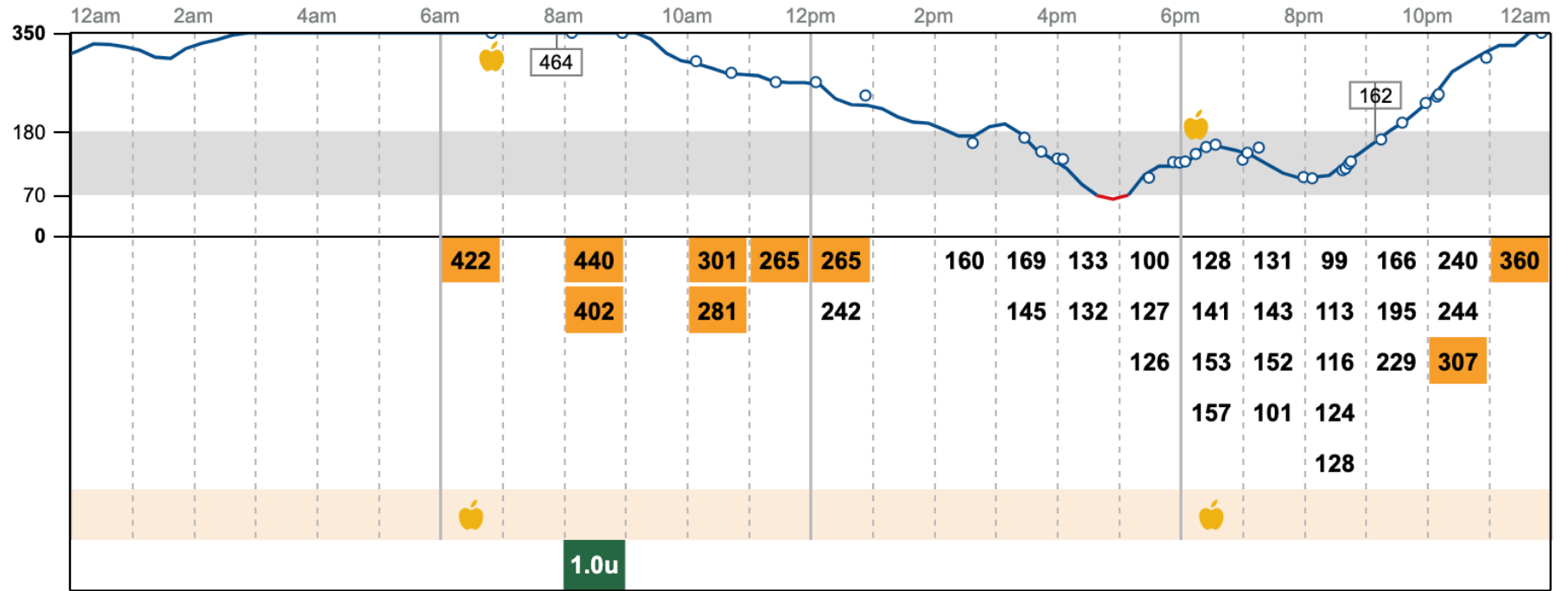
Carbs grams

Long-Acting Insulin



THU Jan 21

Glucose mg/dL

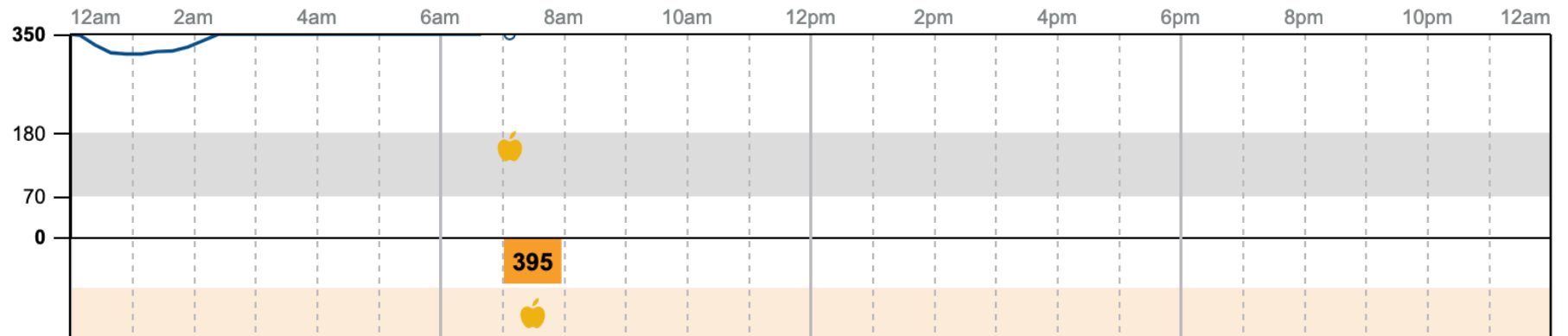


Carbs grams

Long-Acting Insulin

FRI Jan 22

Glucose mg/dL



Carbs grams

CGM: Case Example

- CGM captured hypoglycemic event
 - Patient was not clinical at the time
- Due to owner comfort elected to maintain patient on glargine 1 unit q12h

CGM: Client Communication

- Set up expectations!!
- Do not adjust dosing without veterinarian guidance
- Day to day fluctuations are normal
- Hyperglycemia is expected
- We do not aim to control veterinary patients as tightly as humans
- Data can be overwhelming

CGM: Client Communication

- Charge for an interpretation fee
- Preschedule specific check ins (weekly) to touch base
- Do not adjust dosing without veterinary input
- Again set expectations e.g.
 - Evaluating trends
 - High BG does not mean imminent DKA
- NOT for every client, which is okay!

Take Home Points

- Clinical signs are still no 1!
- Avoid in hospital BG curves for routine monitoring if possible
- HbA1C good option over fructosamine in patients with high protein turnover
- CGM (Freestyle Libre) excellent option especially in complicated or difficult to control cases
- Set up client expectations
- Every client/patient will need tailored approach

Thank You

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Questions?



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- Following our CE Conference, you will receive an evaluation survey via email. Please complete the MedVet survey.
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