



Glycemic Variability:

Do the Differences Make a Difference?

Kim L Kelly, PharmD, BCPS, FCCP

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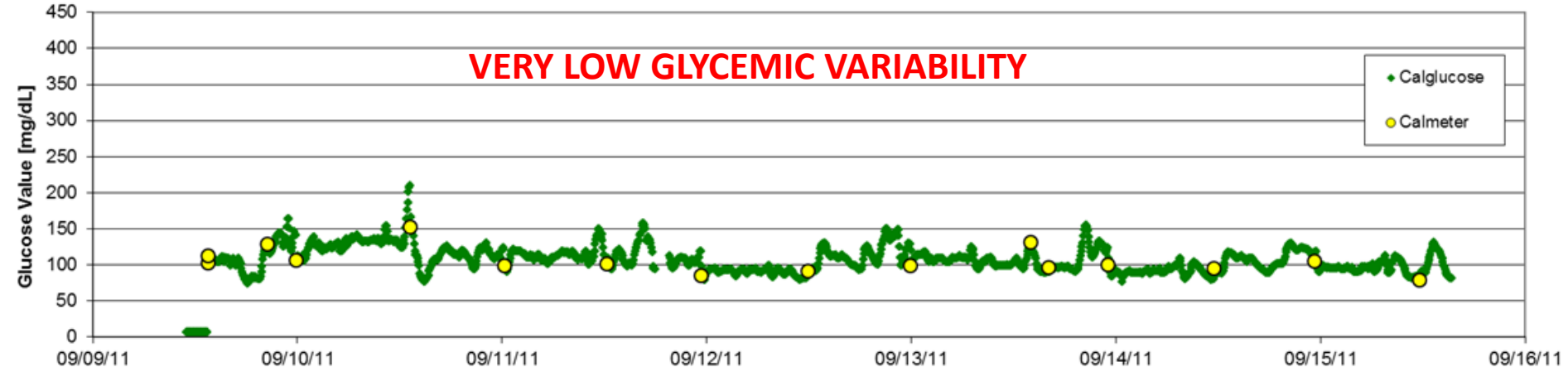
Define ‘Variability’


VERY LOW GLYCEMIC VARIABILITY
Glucose Value [mg/dL]
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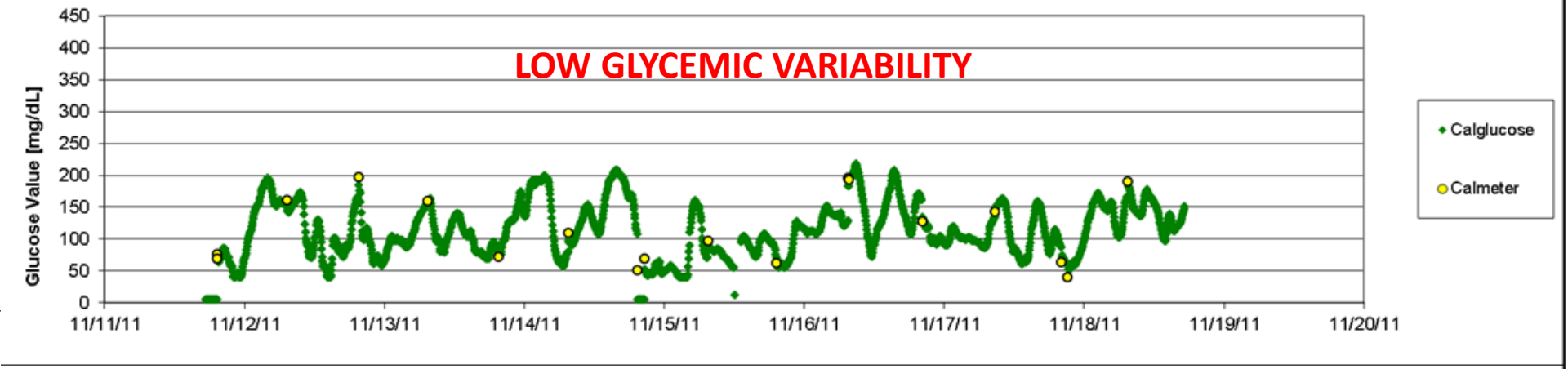
Calglucose
Calmeter


LOW GLYCEMIC VARIABILITY
Glucose Value [mg/dL]
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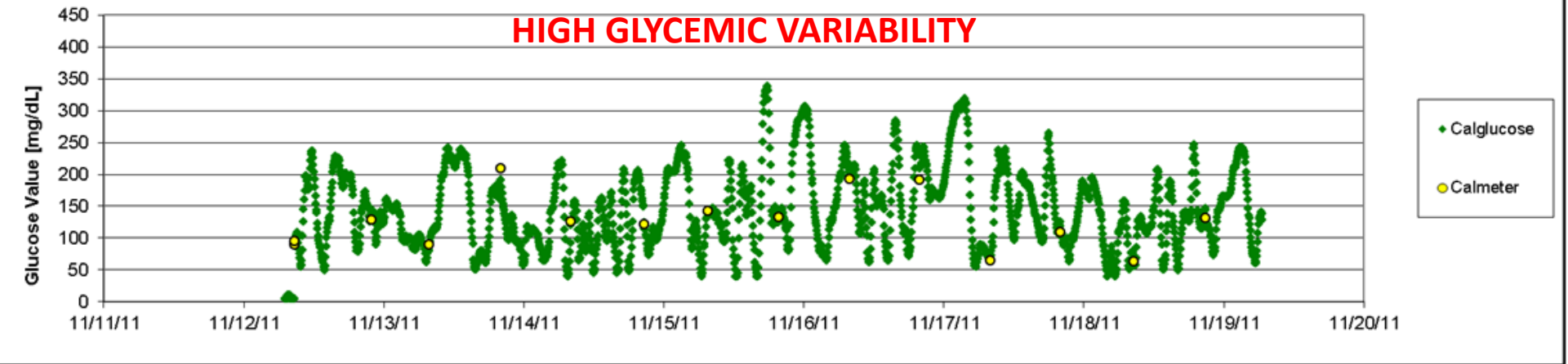
HIGH GLYCEMIC VARIABILITY
Glucose Value [mg/dL]
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Calglucose
Calmeter

So what's the big deal, we've known since DCCT that A1C is the marker for risk of complications…

Polling Question 1:

What percentage of the risk of retinopathy in DCCT was explained by knowing A1C and diabetes duration?

- ❑ ~ 90%
- ❑ ~ 70%
- ❑ ~ 50%
- ❑ ~ 30%
- ❑ ~ 10%

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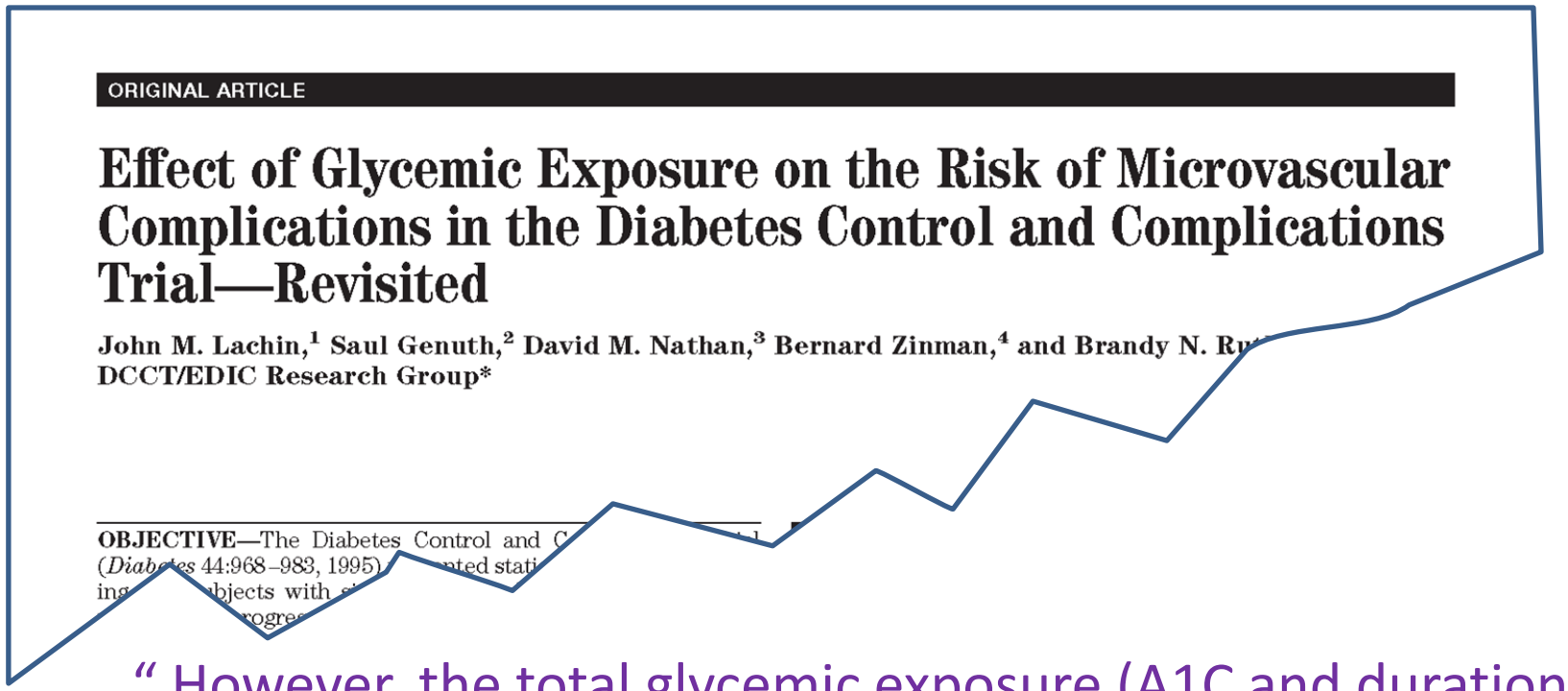
…Really?



ORIGINAL ARTICLE

Effect of Glycemic Exposure on the Risk of Microvascular Complications in the Diabetes Control and Complications Trial—Revisited

John M. Lachin,[1] Saul Genuth,[2] David M. Nathan,[3] Bernard Zinman,[4] and Brandy N. Ru
DCCT/EDIC Research Group*

OBJECTIVE—The Diabetes Control and C
(*Diabetes* 44:968–983, 1995)
ing bjects with
rogres

" However, the total glycemic exposure (A1C and duration of diabetes) explains only 11% of the variation in retinopathy risk, …so that other factors may presumably explain the remaining 89% of the variation in risk among subjects independent of A1C."

Lachin JM, et al. Diabetes 2008;57:995-1001

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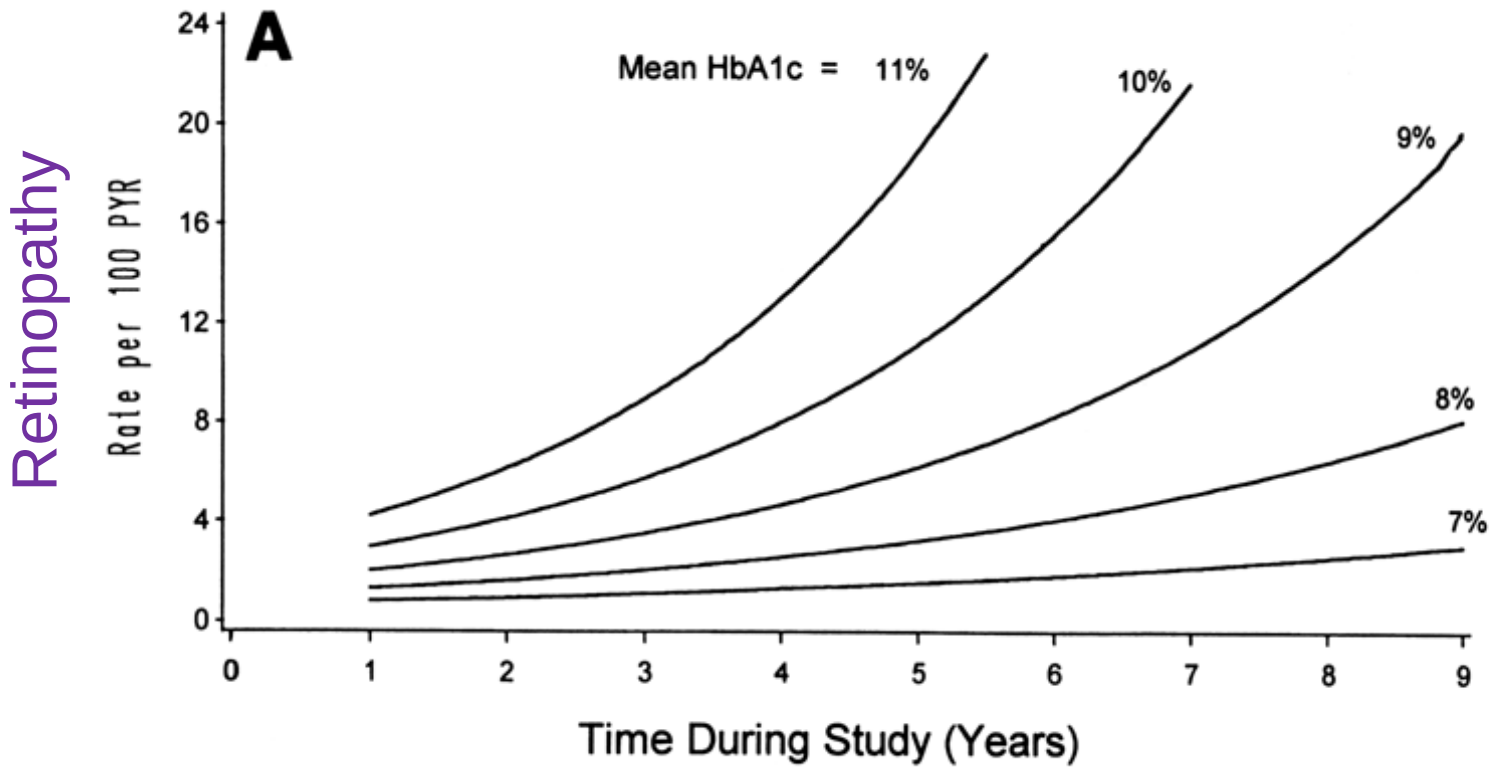
Relationship Between Increasing A1C and Retinopathy

… it all started with an article in *Diabetes* in 1995



DCCT Study Group. Diabetes August 1995 44:968-983

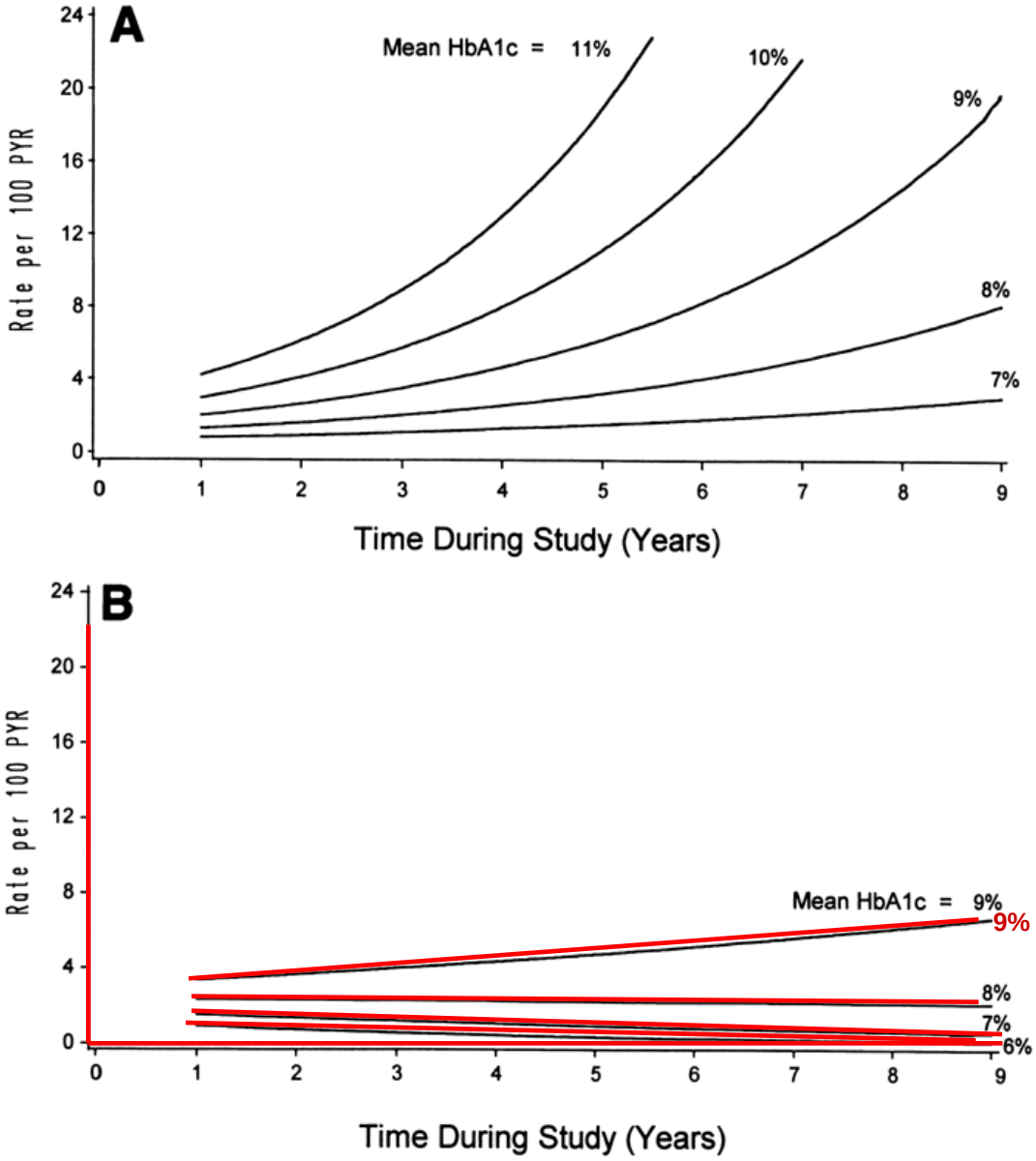


FIG. 6. Absolute risk of sustained retinopathy progression as a function of the updated mean HbA_{1c} (percentage) during the study and the time of follow-up during the study (years), estimated from absolute risk (Poisson) regression models (Table 8). *A*: Conventional treatment group. *B*: Intensive treatment group.

DCCT Study Group.
Diabetes August 1995 44:968-983

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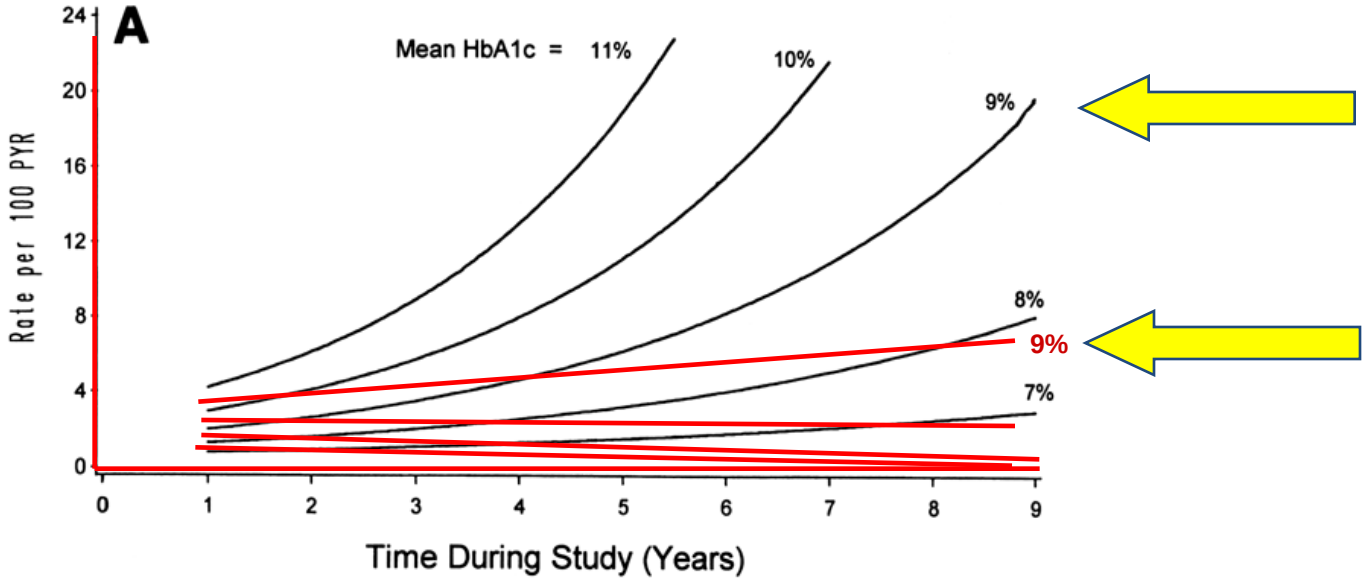

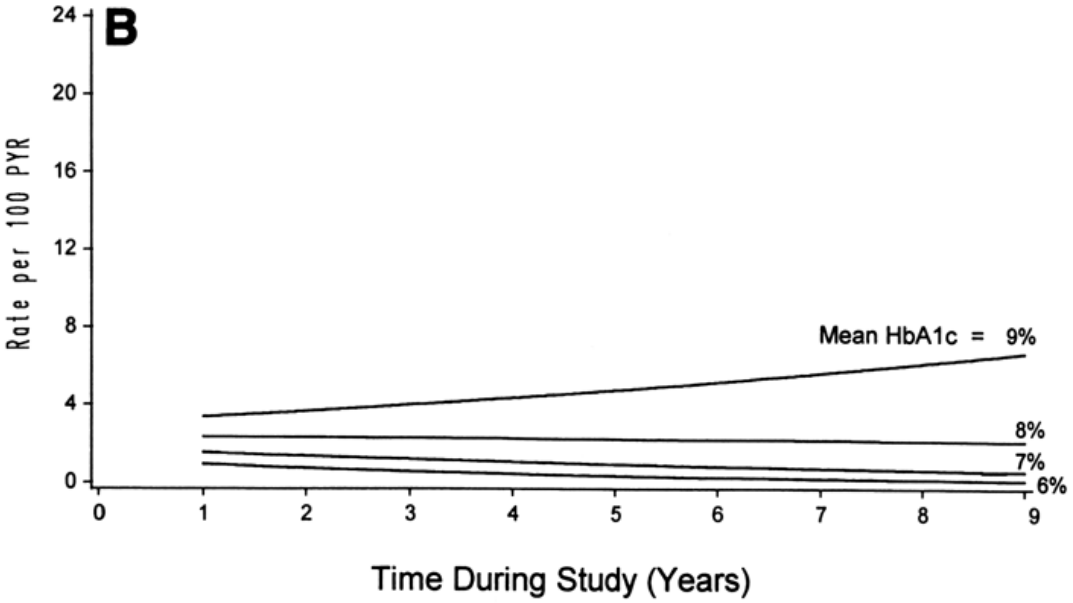

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What's the difference?

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Have there been studies which show glucose variability to be a risk factor independent of A1C?

Numerous Studies on PPG/PCG and CV Risk

- In at least 16 studies performed over the last 15 years, glycemic variability has been associated with
  - Overall mortality
  - Intensive care unit mortality
  - Cardiovascular risk (including Stroke risk)
  - Retinopathy
  - Nephropathy

  …..and more

HEART 2D

DECODE

San Luigi Gonzaga

Honolulu Heart Study

WHITEHALL

HOORN

Rancho Bernardo

NAVIGATOR

HELSINKI POLICEMAN STUDY

Funagata Diabetes Study

Stop-NIDDM

Standl E, Schnell O, Ceriello A. *Diabetes Care* 2011;34 (Suppl 2):S120

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Glycemic variability in normal and impaired glucose tolerance, and type 2 diabetes

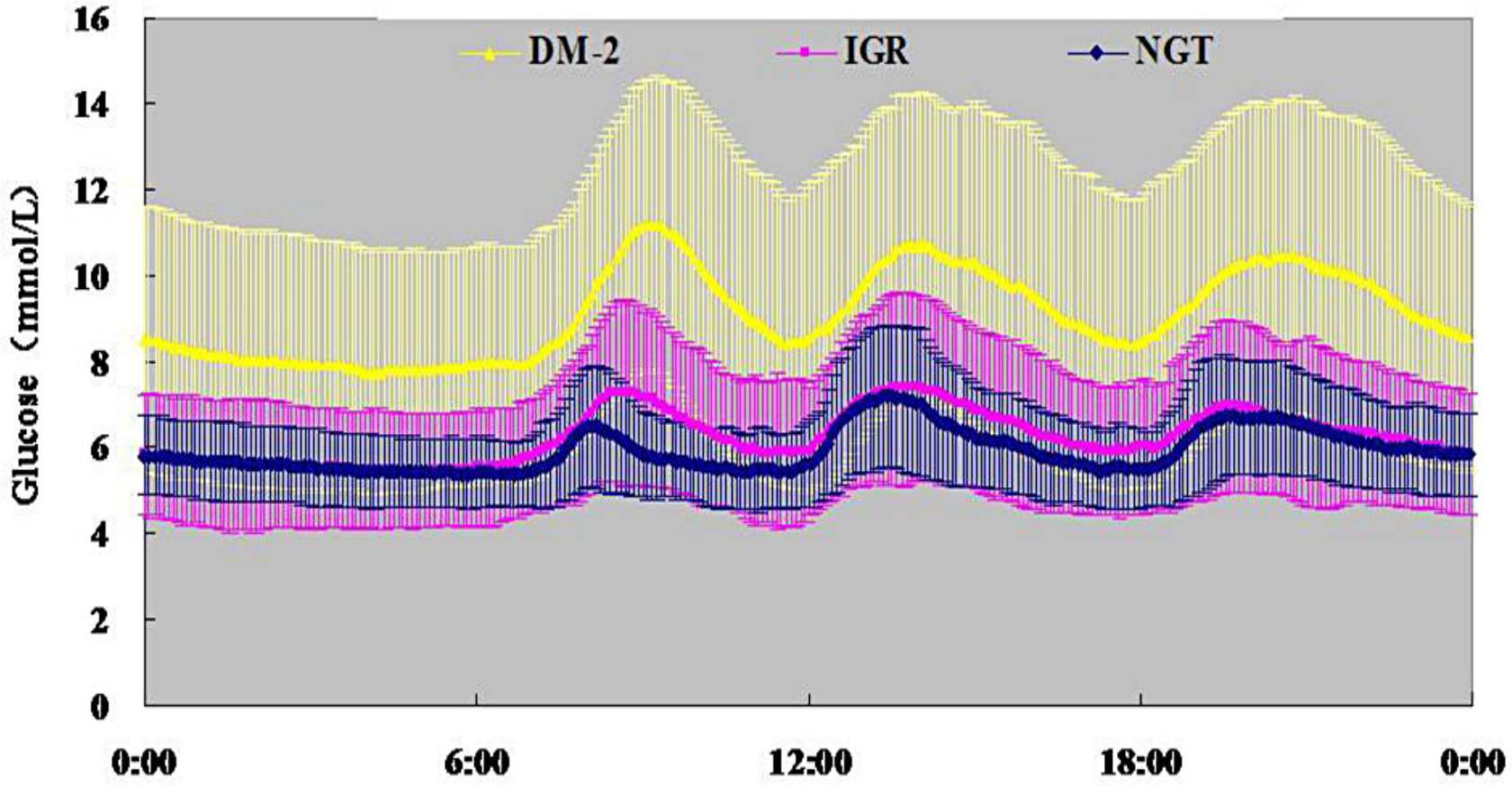

Figure 1. 24h sensor glucose profiles of the studied groups. The data represent means±SD.

Wang C, et al. Clinical Endocrinology [Epub ahead of print; Aug 13, 2011]

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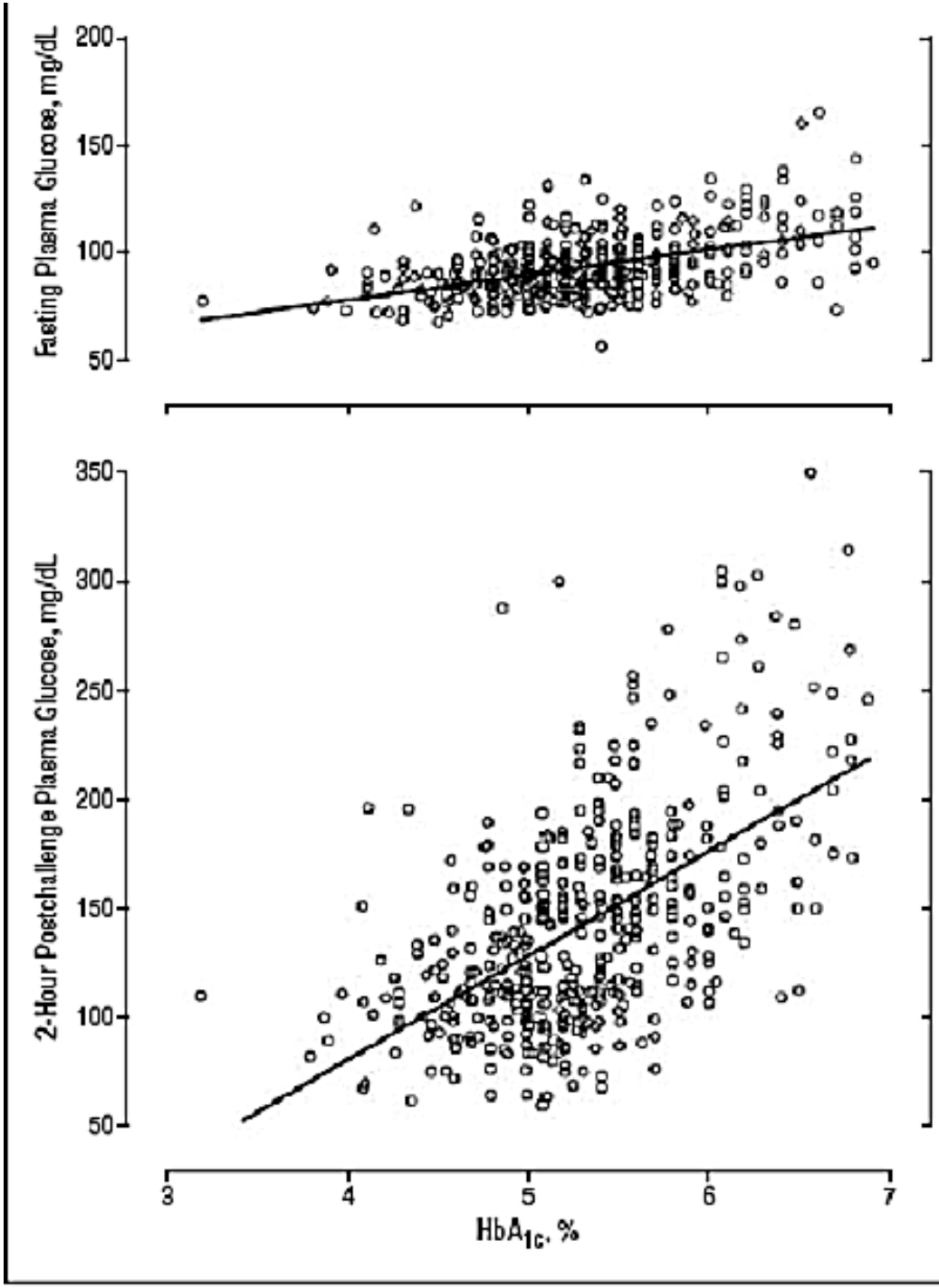
Fasting, 2-hr Post challenge plasma glucose (PCPG) and A1C

- Both FPG and 2-hour PCPG increase as A1C increases
- 2-hour PCPG increases at a rate 4 X greater than FPG accounting for > % A1C.
- People at IDF and ACE targets for A1C(<6.5%) had lower 2-hour PCPG than those at ADA target (<7.0%)

Worle H. et al Arch Intern Med 2004:164;1927



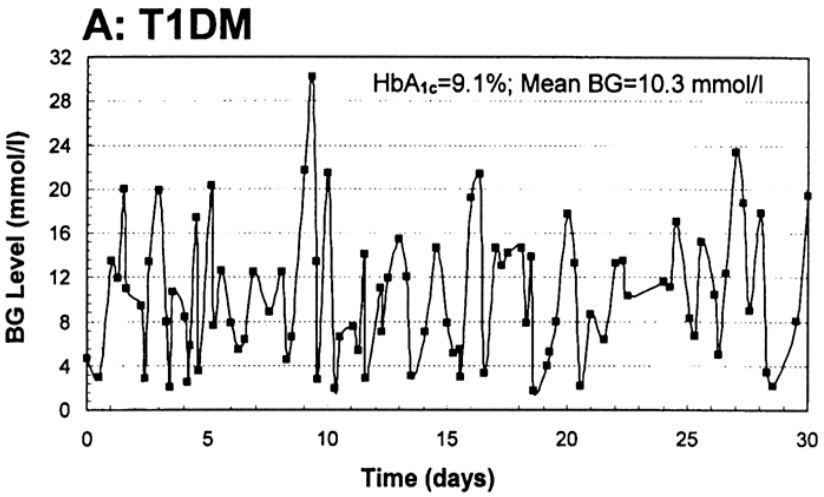
Polling Question 2:

Glucose variability is not considered much of a problem in type 2 patients as their glucose levels are pretty stable?

- ❑ True
- ❑ False

Variability of Blood Glucose Results in Type 1 and Type 2 Diabetes

- N=277 T1DM, and 323 T2DM
- Avg of 230 SMBG and 3 A1c readings over 3 months
- Calculated indices of hypo- and hyperglycemic episodes



Kovatchev BP, Cox DJ, Gonder-Frederick L.
Diab Technol & Therapeutics 2002;4:295-303

Variability of Blood Glucose Results in Type 1 and Type 2 Diabetes

TABLE 3. GROUP COMPARISON OF T1DM VERSUS T2DM SUBJECTS

Variable	Mean (SD) T1DM		Mean (SD) T2DM		Significance
A: Glycemic control averages					
HbA_{1c} at 1.5 months	9.6 (1.2)		9.7 (1.2)		$t = 0.7$, $p = 0.48$
HbA_{1c} at 3 months	9.2 (1.2)		9.3 (1.1))		$t = 1.6$, $p = 0.11$
Average BG	10.2 (1.9)	183	10.4 (2.2)	187	$t = 1.5$, $p = 0.13$
B: BG range					
Minimal BG (mmol/L)	2.2 (0.7)		3.5 (1.2)		$t = 15.0$, $p < 0.0001$
Maximal BG (mmol/L)	24.9 (3.8)		21.2 (4.3)		$t = 11.0$, $p < 0.0001$
BG range (mmol/L)	22.7 (3.9)	409	17.8 (4.5)	320	$t = 14.1$, $p < 0.0001$
C: Risk measures					
LBGI	2.7 (2.0)		0.8 (1.1)		$t = 14.5$, $p < 0.0001$
HBGI	13.1 (5.8)		12.0 (7.1)		$t = 2.0$, $p = 0.04$[1]
BG Risk Index	15.8 (5.1)		12.8 (6.9)		$t = 6.1$, $p < 0.001$
Rate of change of Low BG Risk/hour	1.2 (0.7)		0.5 (0.6)		$t = 13.2$, $p < 0.0001$
D: Frequency of moderate and mild hypoglycemia (% of readings)					
<2.2 mmol/L	1.1%		0.1%		$t = 8.3$, $p < 0.0001$
2.2–3.0 mmol/L	4.4%		1.0%		$t = 13.4$, $p < 0.0001$
3.0–3.9 mmol/L	6.0%		2.1%		$t = 14.8$, $p < 0.0001$
E: BG irregularity (stationary and dynamic)					
BG SD	4.8 (0.9)	86	3.3 (1.0)	60	$t = 18.3$, $p < 0.0001$
Average BG rate of change/hour (mmol/L)	0.7 (0.3)		0.4 (0.2)		$t = 12.7$, $p < 0.0001$

[1]In order to account for multiple comparisons, a p value of 0.05 is not considered significant.

Kovatchev BP, et al Diab Technol & Therapeutics 2002;4:295-303

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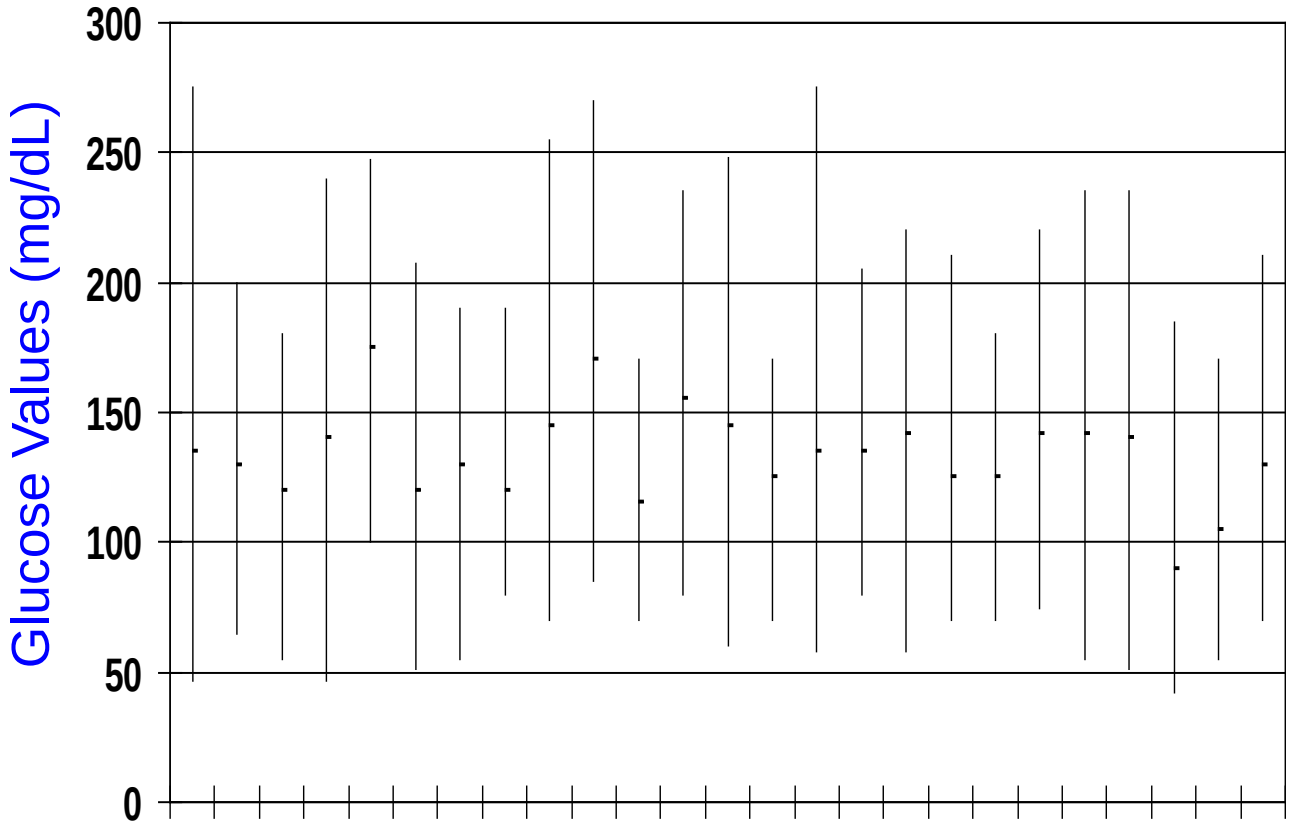
Glucose excursions in ‘stable’ patients with type 2 diabetes on oral agents



Glucose Values (mean, 5th to 95th percentile) for each patient during the study

During CGM, glucose excursions showed significant variation in nearly every patient despite their being ‘controlled’ and ‘stable’ by current definitions

Hay LC, Wilmshurst EG, Fulcher G.,et al. *Diab Techol Ther* 2003; 5:19-26

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Polling Question 3:

Which of the following is a way to measure and quantify glycemic variability?

- ❑ Standard Deviation
- ❑ Mean Amplitude of Glycemic Excursions
- ❑ Continuous Overlapping Net Glycemic Action
- ❑ 1 and 2
- ❑ All the above

“So many measures, I just can’t count them all…”

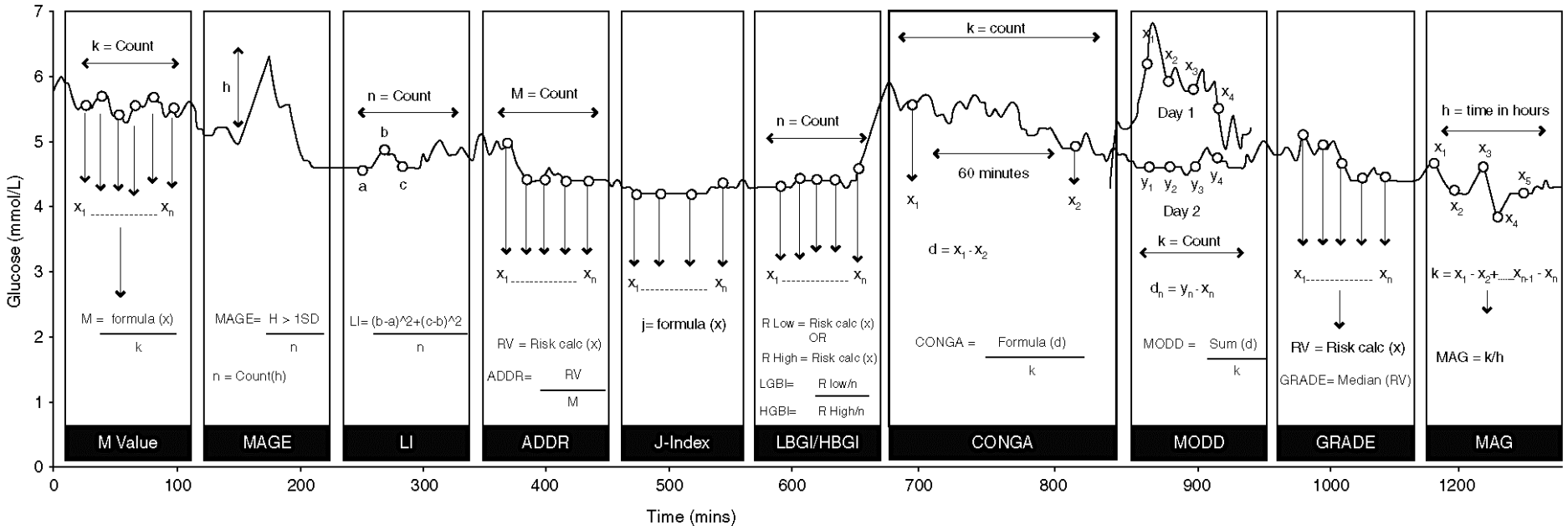

FIG. 1. Graphical illustration of how each of the 10 methods of glycemic variability assessment are calculated from a continuous glucose monitoring trace: average daily risk ratio (ADRR), continuous overlapping net glycemic action (CONGA), Glycemic Risk Assessment in Diabetes Equation (GRADE), High Blood Glucose Index (HBGI), Low Blood Glucose Index (LBGI), J-Index, Lability Index (LI), mean absolute glucose (MAG), mean amplitude of glucose excursions (MAGE), and mean of daily differences (MODD). In practice each method would independently assess the entire trace.

Hill NR, et al Diabetes Technology & Therapeutics 2011;13:921

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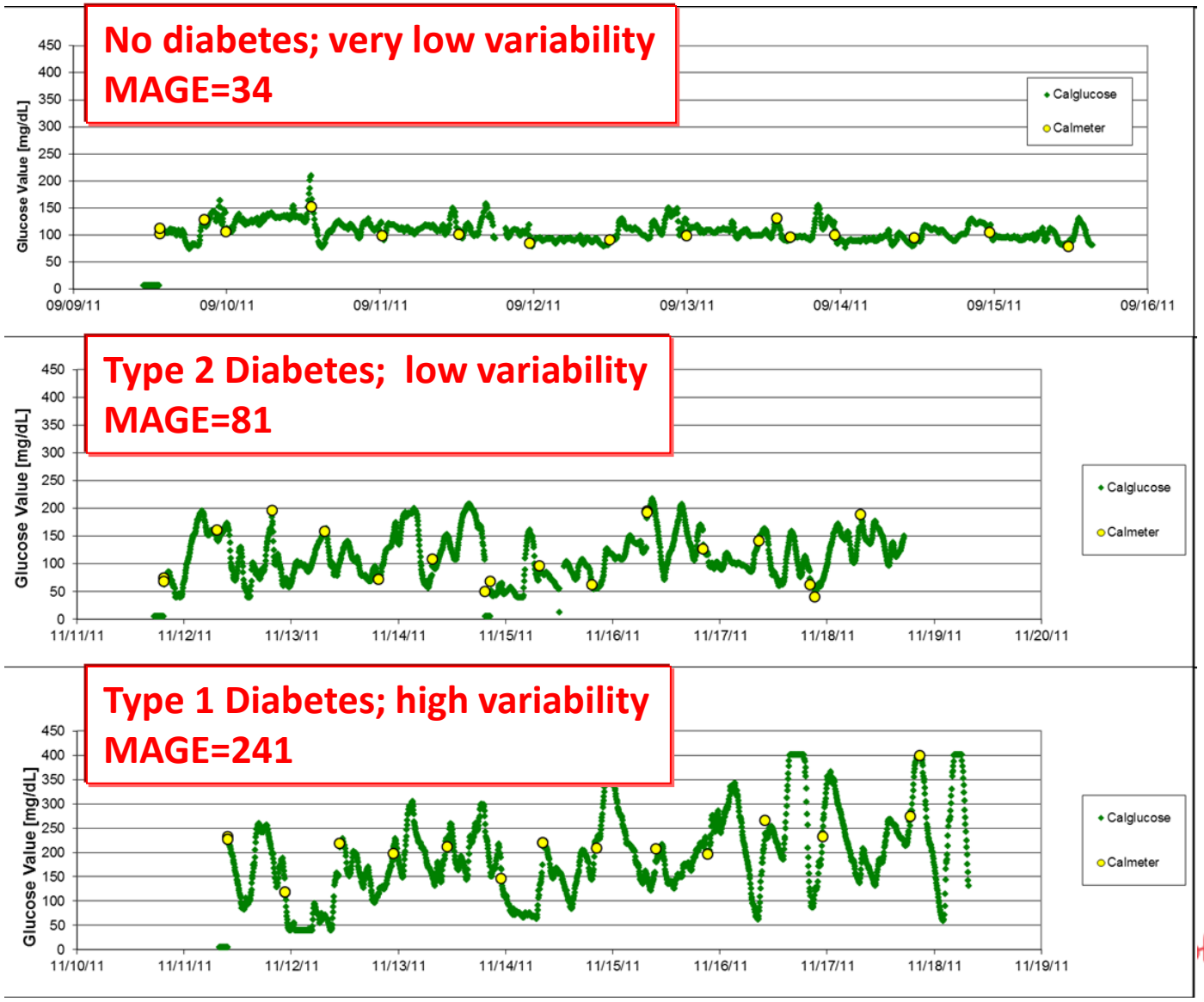
Mean Amplitude of Glycemic Excursions (MAGE)



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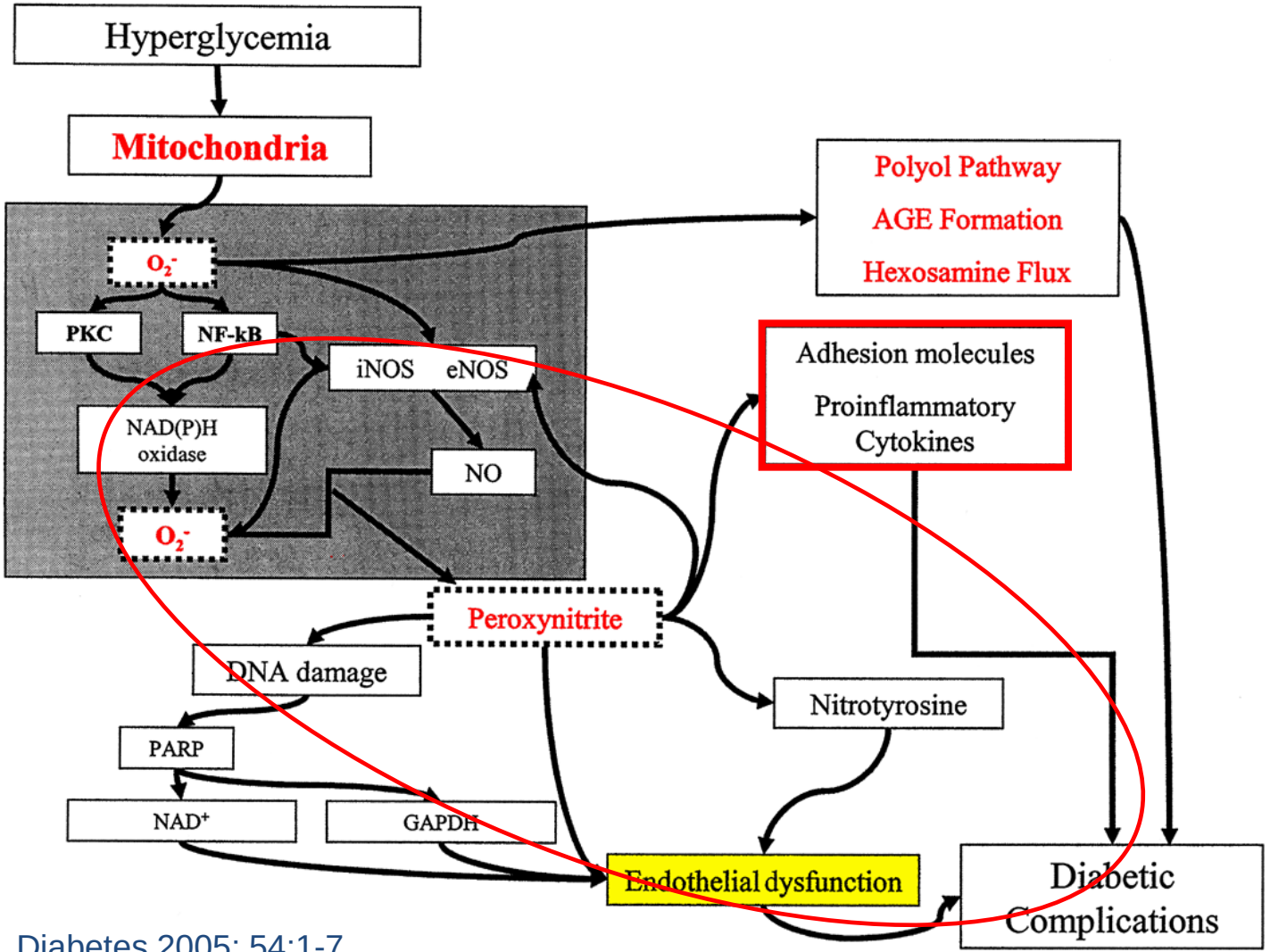
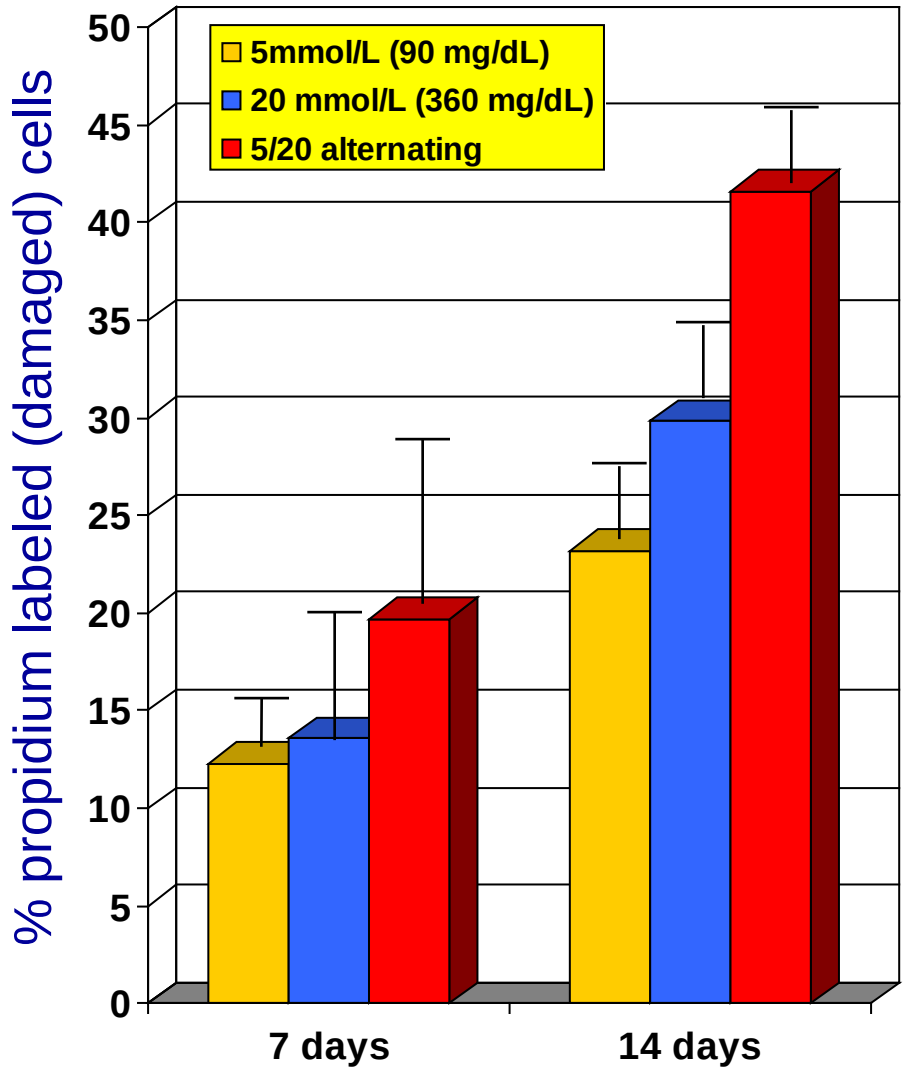
So how might variability affect processes we know are involved in complications?

Overload in the mitochondria results in increased Reactive Oxygen Species (ROS)



Ceriello A. Diabetes 2005; 54:1-7

Glucose fluctuations cause cell damage



- Human umbilical vein endothelial cells were incubated in 5 mmol or 20 mmol or alternating 5 and 20 mmol/L solutions of glucose and tested for markers of cell damage
- At 7 days and 14 days, there were significantly more damaged cells with the higher glucose concentration and even more damaged cells when the glucose was alternated between 5 and 20 mmol/L each day.

Quagliaro L, et al. *Diabetes* 2003; 52:2795-2804

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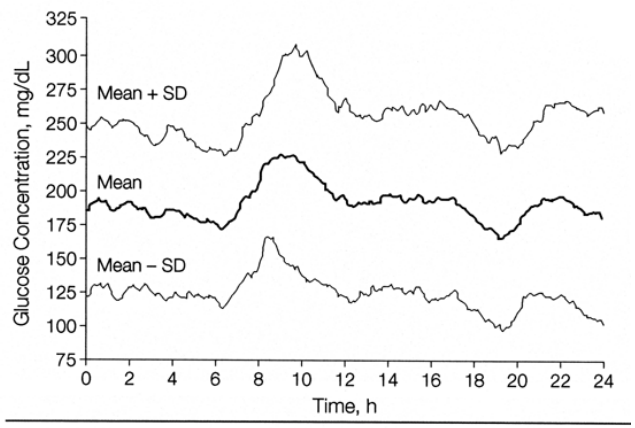
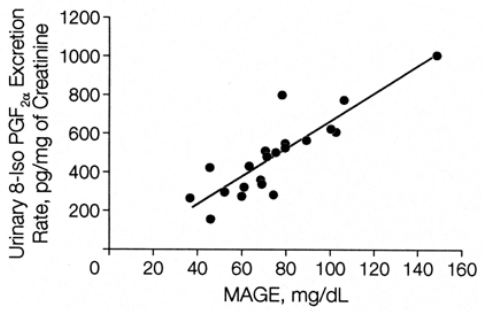
Increased oxidative stress has been demonstrated in people with type 2diabetes

Figure 1. 24-Hour Recordings From the Continuous Glucose Monitoring System in 21 Patients



To convert glucose to mmol/L, multiply values by 0.0555.

Figure 2. Linear Correlation Between 24-Hour Urinary Excretion Rates of 8-Iso Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) and Mean Amplitude of Glycemic Excursions (MAGE)



r=0.86; P<.001.

- 21 patients were studied with urinary excretion rates of 8-iso-prostaglandin $F_{2\alpha}$ (marker of oxidative stress)
- Glucose fluctuations monitored with CGMS; calculated Mean Amplitude of Glycemic Excursions (MAGE)
- "Glucose fluctuations during postprandial periods exhibited a more specific triggering effect on oxidative stress than chronic sustained hyperglycemia"

Monnier, et al JAMA 2006;295:1681

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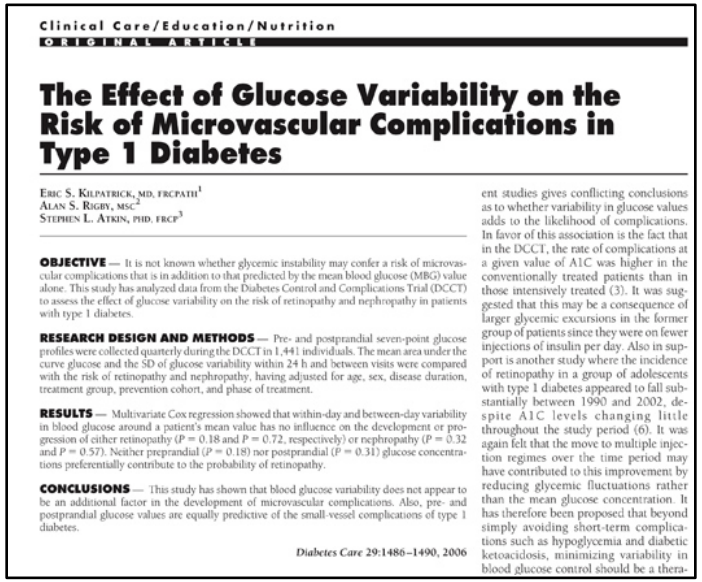
Is there controversy about the importance of glycemic variability?



Clinical Care/Education/Nutrition

ORIGINAL ARTICLE

The Effect of Glucose Variability on the Risk of Microvascular Complications in Type 1 Diabetes

ERIC S. KILPATRICK, MD, FRCPATH[1]
ALAN S. RIGBY, MSC[2]
STEPHEN L. ATKIN, PHD, FRCP[3]

OBJECTIVE — It is not known whether glycemic instability may confer a risk of microvascular complications that is in addition to that predicted by the mean blood glucose (MBG) value alone. This study has analyzed data from the Diabetes Control and Complications Trial (DCCT) to assess the effect of glucose variability on the risk of retinopathy and nephropathy in patients with type 1 diabetes.

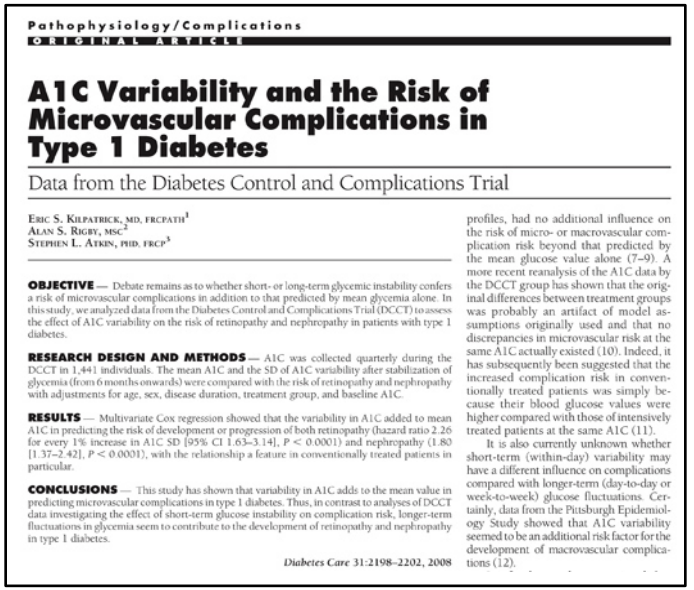
RESEARCH DESIGN AND METHODS — Pre- and postprandial seven-point glucose profiles were collected quarterly during the DCCT in 1,441 individuals. The mean area under the curve glucose and the SD of glucose variability within 24 h and between visits were compared with the risk of retinopathy and nephropathy, having adjusted for age, sex, disease duration, treatment group, prevention cohort, and phase of treatment.

RESULTS — Multivariate Cox regression showed that within-day and between-day variability in blood glucose around a patient's mean value has no influence on the development or progression of either retinopathy ($P = 0.18$ and $P = 0.72$, respectively) or nephropathy ($P = 0.32$ and $P = 0.57$). Neither preprandial ($P = 0.18$) nor postprandial ($P = 0.31$) glucose concentrations preferentially contribute to the probability of retinopathy.

CONCLUSIONS — This study has shown that blood glucose variability does not appear to be an additional factor in the development of microvascular complications. Also, pre- and postprandial glucose values are equally predictive of the small-vessel complications of type 1 diabetes.

Diabetes Care 29:1486–1490, 2006

ent studies gives conflicting conclusions as to whether variability in glucose values adds to the likelihood of complications. In favor of this association is the fact that in the DCCT, the rate of complications at a given value of A1C was higher in the conventionally treated patients than in those intensively treated (3). It was suggested that this may be a consequence of larger glycemic excursions in the former group of patients since they were on fewer injections of insulin per day. Also in support is another study where the incidence of retinopathy in a group of adolescents with type 1 diabetes appeared to fall substantially between 1990 and 2002, despite A1C levels changing little throughout the study period (6). It was again felt that the move to multiple injection regimes over the time period may have contributed to this improvement by reducing glycemic fluctuations rather than the mean glucose concentration. It has therefore been proposed that beyond simply avoiding short-term complications such as hypoglycemia and diabetic ketoacidosis, minimizing variability in blood glucose control should be a thera-



Pathophysiology/Complications

ORIGINAL ARTICLE

A1C Variability and the Risk of Microvascular Complications in Type 1 Diabetes

Data from the Diabetes Control and Complications Trial

ERIC S. KILPATRICK, MD, FRCPATH[1]
ALAN S. RIGBY, MSC[2]
STEPHEN L. ATKIN, PHD, FRCP[3]

OBJECTIVE — Debate remains as to whether short- or long-term glycemic instability confers a risk of microvascular complications in addition to that predicted by mean glycemia alone. In this study, we analyzed data from the Diabetes Control and Complications Trial (DCCT) to assess the effect of A1C variability on the risk of retinopathy and nephropathy in patients with type 1 diabetes.

RESEARCH DESIGN AND METHODS — A1C was collected quarterly during the DCCT in 1,441 individuals. The mean A1C and the SD of A1C variability after stabilization of glycemia (from 6 months onwards) were compared with the risk of retinopathy and nephropathy with adjustments for age, sex, disease duration, treatment group, and baseline A1C.

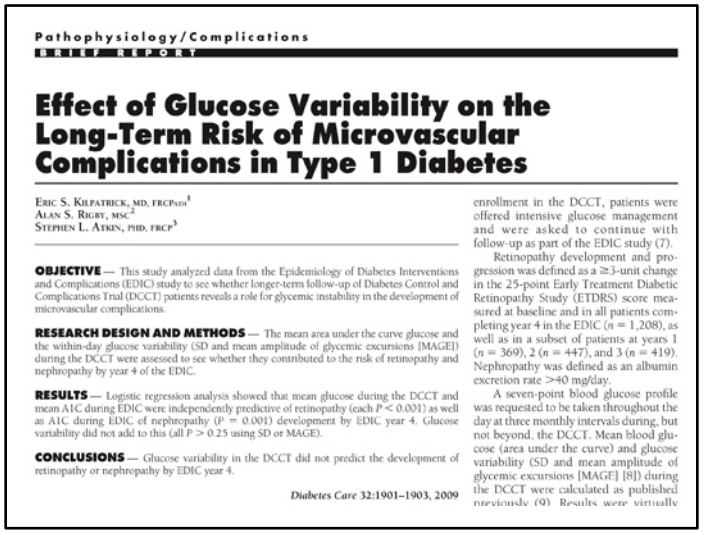
RESULTS — Multivariate Cox regression showed that the variability in A1C added to mean A1C in predicting the risk of development or progression of both retinopathy (hazard ratio 2.26 for every 1% increase in A1C SD [95% CI 1.63–3.14], $P < 0.0001$) and nephropathy (1.80 [1.37–2.42], $P < 0.0001$), with the relationship a feature in conventionally treated patients in particular.

CONCLUSIONS — This study has shown that variability in A1C adds to the mean value in predicting microvascular complications in type 1 diabetes. Thus, in contrast to analyses of DCCT data investigating the effect of short-term glucose instability on complication risk, longer-term fluctuations in glycemia seem to contribute to the development of retinopathy and nephropathy in type 1 diabetes.

Diabetes Care 31:2198–2202, 2008

profiles, had no additional influence on the risk of micro- or macrovascular complication risk beyond that predicted by the mean glucose value alone (7–9). A more recent reanalysis of the A1C data by the DCCT group has shown that the original differences between treatment groups was probably an artifact of model assumptions originally used and that no discrepancies in microvascular risk at the same A1C actually existed (10). Indeed, it has subsequently been suggested that the increased complication risk in conventionally treated patients was simply because their blood glucose values were higher compared with those of intensively treated patients at the same A1C (11).

It is also currently unknown whether short-term (within-day) variability may have a different influence on complications compared with longer-term (day-to-day or week-to-week) glucose fluctuations. Certainly, data from the Pittsburgh Epidemiology Study showed that A1C variability seemed to be an additional risk factor for the development of macrovascular complications (12).



Pathophysiology/Complications

BRIEF REPORT

Effect of Glucose Variability on the Long-Term Risk of Microvascular Complications in Type 1 Diabetes

ERIC S. KILPATRICK, MD, FRCPATH[1]
ALAN S. RIGBY, MSC[2]
STEPHEN L. ATKIN, PHD, FRCP[3]

OBJECTIVE — This study analyzed data from the Epidemiology of Diabetes Interventions and Complications (EDIC) study to see whether longer-term follow-up of Diabetes Control and Complications Trial (DCCT) patients reveals a role for glycemic instability in the development of microvascular complications.

RESEARCH DESIGN AND METHODS — The mean area under the curve glucose and the within-day glucose variability (SD and mean amplitude of glycemic excursions [MAGE]) during the DCCT were assessed to see whether they contributed to the risk of retinopathy and nephropathy by year 4 of the EDIC.

RESULTS — Logistic regression analysis showed that mean glucose during the DCCT and mean A1C during EDIC of nephropathy ($P < 0.001$) as well as A1C during EDIC of nephropathy ($P = 0.001$) development by EDIC year 4. Glucose variability did not add to this (all $P > 0.25$ using SD or MAGE).

CONCLUSIONS — Glucose variability in the DCCT did not predict the development of retinopathy or nephropathy by EDIC year 4.

Diabetes Care 32:1901–1903, 2009

enrollment in the DCCT, patients were offered intensive glucose management and were asked to continue with follow-up as part of the EDIC study (7).

Retinopathy development and progression was defined as a ≥3-unit change in the 25-point Early Treatment Diabetic Retinopathy Study (ETDRS) score measured at baseline and in all patients completing year 4 in the EDIC ($n = 1,208$), as well as in a subset of patients at years 1 ($n = 369$), 2 ($n = 447$), and 3 ($n = 419$). Nephropathy was defined as an albumin excretion rate >40 mg/day.

A seven-point blood glucose profile was requested to be taken throughout the day at three monthly intervals during, but not beyond, the DCCT. Mean blood glucose (area under the curve) and glucose variability (SD and mean amplitude of glycemic excursions [MAGE] [8]) during the DCCT were calculated as published previously (9). Results were virtually

- Kilpatrick et al used DCCT 7-point profiles to assess glycemic variability and were unable to connect glycemic variability with outcomes
- Other studies connect A1C variability with complications, and still others have connected glucose variability with A1C variability
- SOOoooo…what about the DCCT dataset?

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Are superoxides and tissue damage the only problems with glucose oscillations?

Relationship between glucose variability and hypoglycemia

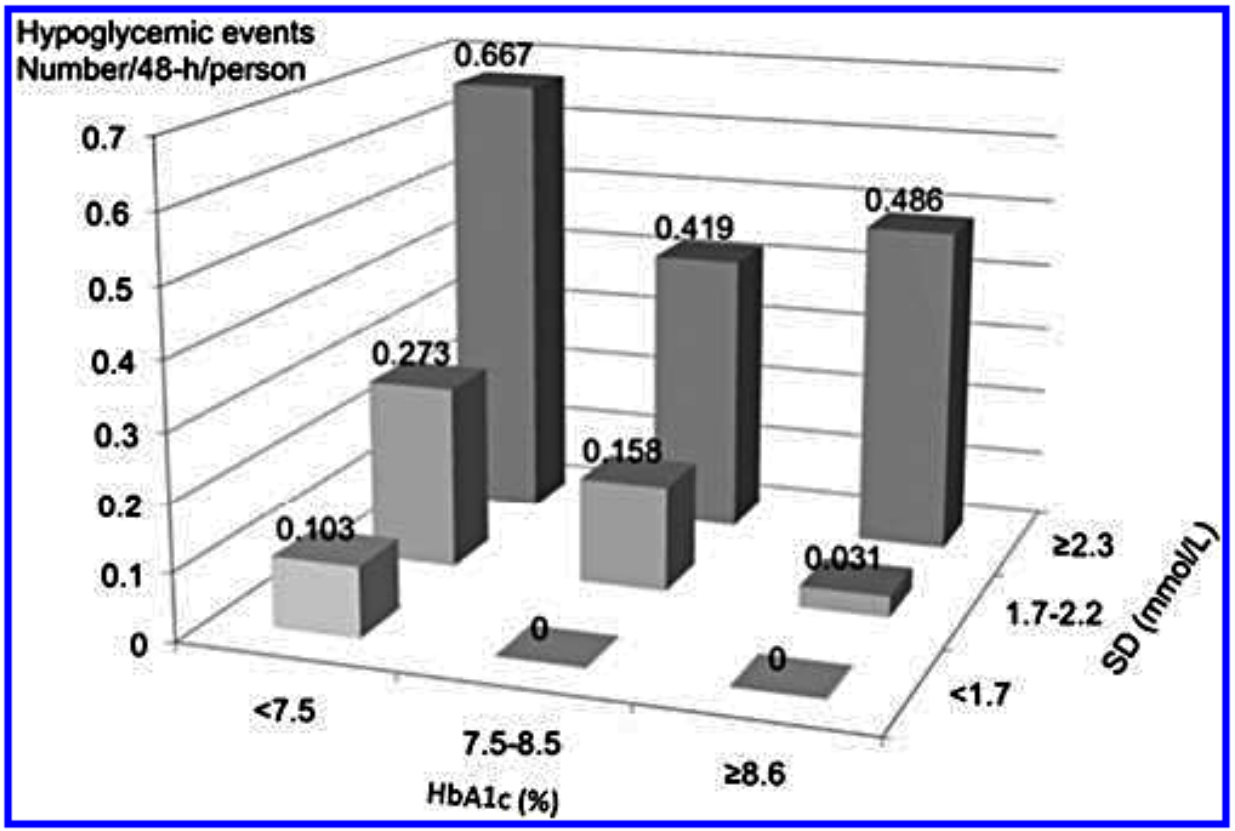

FIG. 2. Number of hypoglycemic events as a function of tertiles of hemoglobin A1c (HbA1c) and tertiles of glycemic variability (SD around the mean glucose concentration).

Monnier L, et al Diabetes Technology & Therapeutics 2011;13:813

Effects of Lower Blood Glucose and Reduced Daily Variability on Quality of Life in Type 2 Diabetes

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Harvard School of Public Health, Phase V Technologies, Inc., Harvard Medical School, Boston, MA

2003 American Diabetes Association 63rd Scientific Sessions, New Orleans

Introduction

The impact of glycemic control on quality of life in type 2 diabetes has been evaluated from the perspective of both ***long- and short-term*** time horizons.

Long-Term Impact of Glycemic Control on QOL

Previous studies in type 2 diabetes have shown that improving HbA_{1c} results in fewer disease complications and better overall health status.

Short-Term Impact of Glycemic Control on QOL

Other studies have focused on shorter 3 - 6 month reductions in HbA_{1c} and have demonstrated a positive association between improvement in glycemic control and improvement in health-related quality of life.

We previously reported data on the health economic and quality-of-life benefits of improved glycemic control using a comprehensive, monthly quality-of-life self assessment questionnaire and HbA_{1c} levels[1].

Aims

Most studies have used HbA_{1c} rather than daily BG to characterize the relationship between glycemic control and quality of life.

However, HbA_{1c} fails to distinguish between BG's that are fairly stable from day to day and those with more variability.

In this study we evaluate the association between day to day fluctuations in glucose and changes in patients' sense of well being, functioning and symptoms using home diaries and home BG monitoring.

Research Questions

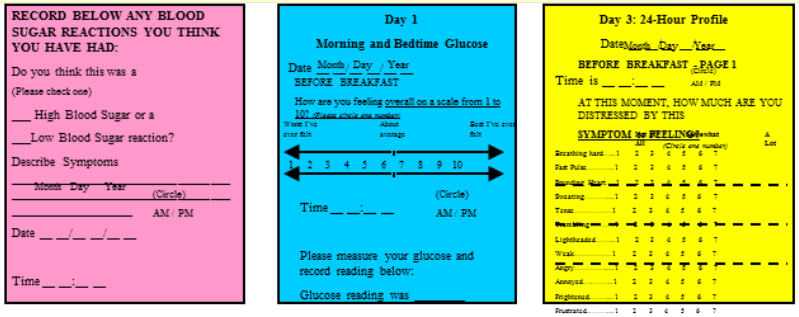
- Does average daily BG predict daily reports of quality of life?
- Does a more stable day to day blood glucose profile lead to more favorable daily reports of overall health and fewer symptoms?

Methods

Study Design and Setting

- Men and women at least 30 years of age with type 2 diabetes previously treated with either diet alone or a sulfonylurea for at least 3 months, and FPG levels between 140 and 250 mg/dL.
- 15-week (3 week placebo washout and 12 weeks active therapy), double-blind, dose-titration study enrolling patients from 62 US sites randomized to either diet/glipizide GITS (n = 377) or diet/placebo (n = 192).
- Monthly, 30-page quality-of-life assessments of physical, emotional, cognitive, and social functioning.
- HbA_{1c} at Weeks 0 and 15 and FPG weekly (titration - 4 weeks) and biweekly

Home Diary Assessments



Sample page excerpts from three-part, wallet-diary carried at all times.

PINK SECTION: *Record of adverse reactions and corresponding blood glucose. Recorded at any time.*

BLUE SECTION: *Two days per week morning and bedtime home glucose and health rating. Recorded every week.*

YELLOW SECTION: *Symptom evaluation (43 items) and home glucose before breakfast, lunch, dinner and bedtime. Recorded every other week.*

Baseline Characteristics and Diary Statistics

Characteristic	Mean (SD) or N (%)
Age (yrs)	58.6 (11.5)
BMI (kg/M^2)	30.2 (5.3)
Duration diabetes (yrs)	5.3 (5.5)
Males N (%)	320 (56)
Race White N (%)	411 (72)
FPG mg/dL **	
Prior Diet Only	194 (49)
Prior Sulfonylurea	230 (64)
HbA$_{1c}$ (SD) % **	
Prior Diet Only	8.6 (1.4)
Prior Sulfonylurea	8.5 (1.5)
M_QOLam (range 1 - 10)	6.5 (1.5)
M_QOLpm (range 1 - 10)	6.4 (1.6)

*** After 3 weeks off all sulfonylurea medication*

Calculations: Single Item Home Diary QOL Ratings

QOL(j)am(i) and QOL(j)pm(i) = QOL ratings pre breakfast (am) and before bedtime (pm) during week j = 1, 2, ...12 on days i = 1, 2.

Calculate 2-day mean value= *M[QOL(j)am] and M[QOL(j)pm]* for week j.

Calculations: Blood Glucose Home Measurements

BG(j)am(i) and BG(j)pm(i) = BG pre breakfast and before bedtime during week j = 0,1, 2, ...12 on days i = 1, 2 ,3.

Calculate 3-day: Means = *M[BG(j)am] and M[BG(j)pm]*, Standard Deviations = *SD[BG(j)am] and SD[BG(j)pm]*, and Coefficients of Variation = *CV[BG(j)am] and CV[BG(j)pm]* during week j.

Blood Glucose Variability and Quality of Life in T2DM

- Overall blood glucose and day to day variability were both negatively correlated with mean Quality- of-Life (QOL) ratings
- “Data provide additional evidence for benefits of maintaining a low and stable glucose profile and support conducting further studies of BG variability and QOL.”

Testa MA, et al Presented at ADA, June 2003

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“Glycemic variability may be associated with lower quality of life and negative moods”

DIABETES TECHNOLOGY & THERAPEUTICS
Volume 14, Number 4, 2012

DOI: 10.1089/dia.2011.0191

Original Articles

Does Glycemic Variability Impact Mood and Quality of Life?

Sue Penckofer, Ph.D., R.N.,[1] Lauretta Quinn, Ph.D., R.N., C.D.E.,[2] Mary Byrn, Ph.D., R.N.,[3]
Carol Ferrans, Ph.D., R.N.,[2] Michael Miller, Ph.D.,[4] and Poul Strange, Ph.D., M.D.[5]

Abstract

Background: Diabetes is a chronic condition that significantly impacts quality of life. Poor glycemic control is associated with more diabetes complications, depression, and worse quality of life. The impact of glycemic variability on mood and quality of life has not been studied.

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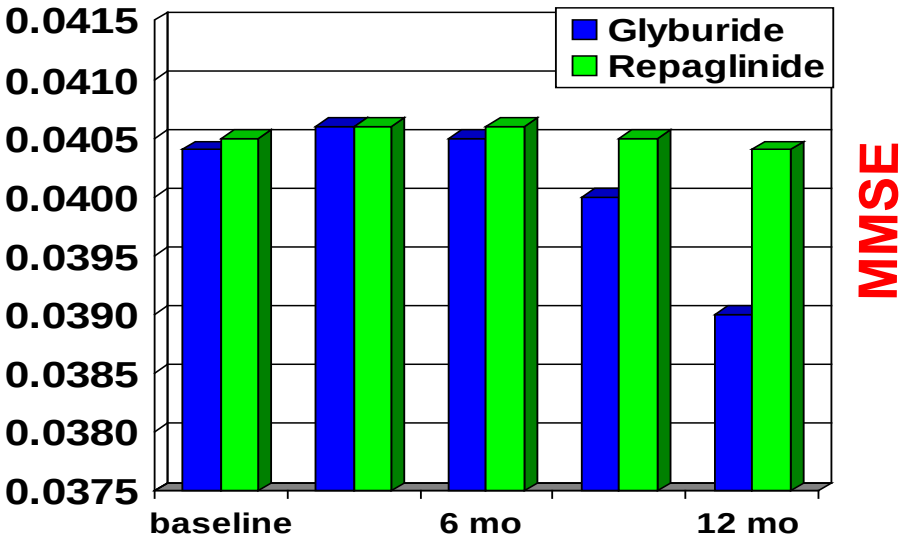
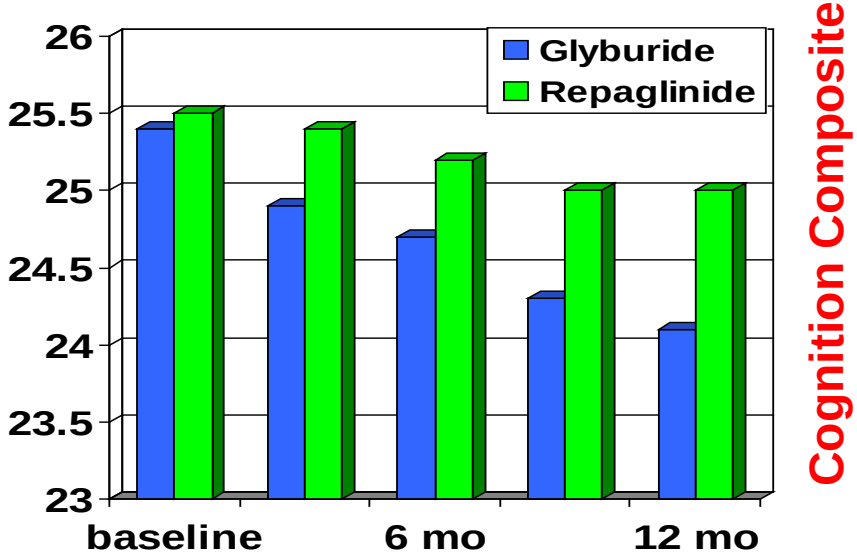
…and reduction in glucose and glycemic variability can affect how you THINK!





- In older patients with T2DM, the coefficient of variation of PPG values was strongly associated with global cognition as well as executive and attention functioning
- Tight control of PPG levels may be useful for preventing derangement in cognitive functioning.

Abbatecola AM, et al. Neurology 2006; 67:235

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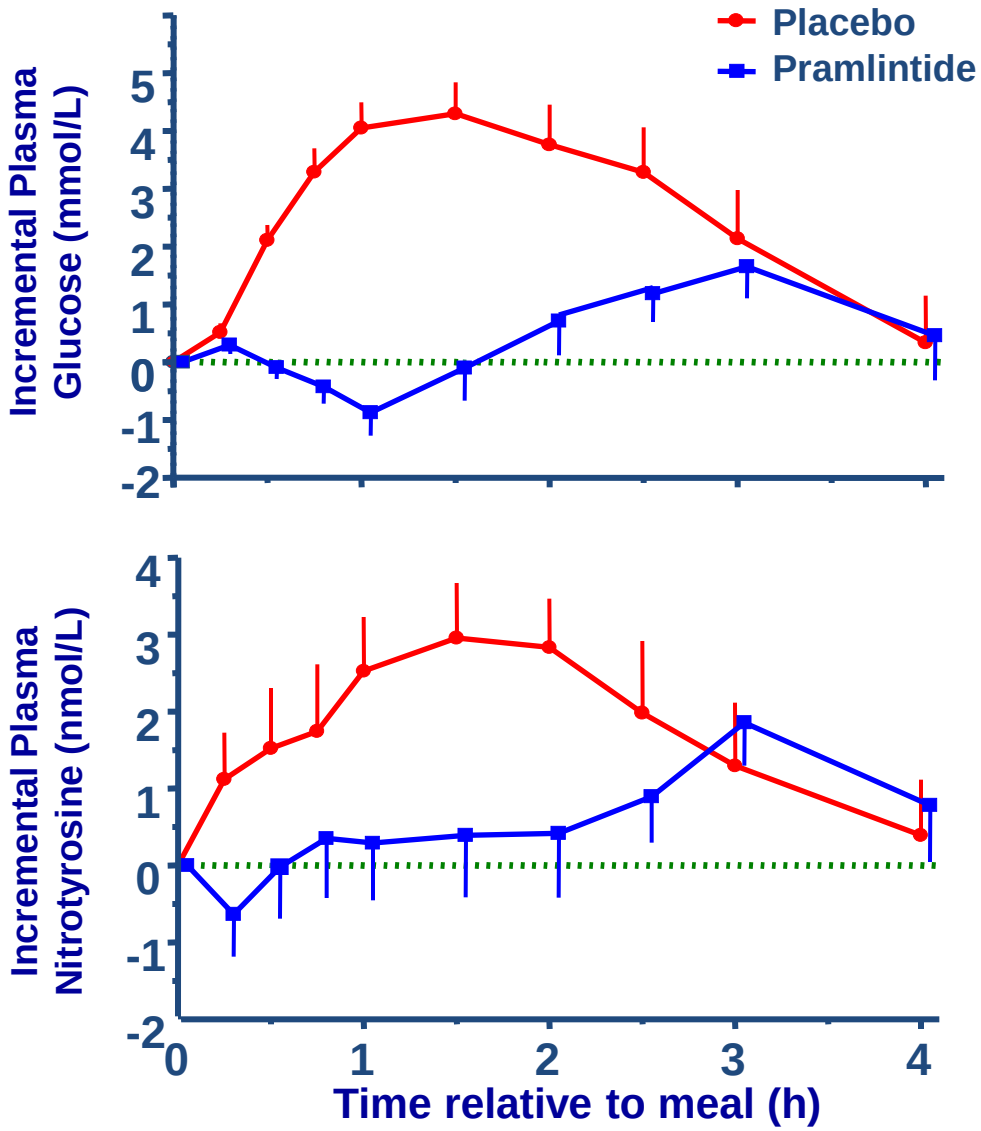
So what should we do to minimize glucose variability

…you can use drugs



- Patients with type 2 diabetes received pramlintide prior to a meal which resulted in lower prandial excursions of glucose and lower levels of oxidative metabolite nitrotyrosine

Type 2 diabetes; N = 19; Mean ±SE; $AUC_{0\text{-}4h}$ significant at $P<0.05$ compared to placebo.

Ceriello A, et al.
Diabetes Metab Res Rev 2008;24:103

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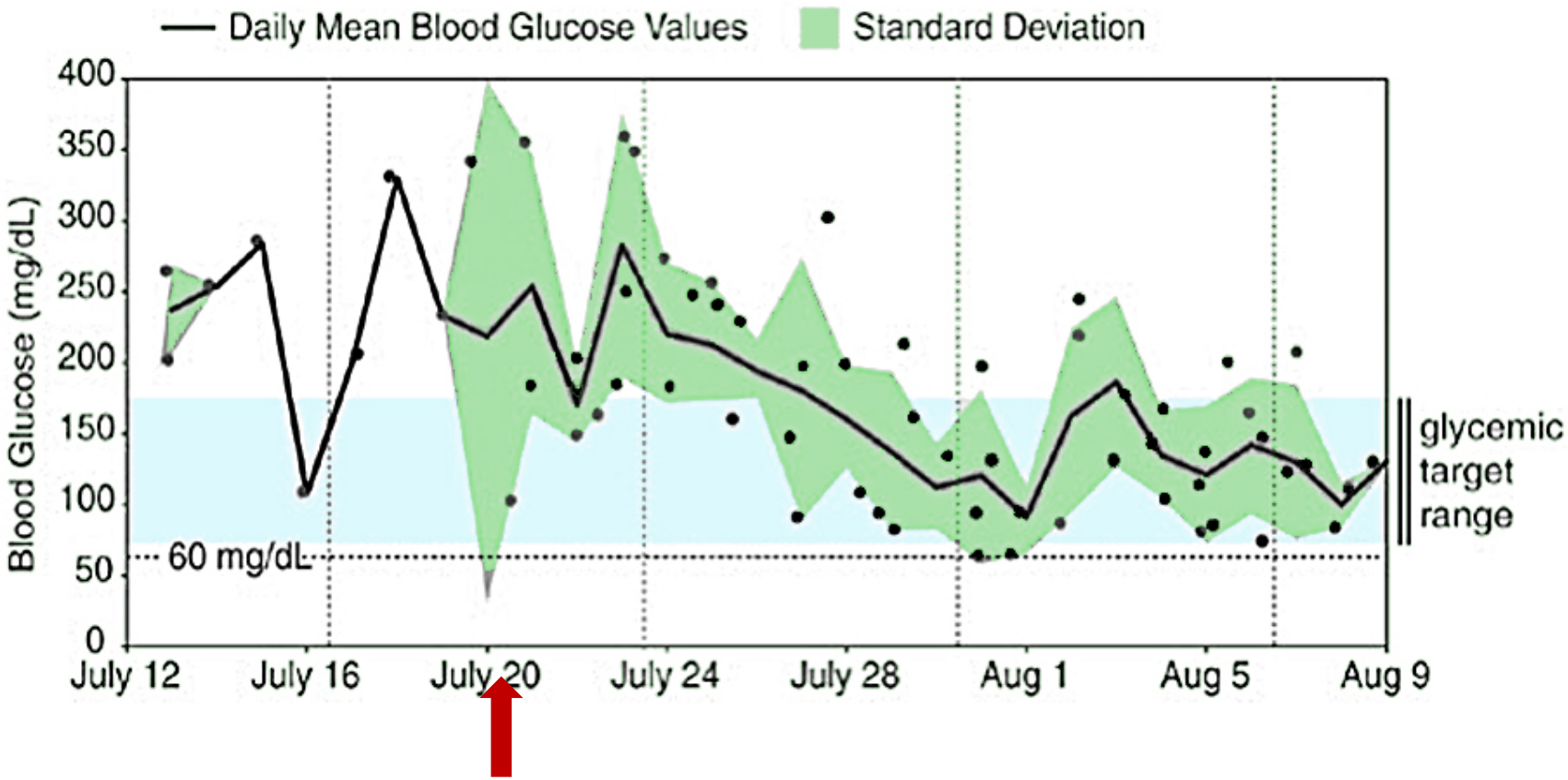
… you can use insulin pumps



Patient started insulin pump July 20th

Unger, J. *Diabetes Management In Primary Care* (2007)

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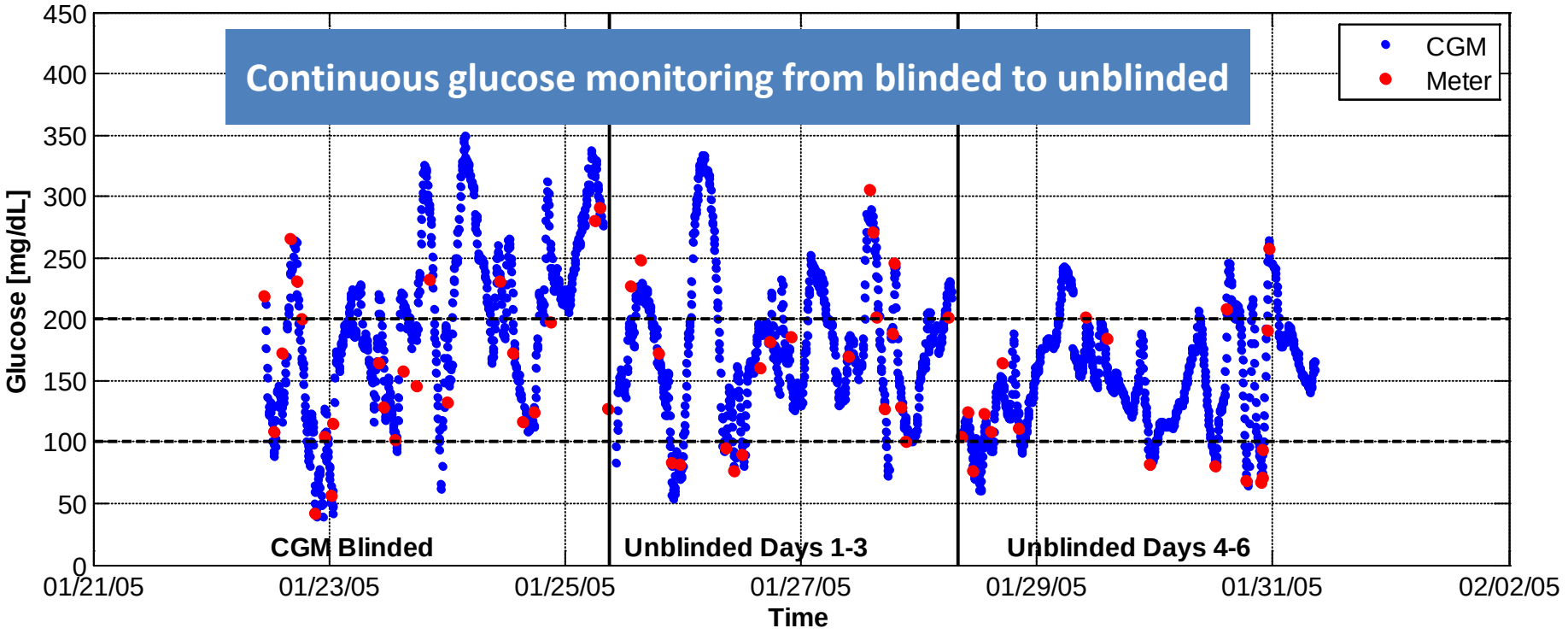
…you can use continuous glucose monitoring (CGM)



Garg S, et al "Improvement in Glycemic Excursions With a Transcutaneous, Real-Time Continuous Glucose Sensor" Diab Care 2006;29:44-50

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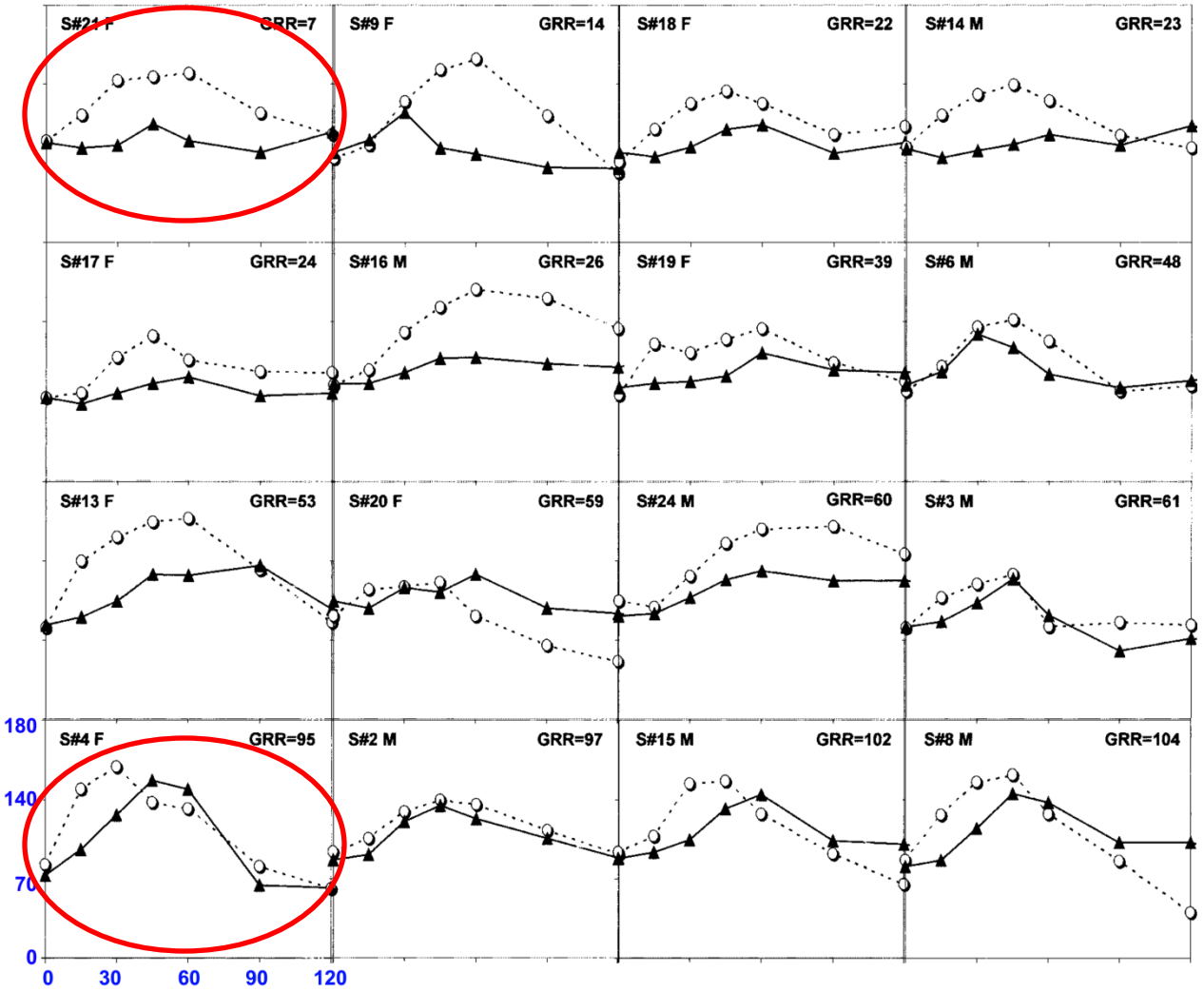
… or you can use SMBG to find out how food affects your glucose



Different responses to oral glucose (open circles) and white bread (dark triangles) among healthy adults

Vega-Lopez, et al.
Diabetes Care 2007;30:1412

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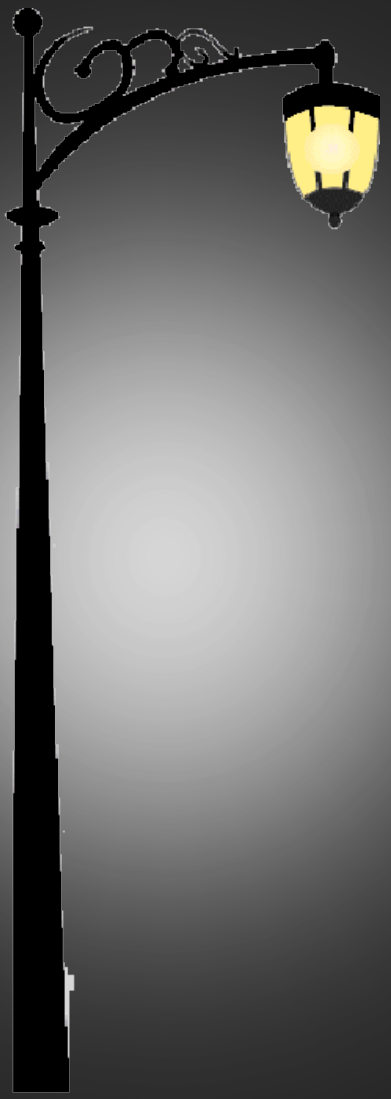
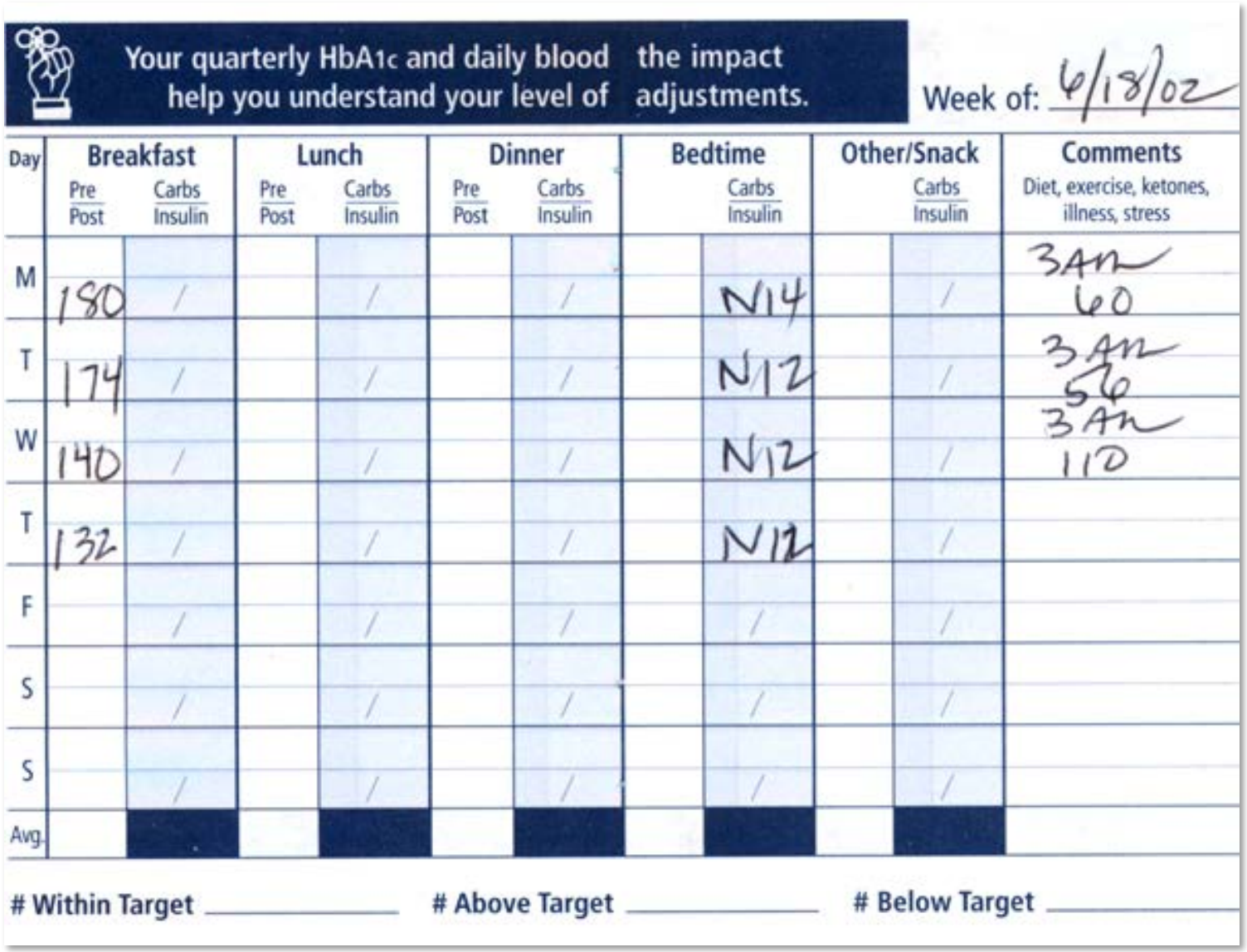
When should I check blood glucose?



What you get at best…



Your quarterly HbA1c and daily blood ___ the impact help you understand your level of ___ adjustments.

Week of: 6/18/02

Day	Breakfast Pre/Post	Breakfast Carbs/Insulin	Lunch Pre/Post	Lunch Carbs/Insulin	Dinner Pre/Post	Dinner Carbs/Insulin	Bedtime Carbs/Insulin	Other/Snack Carbs/Insulin	Comments (Diet, exercise, ketones, illness, stress)
M	180 /	/		/		/	N14	/	3AM 60
T	174 /	/		/		/	N12	/	3AM 56
W	140 /	/		/		/	N12	/	3AM 110
T	132 /	/		/		/	N12	/	
F	/	/		/		/	/	/	
S	/	/		/		/	/	/	
S	/	/		/		/	/	/	
Avg.									

Within Target _____ # Above Target _____ # Below Target _____

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Polling Question 4:

Which of the following SMBG regimens has been shown to result in a significant decrease in A1C?

- ❑ Pre- and post meals and at bedtime; 3 days/mo
- ❑ Fasting and post meals once every two weeks
- ❑ Pre- and post meals two days per week
- ❑ 1 and 2
- ❑ All the above

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Structured testing: Other examples

4-point profile (1 weekday every 2 weeks) Bonomo; DiabResClinPract 2010

	Pre-Breakfast	Post-Breakfast	Pre-Lunch	Post-Lunch	Pre-Supper	Post-Supper	Bedtime
Monday	X	X		X		X	
Tuesday							
Wednesday							
Thursday							
Friday							
Saturday							
Sunday							

6-point profile (1 weekday & 1 weekend per week) Schwedes; DiabCare 2002

	Pre-Breakfast	Post-Breakfast	Pre-Lunch	Post-Lunch	Pre-Supper	Post-Supper	Bedtime
Monday	X	X	X	X	X	X	
Tuesday							
Wednesday							
Thursday							
Friday							
Saturday	X	X	X	X	X	X	
Sunday							

Staggered SMBG Regimen

	Pre-Breakfast	Post-Breakfast	Pre-Lunch	Post-Lunch	Pre-Supper	Post-Supper	Bedtime
Monday	X	X					
Tuesday			X	X			
Wednesday					X	X	
Thursday	X	X					
Friday			X	X			
Saturday					X	X	
Sunday	X	X					

- There are many schedules and suggested schedules and various studies document their effectiveness
- In general, the more times the patient tests before and after meals the better the outcome

Bonomo K, et al Diab Res & Clin Pract 2010;87:249
Schewedes U, et al Diab Care 2002; 25:1928

Structured Testing: 7 Point Profiles

	Pre-Breakfast	Post-Breakfast	Pre-Lunch	Post-Lunch	Pre-Supper	Post-Supper	Bedtime
Monday	X	X	X	X	X	X	X
Tuesday	X	X	X	X	X	X	X
Wednesday	X	X	X	X	X	X	X
Thursday							
Friday							
Saturday							
Sunday							

	Pre-Breakfast	Post-Breakfast	Pre-Lunch	Post-Lunch	Pre-Supper	Post-Supper	Bedtime
Monday							
Tuesday							
Wednesday							
Thursday							
Friday	X	X	X	X	X	X	X
Saturday	X	X	X	X	X	X	X
Sunday	X	X	X	X	X	X	X

- 7-Point Profiles: testing before & after meals & bed-time three days in a row.
- One study suggested the three days before the quarterly physician visit
- One study suggested doing these once/month
- Both weekdays and weekend days should be evaluated.

Polonsky W, et al Diab Care 2011;34:262
Parkin C., Davidson JA. J Diab Sci Technol 2009;3:500

Take Home Messages

- Chronic elevations of glucose produce toxicity to major end organs; oxidative stress and superoxides are major culprits of glucotoxicity
- Glucose excursions are associated with cardiovascular risk and increased risk for many diabetes complications
- Lowering glucose variability should be a therapeutic goal
- Good glucose control means controlling glucose at all times, not just fasting
- SMBG can guide providers to make medication changes
- SMBG can guide patients to make changes in food and exercise
- In short….

When it Comes to Glucose Control…

The Best
Helping Hand…

Is At the End
of Your Arm!

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THANK YOU

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