

Technology for Managing Diabetes

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Disclosure Statement

- Advisory Boards: Sanofi, Medscape, LifeScan, DKSH Singapore, and NovoNordisk
- Co-Director, Diabetes Dialog: 3-days educational program for Endocrine Fellows sponsored by NovoNordisk, Lilly, Mannkind, Dexcom, Insulet, Medtronic, Tandem Diabetes Care, Abbott and Senseonics
- Speaking: Dexcom, Insulet, Tandem Diabetes Care and Embecta
- Research Grants: Eli-Lilly, NovoNordisk, Insulet, Tandem Diabetes Care, Dexcom, NIH and JDRF
- Other:
 - ADA Scientific Session Planning Committee
 - Chair, ADA Diabetes Technology Interest Group
 - ATTD Scientific Session Planning Committee



Learning Objectives

1. Review of technologies in diabetes management
2. When, what and how to use diabetes technology
3. Individualizing selection of diabetes technologies to improve outcomes in clinical practice



Case 1

48-year-old Asian Indian with T2D of 10 years. He is on metformin 1000 mg BID, Glimepiride 4 mg OD, Sitagliptin 100 mg OD, and Pioglitazone 15 mg OD. His fasting glucose are ~100-120. **A1c was 8.2**. Other medical history includes hypertension and dyslipidemia.

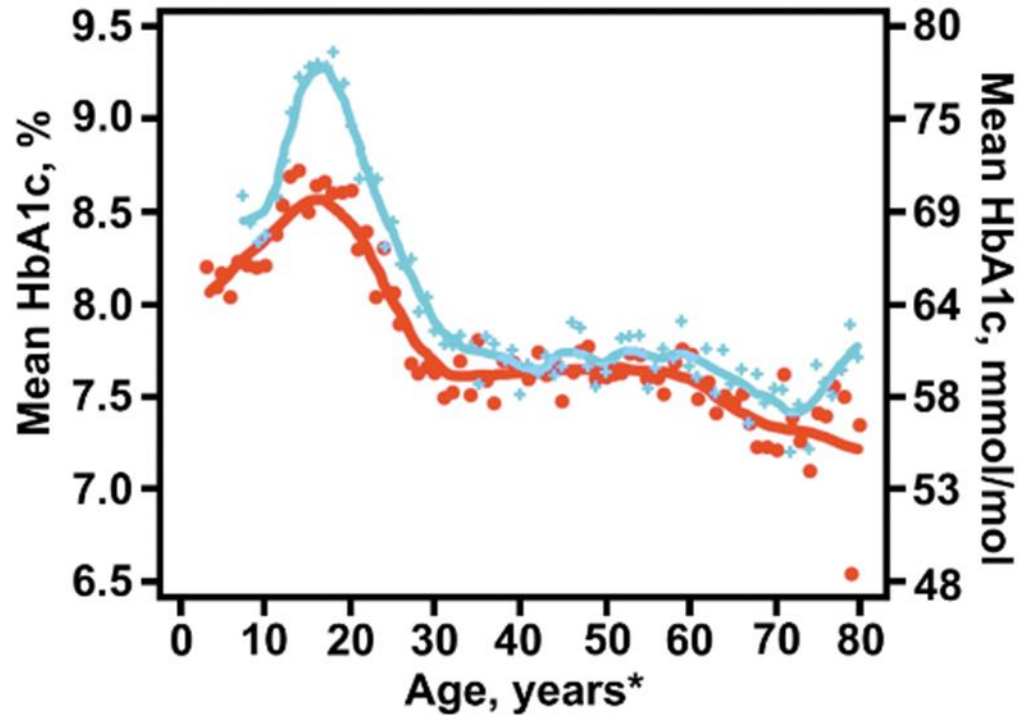
Examination: Vitals are normal. BMI 29.

What is next best step to manage his diabetes?

- A. Add a SGLT-2 inhibitor
- B. Increase dose of pioglitazone to 45 mg
- C. Add basal insulin
- D. Stop Sitagliptin and consider GLP-1R analog



Current Status of Glycemic Control in T1D



Red Line: 2010-2012

Blue Line: 2016-2018

- ✓ Only 21% adults achieve ADA goal of A1c <7%
- ✓ Only 37% adults achieve A1c <7.5%



How Can We Change Current Situation?



A1c Alone is Not Helpful in Managing Diabetes

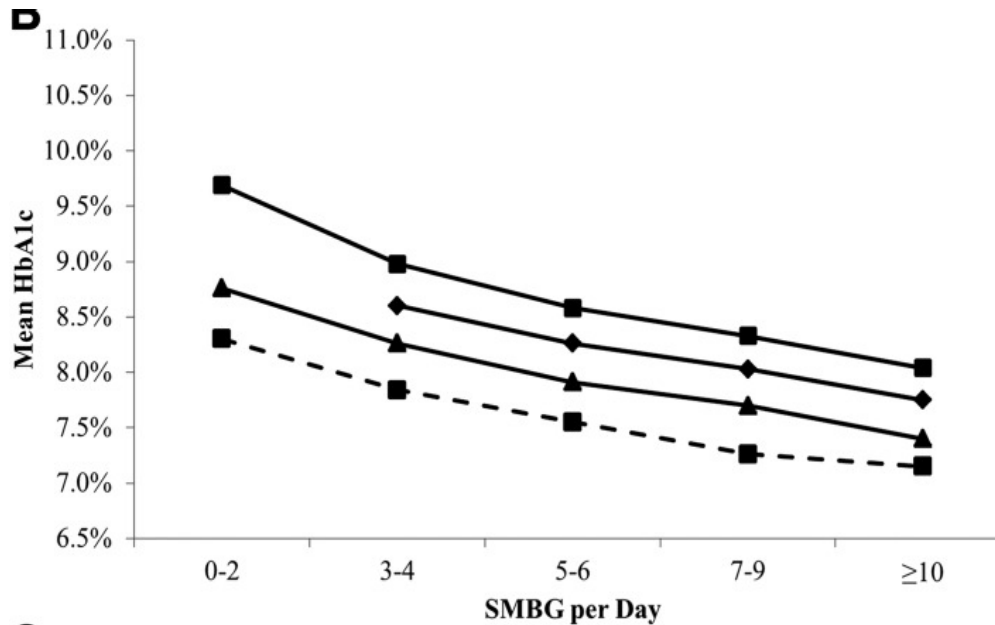
Conditions causing inappropriately high or low HbA1c^[10]

Inappropriately Low HbA1c	Inappropriately High HbA1c	Variable Effect on HbA1c+
<ul style="list-style-type: none"> • Hemolysis • Certain hemoglobinopathies • Recent blood transfusion • Acute blood loss • Hypertriglyceridemia • Drugs* • Chronic liver disease 	<ul style="list-style-type: none"> • Iron deficiency • Vitamin B12 deficiency • Alcoholism • Uremia • Hyperbilirubinemia • Drugs* 	<ul style="list-style-type: none"> • Fetal hemoglobin • Methemoglobin • Certain hemoglobinopathies

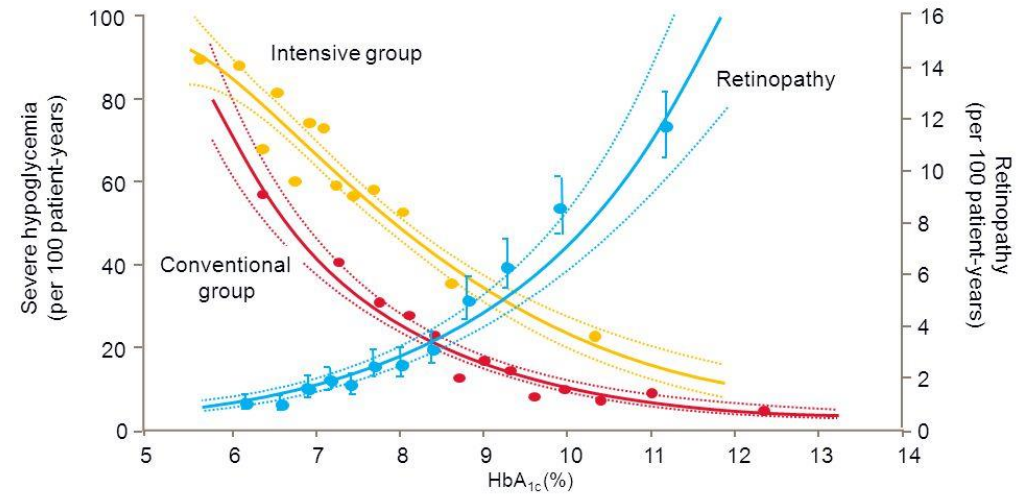
Drugs causing inappropriately low or high HbA1c

Postulated Mechanism	Falsely Low HbA1c	Falsely High HbA1c
Increased erythrocyte destruction	Dapsone ^[11-16] Ribavirin ^[17] Antiretrovirals ^[18] Trimethoprim-Sulfamethoxazole ^[14]	
Altered hemoglobin Altered glycation	Hydroxyurea ^[19] Vitamin C ^[10] Vitamin E ^[10] Aspirin (small doses) ^[10]	
Interference with assays		Aspirin (large doses) ^[20] Chronic opiate use ^[21]

Self Monitoring of Blood Glucose (SMBG)



Hypoglycemia: benefits and risks (DCCT)



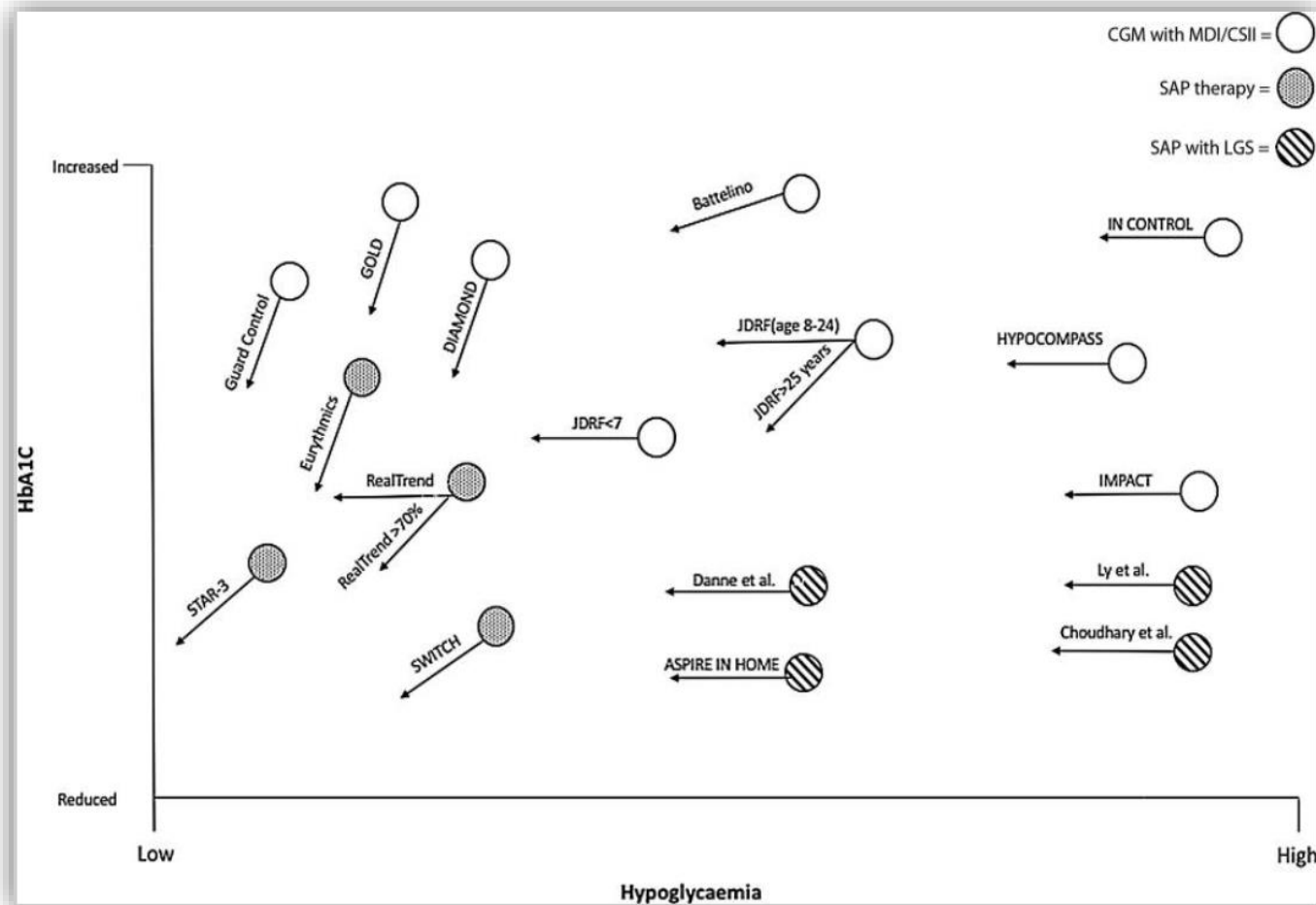
DCCT, Diabetes Control and Complications Trial
DCCT Research Group. *N Engl J Med* 1993;329:977-86

Data by age groups (<13, 13-<26, 26-50, >50 years)
Adjusted for insulin delivery method, sex, race/ethnicity, insurance status, and household income

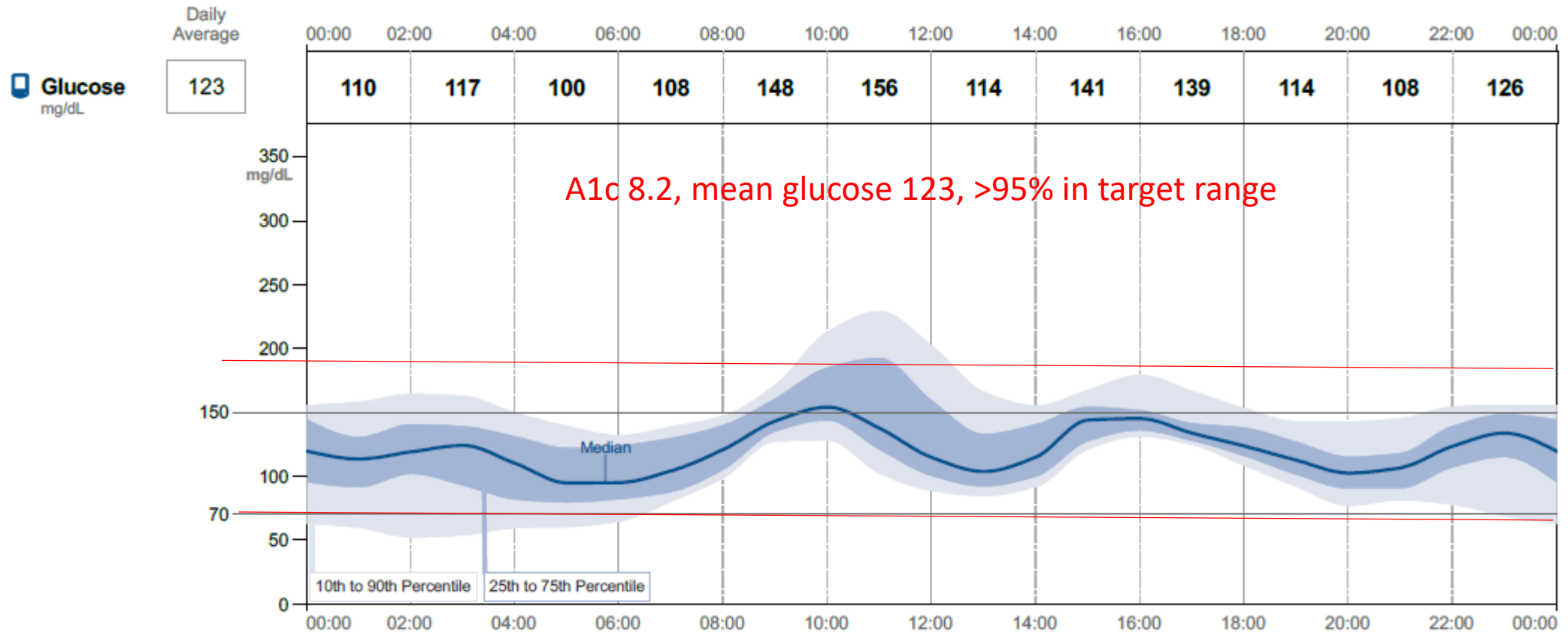
Diabetes Care. Jul 2013; 36(7): 2009-2014.



Why CGM?



Case 1



Labs

Hemoglobin	13.3	g/dL	13.0 - 16.5
RBC Count	4.90	million/cmm	4.5 - 5.5
Hematocrit	42.1	%	40 - 49
MCV	85.9	fL	83 - 101
MCH	27.1	pg	27.1 - 32.5
MCHC	L 31.6	g/dL	32.5 - 36.7
RDW CV	H 14.70	%	11.6 - 14

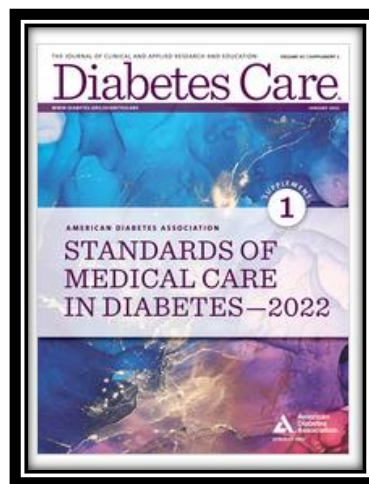
Iron	L 47.00	micro g/dL	50 - 175
Ferritin <small>CMIA</small>	L 16.29	ng/mL	21.81 - 274.66



Guidelines for CGM Use

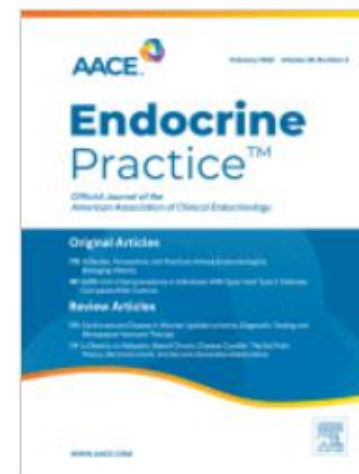


Volume 101, Issue 11
1 November 2016



7. Diabetes Technology: *Standards of Care in Diabetes—2023*

Diabetes Care 2023;46(Suppl. 1):S111–S127 | <https://doi.org/10.2337/dc23-S007>

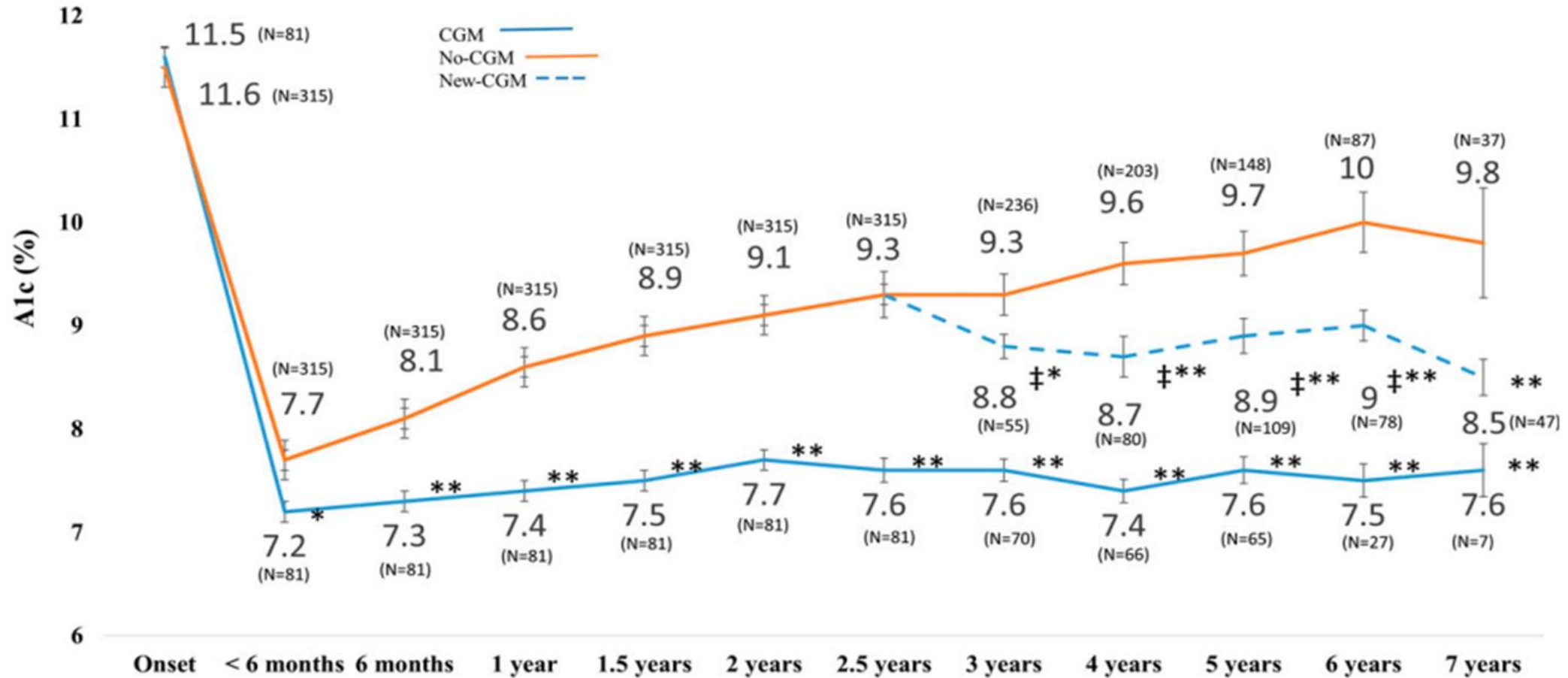


AACE Guideline

American Association of Clinical Endocrinology Clinical Practice Guideline: The Use of Advanced Technology in the Management of Persons With Diabetes Mellitus



When to Start CGM in T1D?



When to Consider CGM in T2D

- Grade A
 - All patients with T2D on insulin therapy
 - Patients with problematic hypoglycemia
 - Age >65 years
- Grade B
 - May be recommended for T2D not on intensive insulin therapy



Which Method of CGM (rtCGM vs isCGM) is Preferred?

- rtCGM should be recommended over isCGM for people with diabetes with problematic hypoglycemia who require alert (Grade B)
- Age > 65 on insulin therapy (Grade A)
- isCGM may be considered for (Grade D)
 - Newly diagnosed T2D
 - T2D treated with non hypoglycemic therapies
 - Motivated to scan device several times per day
 - At low risk for hypoglycemia but desire more data than SMBG



When Should Professional CGM be Considered?

- Professional CGM should be used in
 - Newly diagnosed DM
 - Not using CGM
 - May have problematic hypoglycemia but no access to personal CGM
 - T2D on non-insulin therapies who would benefit from episodic CGM use
 - As a trial before committing to daily use

Level of evidence: **Grade B**



Currently Available CGMs



	Libre2	Libre 3	Dexcom G6	Dexcom G7	Eversense E3
Age (years)	≥4	≥4	≥2	≥2	≥18
Accuracy (MARD)		MARD provides limited values and clinically less relevant			
Alerts	Optional alerts you have to scan to see numbers	Customizable alerts Every 1 min, repeat 5 min till acknowledged Urgent low glucose alarm-defaulted	Customizable alerts + Urgent low soon + (predicted to reach 55 within 20 min)	Predictive alert + Silence all (new feature)- no sound or vibration up to 6 hour, delay 1 st alert, Quiet mode,	Predictive alert + You can choose 10,20,30 minutes prior to high or low
Glucose arrow	1-2 mg/dL	1-2 mg/dL	2-3 mg/dL	2-3 mg/dL	1-2 mg/dL
Warm-up time , min	60	60	120	30	24 hour
Duration (days)	14	14	10	10.5	180
Real-time display	No	Yes (33 feet)	Yes (20 feet)	Yes (20 feet)	Yes
Size	5X35 mm	2.9X21 mm	1.8 X 1.2 X 0.6 inch	4.6 mmX24 mm	1.48 X 1.89 X 0.35 inch (transmitter)
Pump integration	Coming	Coming	Yes	Coming	No
Calibration	No	No	No	No	2/day X21 days and 1/day afterwards
Share	Yes/ Librelinkup	Yes/ LibreLinkup	Yes	Yes	yes
Deep water testing	3 ft, 30 min	3 ft, 30 min	8 feet up to 24 hr	8 feet up to 24 hr	3.2 feet for 30 minutes
Siri integration, text messaging	No	NO	Yes	Yes	No
Interference	Vitamin C- false high	No	No	No	Mannitol, sorbitol & tetracycline
Airport	No	No	No	yes	Safe
Radiology (CT/MRI)	Remove sensor before CT/MRI or X-ray	Same as Libre 2	Remove	Remove for MRI/ okay for CT as long as it's on same organ of scanning	Sensor is MRI safe for 1.5 or 3T



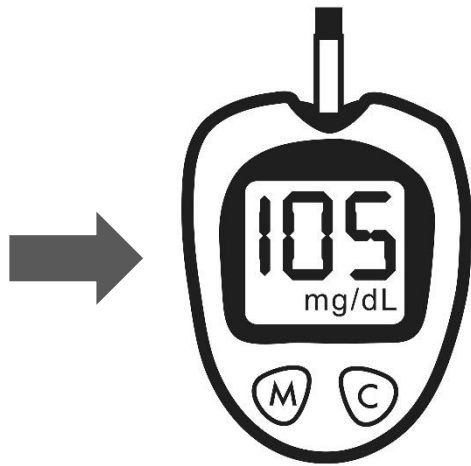
Changing Landscape of Diabetes Management



1908-1945

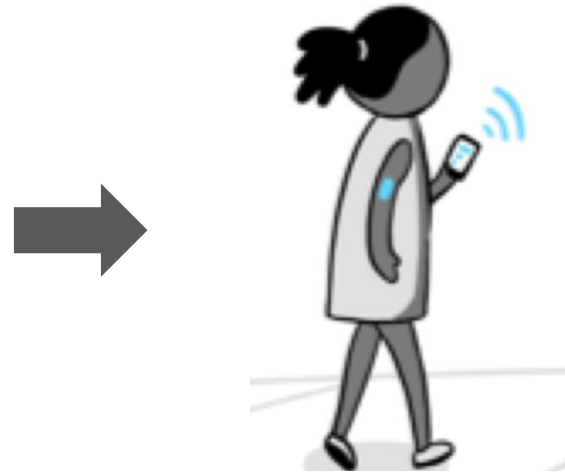
A1c <7%

?



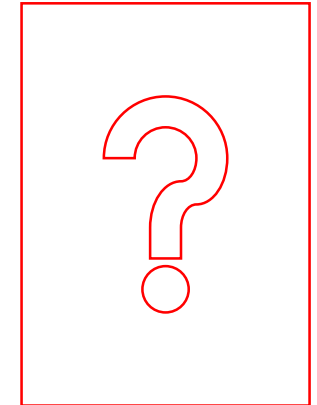
1965-2000

10-15%



1999-2022

35-40%



Case 2

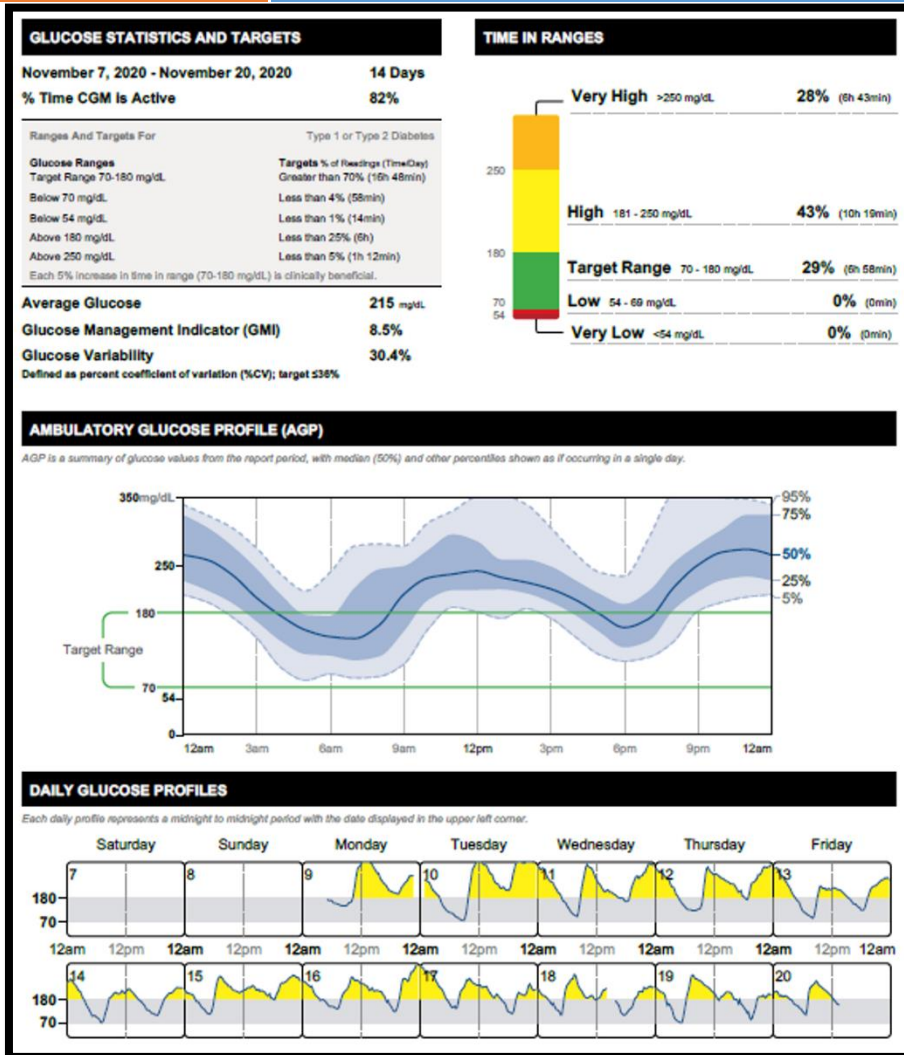
- 62 year with T2D of 15 years. He is on metformin and basal insulin, glargine U100 of 42 units at night. He could not tolerate DPP-4i or GLP-1RA in the past. He had recurrent UTIs with SGLT-2i.
- **A1c 8.5%**
- Fasting glucose: 90-140 mg/dL

What is next best step to manage his diabetes?

- A. Consider pioglitazone 15 mg per day
- B. Increase basal insulin
- C. Consider trial of DPP-4i
- D. Consider CGM



Professional CGM



- ✓ Fasting first approach may lead to overbasalization
- ✓ Consider CGM to review glucose data
- ✓ Based on CGM, if drop in glucose from midnight to morning is >50- Reduce basal rate and consider additional therapy



Case 2: 3-Month Follow-up after MDI

- We started on multiple daily injections with long-acting and short acting insulin. Patient was trained on the use of both types of insulin pen.
- At 3-month follow up: A1c was **8.7%**

What is next best step to manage his diabetes?

- A. Increase basal insulin dose
- B. Increase prandial insulin dose
- C. Consult dietitian
- D. Continue same and follow up after 3 month



Connected Pens in DM Management

DIABETES TECHNOLOGY & THERAPEUTICS
Volume 23, Number 12, 2021
Mary Ann Liebert, Inc.
DOI: 10.1089/dia.2021.0164



REVIEW ARTICLE

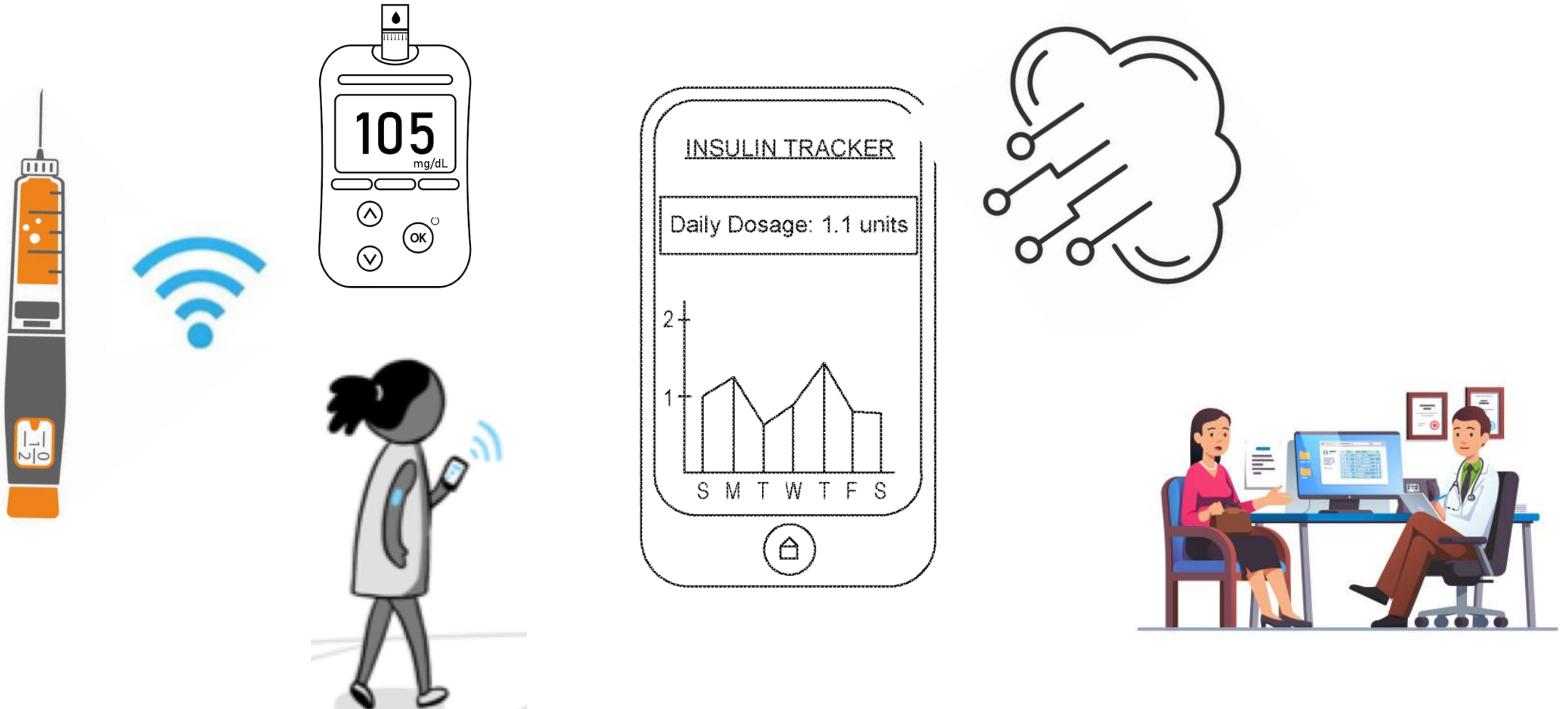
Missed and Mistimed Insulin Doses in People with Diabetes: A Systematic Literature Review

Susan Robinson, PhD,¹ Rachel S. Newson, PhD,^{2,1} Birong Liao, PhD,³
Tessa Kennedy-Martin, MSc,¹ and Tadej Battelino, MD, PhD⁴

- 10-59% of individuals with T1D reported missing at least 1 bolus dose per week
- 10-30% of individuals with T1D reported missing at least 1 basal dose per month
- 1-30% of individuals with T2D reported missing at least 1 basal insulin dose per month

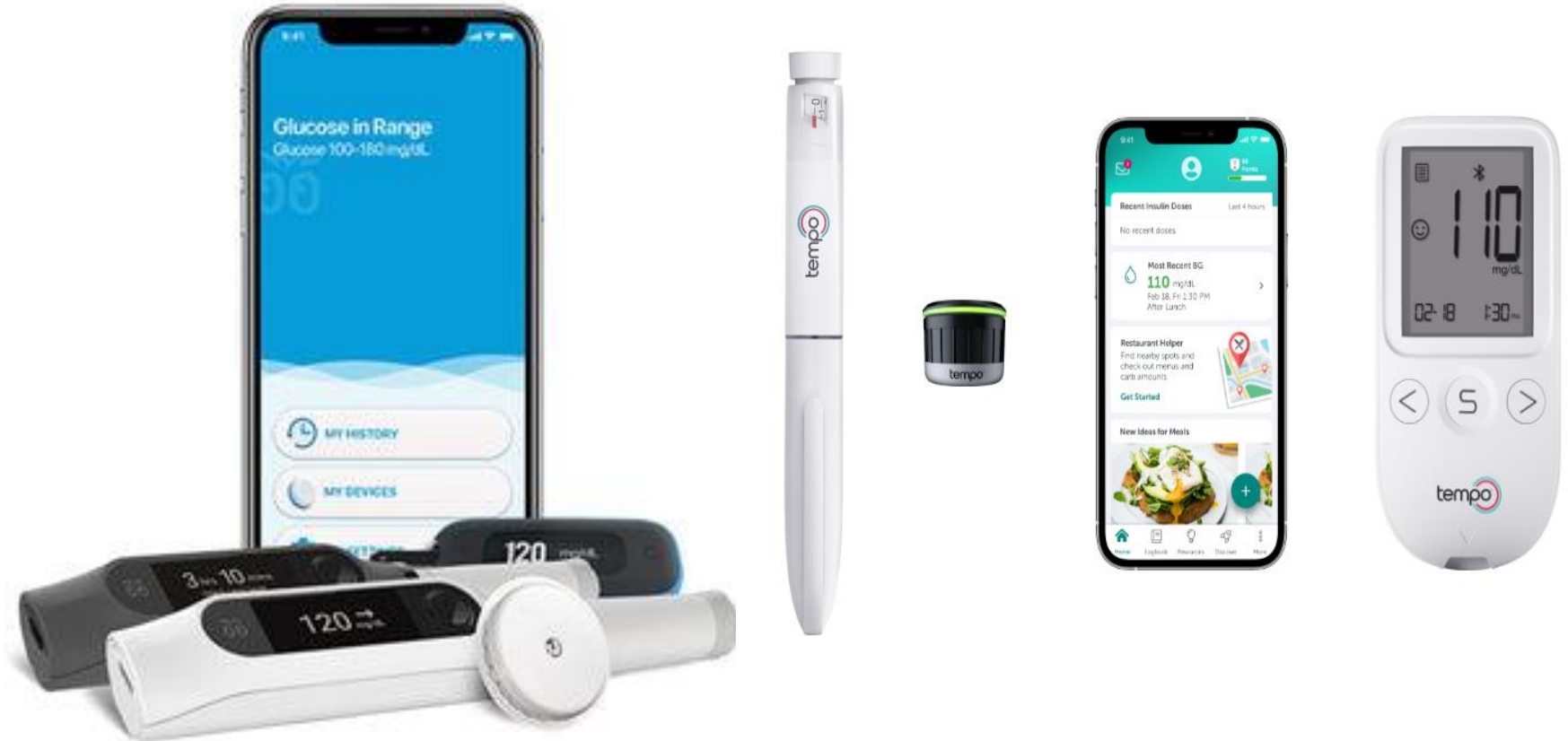
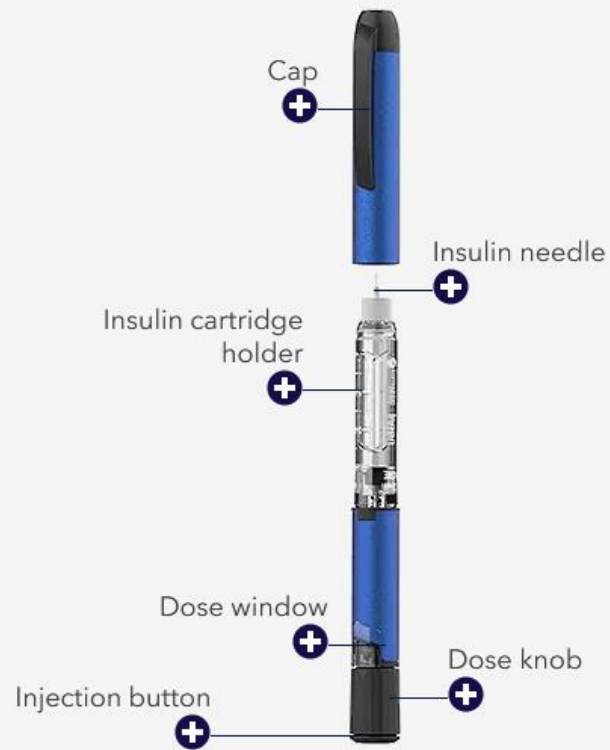


Connected Insulin Pen Concept



Connected Pens in US Market

The pen



Connected Pen Caps

The InsulCheck Range

InsulCheck
CLASSIC



InsulCheck
CONNECT



InsulCheck
DOSE



“Advantages and Disadvantages of Connected Insulin Pens in Diabetes Management”

Kathryn Lingen¹, Talia Pikounis², Natalie Bellini³, and Diana Isaacs⁴

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Corresponding author: Diana Isaacs (ISAACSD@ccf.org)
10685 Carnegie Ave. X20 Cleveland, OH 44106

Short Title: Connected Insulin Pen Review

Four keywords describing manuscript: connected insulin pens, pen caps

Word Count (excluding references and figure legends): 4,446



Case 2: 6-Month Follow-up

- Patient is currently on MDI with once daily long-acting insulin and three time short acting insulin for meals. We considered connect pen for this patient. However, patient did not like it as it required some additional work and stopped using it.
- HbA1c was 8.0%

What is next best step to manage his diabetes?

- A. Increase basal insulin dose
- B. Increase prandial insulin dose
- C. Consider insulin pump
- D. Consider automated insulin delivery system



Evidence with AID Systems in T1D

AID system (author & publication year)	Study design (type, duration, comparison group)	Study population (number of participants & age, mean baseline HbA1c)	Glycemic outcomes ^a					
			ΔMean sensor glucose	ΔTIR 70–180 mg/dL	ΔTBR < 70 mg/dL	ΔTBR < 54 mg/dL	ΔTAR > 250 mg/dL (or 300 or 180 mg/dL)	ΔHbA1c
Children/Adolescents								
AHCL vs 670G Bergenstal et al, 2021 (23)	Crossover trial, 2 13-week periods, comparison of AHCL vs 670G ^b and vs baseline ^c	N= 113, 14–29 yo, T1D, baseline mean HbA1c: 7.9%, TIR: 57%	-7 mg/dL ^b -7 mg/dL: 670G -14 mg/dL: AHCL	+4% ^b +6%: 670G +10%: AHCL	0% ^b -0.1%: 670G -0.2%: AHCL	-0.04% ^b +0.04%: 670G 0%: AHCL	-1% ^b -3%: 670G -4%: AHCL	-0.2% ^b -0.3%: 670G -0.5%: AHCL
AHCL Collins et al, 2021 (5)	Crossover trial, 2 4-week periods, comparison of AHCL vs PLGS	N= 33, 7–21 yo, (N=14, 14–21 yo, N=19, 7–13 yo), T1D, baseline mean HbA1c, TIR: NA	-13 mg/dL: 14–21 yo -9 mg/dL: 7–13 yo	+14%: 14– 21 yo +12%: 7–13 yo	-0.4%: 14– 21 yo -0.7%: 7– 13 yo	-0.1%: 14– 21 yo -0.2%: 7–13 yo	-14%: 14–21 yo -11%: 7–13 yo (T > 300 mg/dL)	NA
Control-IQ Isganaitis et al, 2020 (3)	6-mo randomized trial, comparing CIQ with SAP	N= 63, 14–24 yo, T1D, baseline mean HbA1c: 8.1%, TIR: 52%	-18 mg/dL	+13%	-0.7%	-0.09%	-8%	-0.30%
Control-IQ Breton et al, 2020 (20)	16-week randomized trial, comparing CIQ with SAP	N= 101, 6–13 yo, T1D, baseline mean HbA1c: 7.7%, TIR: 53%	-13 mg/dL	+11%	-0.40%	-0.07%	-6%	-0.40%
CamAPS FX Ware et al, 2022 (28)	4-mo randomized trial, comparing CamAPS FX with SAP	N= 74, 1–7 yo, T1D, baseline mean HbA1c: 7.3%, TIR: NA	-13 mg/dL	+9%	+0.07%	+0.02%	-1% (T > 300 mg/dL)	-0.4%
Adults								
670G McAuley et al, 2020 (4)	6-mo randomized trial comparing 670G with MDI/CSII	N= 120, ≥ 25 yo, T1D, baseline mean HbA1c: 7.4%, TIR: 55%	-13 mg/dL	+15%	-2.0% Median	-0.6% Median	-2.9% Median	-0.4%
Control-IQ Brown et al, 2019 (2)	6-mo randomized trial, comparing CIQ with SAP	N= 168, 14–71 yo, T1D, baseline mean HbA1c: 7.4%, TIR: 61%	-13 mg/dL	+11% +10%	-0.9% -2.2%	-0.1%	-5.3%	-0.33%
CamAPS, FX Tauschmann et al, 2018 (6)	3-mo randomized trial, comparing CamAPS FX algorithm with SAP	N= 86, ≥ 6 yo, T1D, baseline mean HbA1c: 8.3% ^d , TIR: NA	-15 mg/dL	+11% +10%	-0.8% -0.5% (<63 mg/dL)	-0.1% (<50 mg/dL)	-1.4% (T > 300 mg/dL)	-0.36% -0.3%
CamAPS FX Boughton et al, 2022 (29)	4-mo randomized trial, comparing CamAPS FX with SAP	N= 37, 60 yo and older, T1D, baseline mean HbA1c: 7.4%, TIR: 70%	-13 mg/dL	+9%	-0.1%	-0.0%	-0.7% (T > 300 mg/dL)	-0.2%
Diabeloop. Benhamou et al, 2019 (24)	Crossover trial, 2 12-week periods, comparing Diabeloop with SAP	N= 68, ≥ 18 yo, T1D, baseline mean HbA1c: 7.6%, TIR: NA	-9 mg/dL	+9%	-2.4%	-0.5% (<50 mg/dL)	-4.3%	-0.15%



Evidence for AID in T2D

Review Article

Automated Insulin Delivery Systems as a Treatment for Type 2 Diabetes Mellitus: A Review

Alexander B. Karol, MD, Grenye O'Malley, MD, Reshmitha Fallurin, MD, Carol J. Levy, MD, CDCES *

Division of Endocrinology, Diabetes, and Metabolism, Icahn School of Medicine at Mount Sinai, New York, New York

Table. AID RCTs in T2D





Study	System	Duration of AID	Control Group	Target Range	Time in target improvement
Kumareswaran 2014	Hovorka	24h	Usual Care	70-144	+16% (40 v 24%)
Thabit 2017	Hovorka	72h	Conventional SQ	100-180	+21.8% (59.8 v 38.1%)
Bally 2018	Hovorka	up to 15d	Conventional SQ	100-180	+24.3% (65.8 v 41.5%)
Taleb 2019	Haidar	24h	MDI	72-180	+23% Overnight (100 v 78%)
Boughton 2021	Hovorka	20d	MDI	100-180	+15.1% (52.8 v 37.7%)
Peters 2022	OP5	8 wk	MDI	70-180	+15.1% (52.8 v 37.7%)



Simplified Pump Options for T2D Management



AID Systems in the US Market

	iLet Bionic Pancreas	MiniMed™ 780G	t:slim X2™ Control-IQ™	Omnipod® 5
				
Ease of start	Weight	TDD/ usual pump settings	Usual pump settings	TDD/usual pump settings
Targets	Usual, lower or higher	100, 110, 120 Temp: 150	112.5-160 Sleep: 112.5-120 Exercise: 140-160	110,120,130,140,150
Auto corrections	Yes	Yes	Yes	No
What can be adjusted to optimize outcomes	Nothing. Adjust weight if >15% change	ICR- 10-20% lower AIT-2	Basal, ICR, correction,	ICR, 10-20% lower Correction+ correct above, AIT*,
Auto exists	No (BG-run mode up to 72 hours)	Safe basal due to min/max or CGM signal loss	No	Automated limited



Limitations of Insulin Delivery Technology in T2D

- Lack of evidence-based clinical trials
- T2D being heterogeneous and progressive disease, there is no guidance on when and how to initiate technology
- Current pumps are designed to hold 200-3000 units only
- Limited evidences on concentrated insulin use
- Lack of education to patients with T2D
- Therapeutic inertia



Technologies Uptake and A1c Over Last 10 Years

Diabetes Care



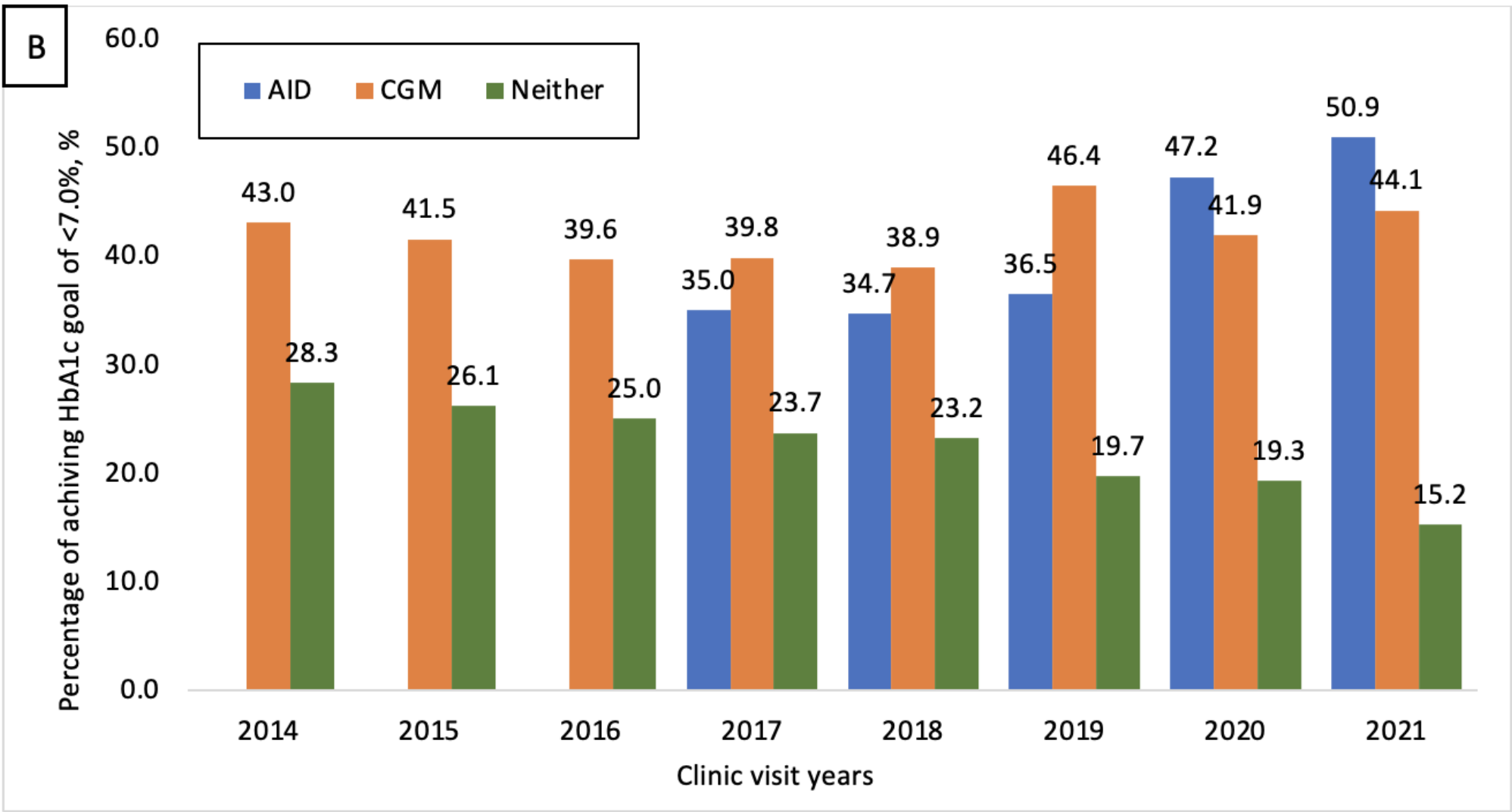
Association Between Diabetes Technology Use and Glycemic Outcomes in Adults With Type 1 Diabetes Over a Decade

*Kagan E. Karakus,^{1,2} Halis K. Akturk,¹
G. Todd Alonso,¹ Janet K. Snell-Bergeon,¹
and Viral N. Shah¹*

<https://doi.org/10.2337/dc23-0495>



% of people with A1c <7% by diabetes technology use



How to Select the Best Option



One Size Does Not Fit All



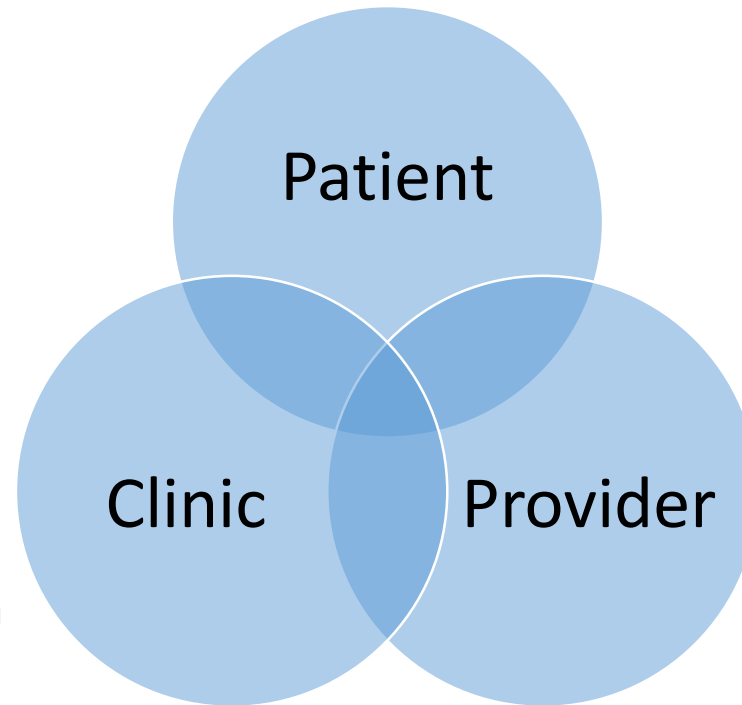
Courtesy of Dr. Wadwa



Barbara Davis Center for Diabetes
UNIVERSITY OF COLORADO ANSCHUTZ MEDICAL CAMPUS

How to Select the Best Option

1. Goal
2. Preference
3. Cost
4. Peer opinion



1. Ease of training
2. Integration in the clinic
3. Less demanding
4. Download and interpretation

1. Best for your patients
2. Cost/insurance coverage
3. Customer care support
4. Future development



Case 3

- 47-year-old male with 44 years of T1D
- Legally blind
- On peritoneal dialysis
- Multiple comorbidities: hypertension, dyslipidemia, stroke, and autonomic neuropathy
- Wife manages diabetes
- Once a day long-acting insulin
- In 2016, **A1c was 5.4%**, most of meter glucoses above 200, and one episode of severe hypoglycemia



Prodigy Voice® – No Code Talking Glucometer



Features

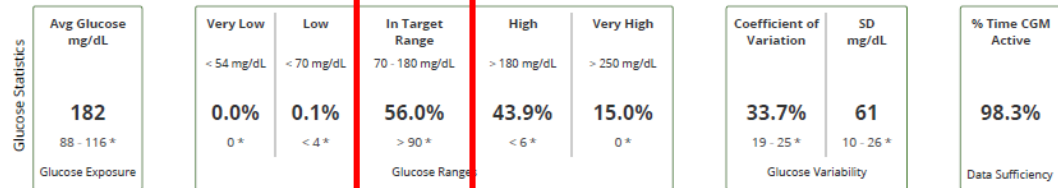
- Fully audible
- Easy to use—No Coding required
- Repeat button replays last message spoken
- Tactile features for easy navigation

"Hey Siri, What's My Blood Sugar?" – 5 New Features on the Dexcom G6 iOS app

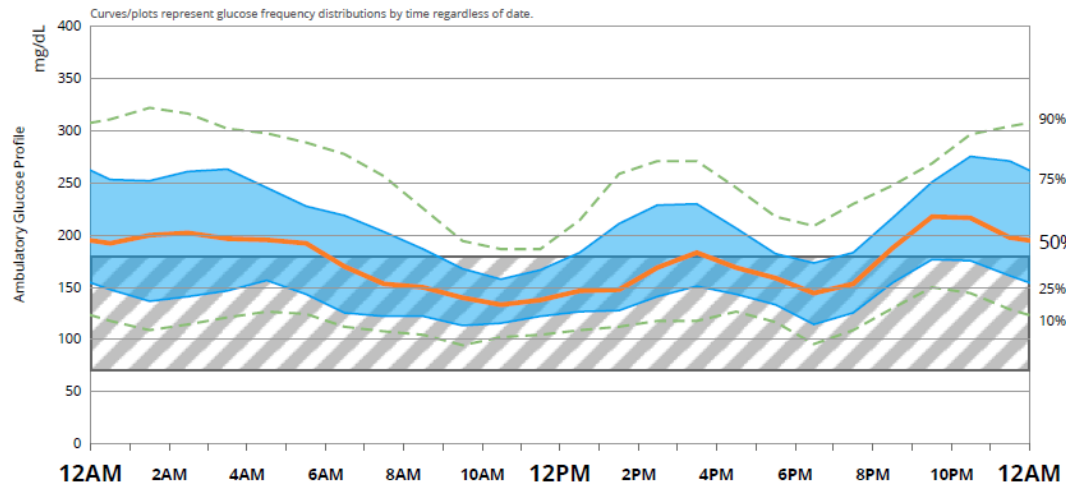
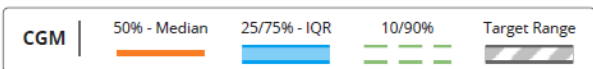
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February 28, 2019

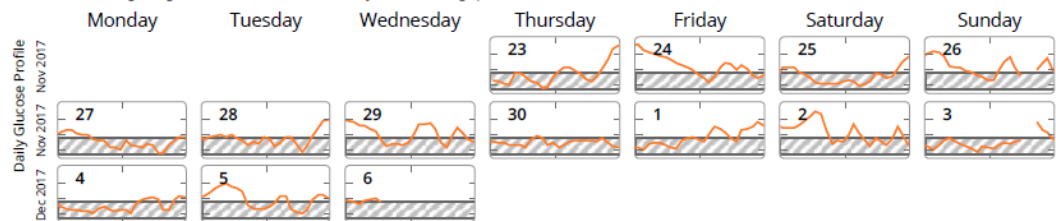




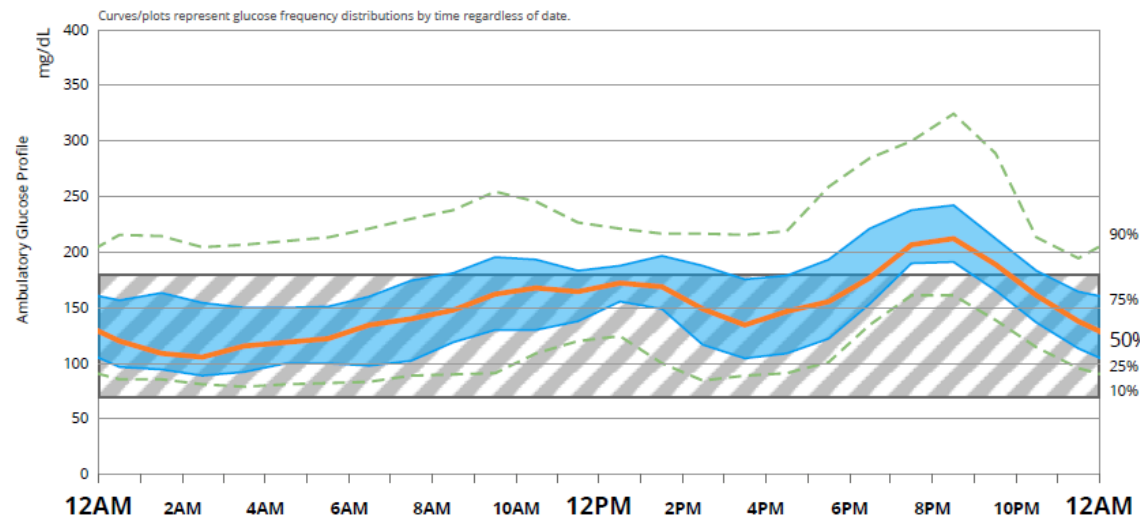
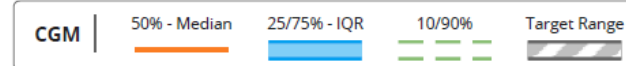
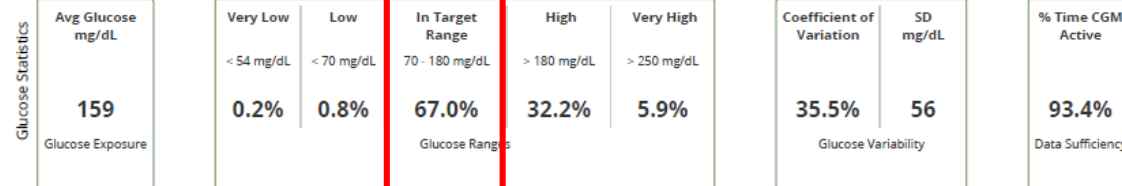
* Reference ranges calculated from population without diabetes. Glucose range reference values based on a target range of 70 - 180 mg/dL.



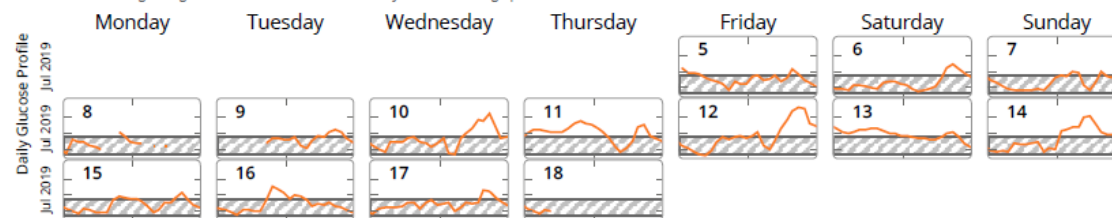
The Y axis and target range are the same as on the Ambulatory Glucose Profile graph above.



U.S. Patent No. Des. 773,478, patents pending - HealthPartners Institute dba International Diabetes Center - All Rights Reserved. CapturAGP v. 3.2



The Y axis and target range are the same as on the Ambulatory Glucose Profile graph above.



U.S. Patent No. Des. 773,478, patents pending - HealthPartners Institute dba International Diabetes Center - All Rights Reserved. CapturAGP v. 3.2



CGM with Siri Integration Improves Glycemic Control in Legally Blind Patients with Diabetes

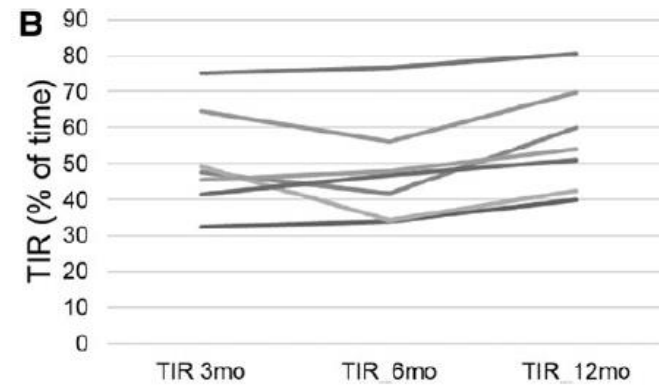
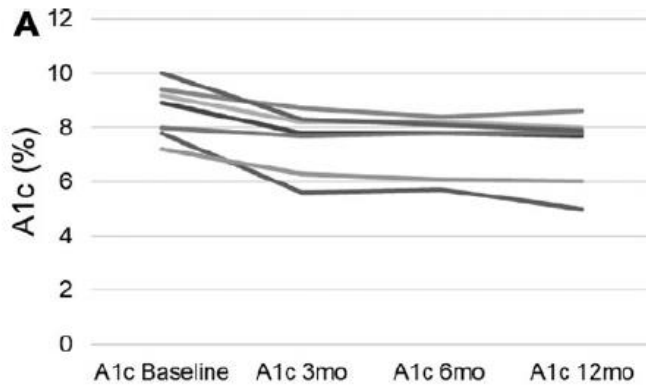
DIABETES TECHNOLOGY & THERAPEUTICS
Volume 23, Number 1, 2021
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<https://doi.org/10.1089/dia.2020.0320>



BRIEF REPORTS

Continuous Glucose Monitor with Siri Integration Improves Glycemic Control in Legally Blind Patients with Diabetes

H. Kaan Akturk, MD, Janet K. Snell-Bergeon, PhD, and Viral N. Shah, MD



Original Article

Health Care Professionals' Perspectives on Use of Diabetes Technologies for Managing Visually Impaired Patients With Diabetes

Halis Kaan Akturk, MD¹, Janet Snell-Bergeon, PhD¹, and Viral N. Shah, MD¹

Journal of Diabetes Science and Technology
1-4
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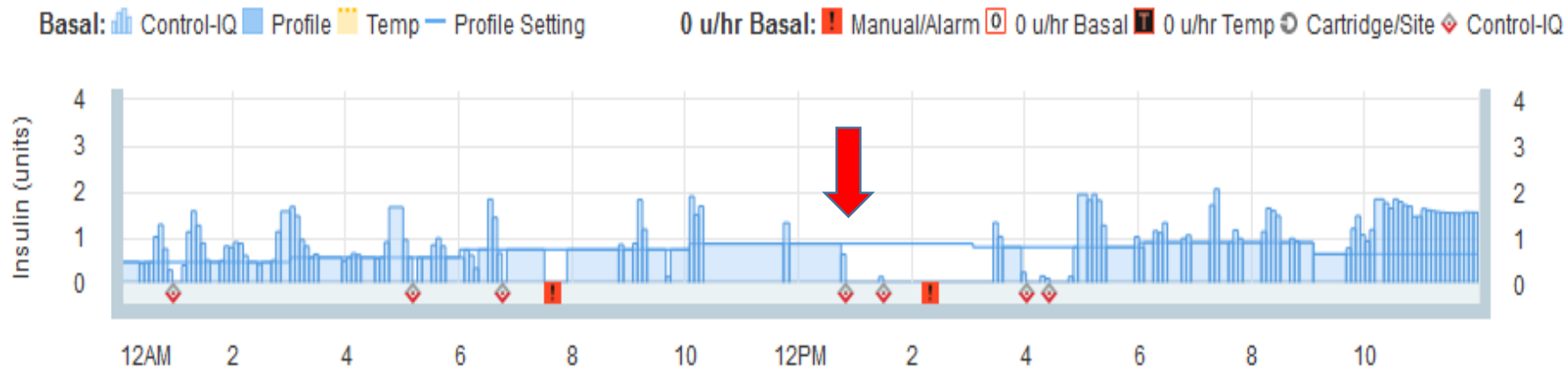
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Case 4

- 68-year-old female with type 1 diabetes for 16 years
- A1c ~7.5-8.2%
- Other medical conditions: dyslipidemia, anxiety disorder, granuloma annulare, and osteoporosis
- No diabetes complications
- Minimal cognitive decline
- Hypo unawareness
- Living with husband who has long-standing T2D on IIT
- On Medtronic 670 G but didn't like it

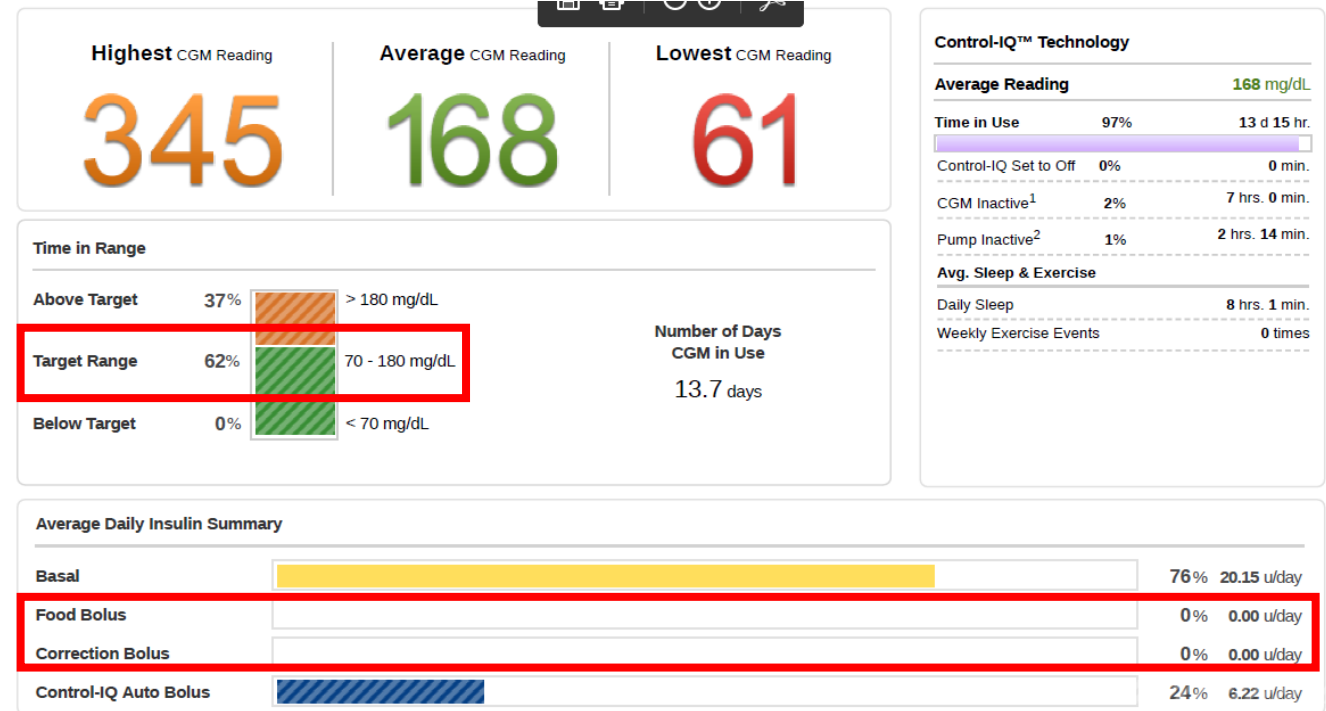


- 2-week follow-up after Control IQ start (1/2021)
- Had severe hypoglycemia in the clinic



Experimental Fully-Automated AID

- Alert Auto-off: off
- Basal rate adjustment
- Set sleep time 2-3 hours after average sleep time
- Aggressive change in correction factor
- The only manual action: If BG is >250 for more than 2 hours, change infusion set and take a bolus



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ORIGINAL ARTICLE

Efficacy and Safety of Tandem Control IQ Without User-Initiated Boluses in Adults with Uncontrolled Type 1 Diabetes

Halis Kaan Akturk, MD, Janet Snell-Bergeon, PhD, and Viral N. Shah, MD



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Take Home Message

- ✓ CGM and AID is the first line of management in T1D.
- ✓ CGM should be considered from onset of T1D.
- ✓ Use of CGM in insulin-requiring T2D improves A1c.
- ✓ CGM first followed by consideration of connected pens or simplified pumps in T2D.
- ✓ AID can be considered in T2D. It is currently off-label. Useful in patients who requires <100 units per day.



Thank you!

