Should we utilize Diabetes Technology in Type 2 diabetes patients?

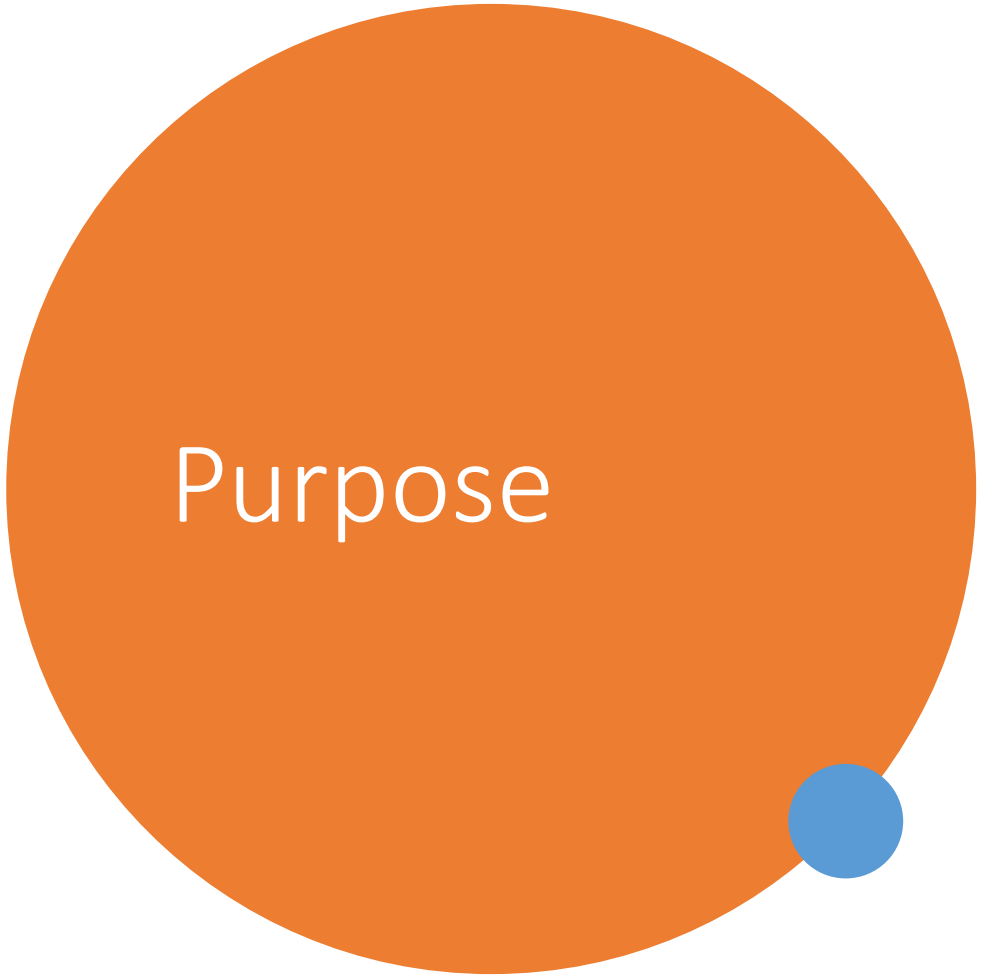
Yanery's Agosto Vargas, MD

Disclosures

None

Use of technology should be individualized, based on a patient's needs, desires, skill level, and availability with technology/devices.

Technology is not intended for everyone.

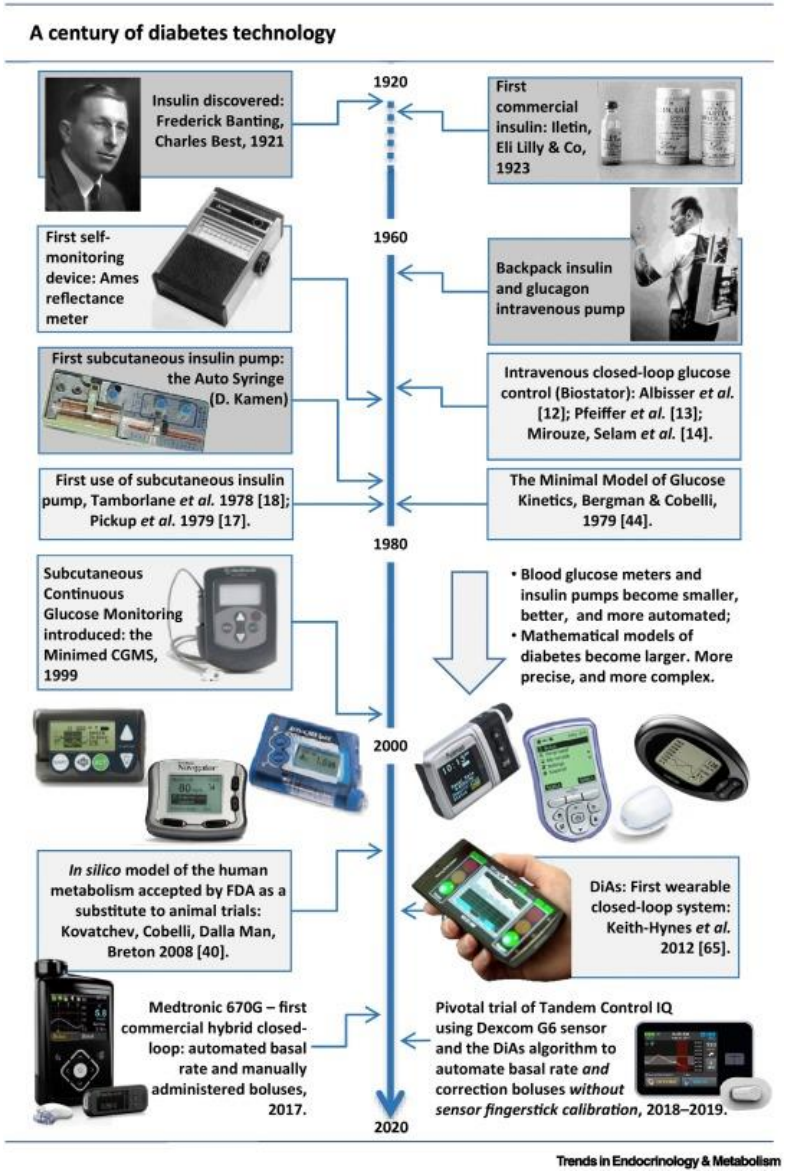


What is diabetes technology

Term used to describe the hardware, devices, and software that diabetic patients use to help manage their condition

Categories

- Insulin administration
  - Pen
  - Syringe
  - Pump
- Blood glucose monitor
  - Meter
  - CGM
- Hybrid devices



Boris Kovatchev. A century od Diabetes Technology: Signals, Models and artificial Pancras Control. 2019


why
not?

Medication Interactions

Glucose oxidase monitors
Uric acid
Galactose
Xylose
Acetaminophen
L-dopa
Ascorbic acid
Glucose dehydrogenase monitors
Icodextrin (used in peritoneal dialysis)

Enzyme	*Coenzyme*	*Blood glucose meter*
GDH	FAD	Ascensia Contour® (Bayer, Tarrytown, NY)
GDH	NAD	Precision Xtra® (Abbott, Abbott Park, IL)
GDH	PQQ	Accu-Chek® Aviva (Roche, Indianapolis, IN) Accu-Chek Compact Plus (Roche) FreeStyle Lite®/FreeStyle Freedom® (Abbott)
GOD	FAD	OneTouch® Ultra2® (LifeScan, Milpitas, CA)

FAD, flavin adenine dinucleotide; GDH, glucose dehydrogenase; GOD, glucose oxidase; NAD, nicotinamide adenine dinucleotide; PQQ, pyrroloquinolinequinine.

Glucose monitor

Glucose meter accuracy

- Oxygen
  - Glucose oxidase monitors are sensitive to oxygen: should be available in patient with normal oxygen saturation
    - Higher oxygen tension
      - Falsely low glucose reading
    - Low oxygen tension
      - Falsely high
  - Glucose dehydrogenase: not sensitive to oxygen

Glucose meter accuracy

Brand	BGM	Test strip	Study 1			Study 2			Study 3			Total number of studies meeting accuracy standard/number of valid trials	95% points within protocol limits	
			N	Percentage compliant†	Met accuracy standard?	*N*	Percentage compliant†	Met accuracy standard?	*N*	Percentage compliant†	Met accuracy standard?		*N*	%
Bayer	Contour Next	Contour Next	98	99	Pass	101	100	Yes	113	100	Yes	3/312	311	100
Roche	Accu-Chek Aviva Plus	Accu-Chek Aviva Plus	97	97	Yes	101	100	Yes	113	98	Yes	3/311	306	98
ARKRAY	Walmart ReliOn Confirm (Micro)	ReliOn Confirm/ Micro	100	96	Yes	114	96	Yes	103	99	Yes	3/317	307	97
AgaMatrix	CVS Advanced	CVS Advanced	101	96	Yes	114	96	Yes	103	98	Yes	3/318	307	97
Abbott Diabetes Care	FreeStyle Lite	FreeStyle Lite	98	92	Yes	101	96	Yes	113	98	Yes	3/312	298	96
Roche	Accu-Chek SmartView	Accu-Chek SmartView	108	98	Yes	106	96	Yes	106	92	Yes	3/320	305	95
ARKRAY	Walmart ReliOn Prime	ReliOn Prime	98	85	No	101	95	Yes	113	96	Yes	2/312	288	92
LifeScan	OneTouch Verio	OneTouch Verio	108	87	No	106	98	Yes	105	91	Yes	2/319	294	92
Prodigy	Prodigy AutoCode	Prodigy No Coding	98	86	No	101	92	Yes	113	93	Yes	2/312	282	90
LifeScan	OneTouch Ultra 2	OneTouch Ultra	97	92	Yes	101	84	No	113	94	Yes	2/311	280	90
Abbott Diabetes Care	Walmart ReliOn Ultima	ReliOn Ultima	107	96	Yes	106	97	Yes	106	75	No	2/319	285	89
Bayer	Contour Classic	Contour	108	95	Yes	106	85	No	106	86	No	1/320	284	89
Omnis Health	Embrace	Embrace No-Code	102	87	No	114	93	Yes	103	84	No	1/319	282	88
HDI/Nipro	TRUEresult	TRUEresult	101	94	Yes	114	83	No	103	86	No	1/318	279	88

Klonoff DC, Parkes JL, Kovatchev BP, et al . Investigation of the accuracy of 18 marketed blood glucose monitors. Diabetes Care 2018; **41**:1681–1688

Self monitoring use

- Adjust food intake, exercise, or pharmacologic therapy to achieve specific goals
- Needs multiple dextro daily that could become overwhelming
  - 6-10 dextro daily
- Once daily SMBG does not change A1c at 1 year
  - Some improvement reported at 6 months aprox. 0.2 -0.3%
- Insufficent evidence when to prescribed SMGB in patient only in basal insulin with or w/o oral therapy

From: **Glucose Self-monitoring in Non–Insulin-Treated Patients With Type 2 Diabetes in Primary Care Settings: A Randomized Trial**

JAMA Intern Med. 2017;177(7):920-929. doi:10.1001/jamainternmed.2017.1233

Table 2. Summary of Primary Outcomes by Randomization Group

Variable	Randomization Group						*P* Value	
	No SMBG		SMBG, No Messaging		SMBG With Messaging			
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)	Overall[a]	Contrast[b]
Hemoglobin A_{1c}, %[c]								
Baseline	152	7.52 (1.12) (58.70 [12.24] mmol/mol)	150	7.55 (1.10) (59.06 [12.07] mmol/mol)	148	7.61 (0.97) (59.65 [10.64] mmol/mol)		
Follow-up	147	7.55 (1.24) (59.01 [13.56] mmol/mol)	141	7.49 (1.12) (58.41 [12.23] mmol/mol)	139	7.51 (1.13) (58.55 [12.34] mmol/mol)	.74	.48
Change	147	0.04 (1.12) (0.41 [12.27] mmol/mol)	141	−0.05 (1.00) (−0.57 [10.89] mmol/mol)	139	−0.10 (1.14) (−1.04 [12.42] mmol/mol)		
Health-Related Quality of Life, SF-36								
Physical score								
Baseline	152	48.72 (8.00)	150	47.27 (8.40)	148	46.22 (10.13)		
Follow-up	143	48.47 (7.21)	142	47.42 (9.03)	135	46.44 (9.68)	.48	.50
Change	143	−0.43 (6.86)	142	0.07 (6.77)	135	−0.35 (6.95)		
Mental score								
Baseline	152	53.52 (9.29)	150	52.94 (8.77)	148	53.43 (9.58)		
Follow-up	143	53.39 (10.55)	142	52.04 (9.57)	135	52.57 (10.39)	.90	>.99
Change	143	−0.94 (7.46)	142	−0.71 (7.72)	135	−1.39 (6.85)		

Abbreviation: SMBG, self-monitoring of blood glucose.

SI conversion factor: To convert percent of total hemoglobin to proportion of total hemoglobin, multiply by .01.

[a] Test comparing all 3 groups from ANCOVA model controlling for site, baseline hemoglobin A_{1c}, prior use of SMBG, duration of T2DM, baseline anti-hyperglycemic treatment, age, race/ethnicity, health literacy, and number of baseline comorbidities; for health-related quality of life scores, we also controlled for baseline score, and for hemoglobin A_{1c} we also controlled for how hemoglobin A_{1c} was measured at baseline.

[b] Contrast test from same ANCOVA model comparing average of SMBG groups with no SMBG group.

[c] Dual reported as percentage and as mmol/mol.

Cons of insulin pumps in type 2 patients

- They’re not always covered by insurance.
- Diabetic ketoacidosis
  - Dislodgment
  - Occlusion
- Lipohypertrophy
- They’re more expensive than other options
- More education programs
- Risks of infection
- Mood disorders
- Not suitable for moderate and severe cognitive impairment
- Wearability
- T2DM patients does not showed significant A1c reduction

CGM devices disadvantage

- Need the ability to do SMGM to calibrate the device
- Frequent scanning minimum once every 8 hours
- Impact quality of life
- Overwhelming

CGM devices disadvantage

- Frequent detachment
- No alerts at night
- Medical Insurance approval/Cost

TABLE. Selected Randomized Clinical Trials of CGM [15-22]

Name (reference)	Population	Design	Goal(s)	Device(s)	Key Outcome(s)
DIAMOND Type[15]	T1D A1C 7.5%-9.9%	Randomized 2:1 to CGM (n = 105) or usual care (n = 53) for 24 weeks	A1C reduction	Dexcom G4	Between-group difference of 0.6 percentage points in favor of CGM (*P* <.001). Significant reduction in hypoglycemia in the intervention group.
DIAMOND Type 2[16]	T2D A1C 7.5%-9.9%	Randomized 1:1 to CGM (n = 79) or usual care (n = 79) for 24 weeks	A1C reduction	Dexcom G4	Between-group difference of 0.3 percentage points in favor of CGM (*P* = .022).
GOLD[17]	T1D A1C ≥7.5%	Crossover CGM vs usual care; Randomized 1:1 to 26 weeks of CGM before (n = 82) or after (n = 79) 26 weeks of usual care	A1C reduction	Dexcom G4	Between-group difference of 0.43 percentage points in favor of CGM (*P* <.001). Significant reduction in hypoglycemia in the intervention group.
I HART CGM[18]	T1D GOLD score ≥4 or recent severe hypo	Randomized 1:1 to CGM (n = 20) or flash glucose monitoring (n = 20) for 8 weeks	Hypoglycemia reduction, CGM vs flash glucose monitoring	Dexcom G5, Abbott FreeStyle Libre	CGM reduces hypoglycemia more effectively than flash glucose monitoring.
HypoDE[19]	T1D History of impaired hypo awareness or severe hypo in past year	Randomized 1:1 to CGM (n = 75) or usual care (n = 74) for 26 weeks	Hypoglycemia reduction in high-risk individuals	Dexcom G5	Incidence of hypoglycemic events fell by 72% for CGM group (*P* <.0001).
Comisair[20]	T1D/MDI or CSII A1C 7.0%-10%	Nonrandomized: CGM (n = 27) or SMBG (n = 38) for 52 weeks	A1C and hypoglycemia reduction	Dexcom G4, Medtronic Enlite	Comparable reductions in A1C and hypoglycemia in CGM/MDI and CGM/CSII groups
IN CONTROL[21]	Adults T1D/MDI Impaired hypo awareness (Gold score ≥4)	Randomized crossover: CGM then SMBG (n =. 26) or SMBG then CGM (n = 26)	Hypoglycemia reduction in high-risk individuals	Medtronic Enlite	Periods of CGM use associated with more TIR, less time in hypo- and hyperglycemia, fewer severe hypoglycemic events
CONCEPTT[22]	T1D with existing or planned pregnancy	Parallel arms, to 34 weeks in pregnant women; for 24 weeks in those planning pregnancy	A1C reduction	Medtronic Guardian REAL-Time	Between-group difference of 0.19 percentage points in favor of CGM (*P* = .02) in pregnant women; no difference in women planning pregnancy. CGM group had fewer LGA babies, fewer ICU stays of >24 hours, and fewer neonatal hypoglycemia events

A1C indicates glycated hemoglobin; CGM, continuous glucose monitoring; CSII, continuous subcutaneous insulin infusion; ICU, intensive care unit; LGA, large for gestational age; MDI, multiple daily injections; SMBG, self-monitoring of blood glucose; T1D, type 1 diabetes; T2D, type 2 diabetes; hypo, hypoglycemia; TIR, time in range (70-180 mg/dL).

*Dexcom G4 Platinum CGM System with an enhanced algorithm, Software 505, the same algorithm used in Dexcom G5

	Eversense CGM System	Abbott Freestyle Libre Flash Glucose Monitoring	Dexcom G6 CGM System	Medtronic Guardian Connect CGM System
Sensor wear	Up to 3 months	Up to 14 days	Up to 10 days	Up to 7 days
Performance 20/20% Agreement	94.3%	90.9%	91.7%	85.7%
Finger stick replacement	No	Yes	Yes	No
Interferents	Tetracyclines	Vitamin C, salicylic acid	Acetaminophen	Acetaminophen
Active, automatic alerts	High, low, rate of change, predictive high and low	U.S.- No; CE-Optional high, low, signal loss	High, low, rate of change, predictive urgent low	High, low, rate of change, predictive high and low
Calibrations/day	2/day	0; scan needed every 8 hrs	0; can optionally enter	2/day
Insertion	Professionally placed by HCP during in-office procedure	Self-insertion every 14 days	Self-insertion every 10 days	Self-insertion every 7 days
Remote monitoring	Yes	Yes	Yes	No
On-body, vibratory alerts	Yes	No	No	No

Table 1. Overview of Features in the FreeStyle Libre Systems Approved in the United States

This overview is representative of the FreeStyle Libre systems approved in the United States at time of publication.* The FreeStyle Libre system is approved in the European Union (EU) as of September 2014 and in the United States as of November 2017. The FreeStyle Libre 14 day system is approved in the United States as of July 2018. EU and US systems have differences in patient indication and interface options. Refer to the table for features of US approved systems only.

Minimum use age:	≥18 years
Sensor placement:	Back of arm; placement is not approved for other sites
Sensor warm-up period:	▶ FreeStyle Libre system: 12 hours after insertion before able to retrieve glucose data ▶ FreeStyle Libre 14 day system: 1 hour after insertion before able to retrieve glucose data
Sensor wear time:	▶ FreeStyle Libre system: 10 days ▶ FreeStyle Libre 14 day system: 14 days
Calibration:	Factory calibrated; does not require daily calibration
Insulin dosing:	Individuals are able to use sensor glucose reading for treatment decisions without confirmatory fingerstick monitoring. Under the following conditions, sensor glucose readings may not be accurate, and you should conduct a fingerstick: ▶ If inaccurate reading is suspected ▶ If experiencing symptoms that may be due to low or high blood glucose ▶ If experiencing symptoms that do not match sensor glucose readings ▶ During times of rapidly changing glucose of more than 2 mg/dL per minute (i.e., straight up or down trend arrow) ▶ When the sensor glucose reading does not include a current glucose number or trend arrow ▶ To confirm hypoglycemia or impending hypoglycemia as reported by the sensor ▶ When "Check Blood Glucose" symbol appears in the reader ▶ During the first 12 hours of wearing a FreeStyle Libre 14 day Sensor
Cautions and Contraindications:	▶ The system is not approved for use in pregnant women or persons on dialysis and has not been evaluated in these populations. ▶ The system has not been evaluated for use in patients with hypoglycemia unawareness and will not automatically alert to current or impending hypoglycemic event without scanning the sensor. The system will not automatically notify the user when experiencing hypoglycemia or hyperglycemia unless the sensor is scanned.
Potential Interferents:	▶ Salicylic acid (used in aspirin and other pain relievers) at doses ≥650 mg may cause falsely lower glucose values ▶ Ascorbic acid (vitamin C) at doses ≥500 mg may cause falsely higher readings. ▶ At lower doses, salicylic acid and ascorbic acid are known to have minimal effect on sensor glucose readings in the FreeStyle Libre systems.

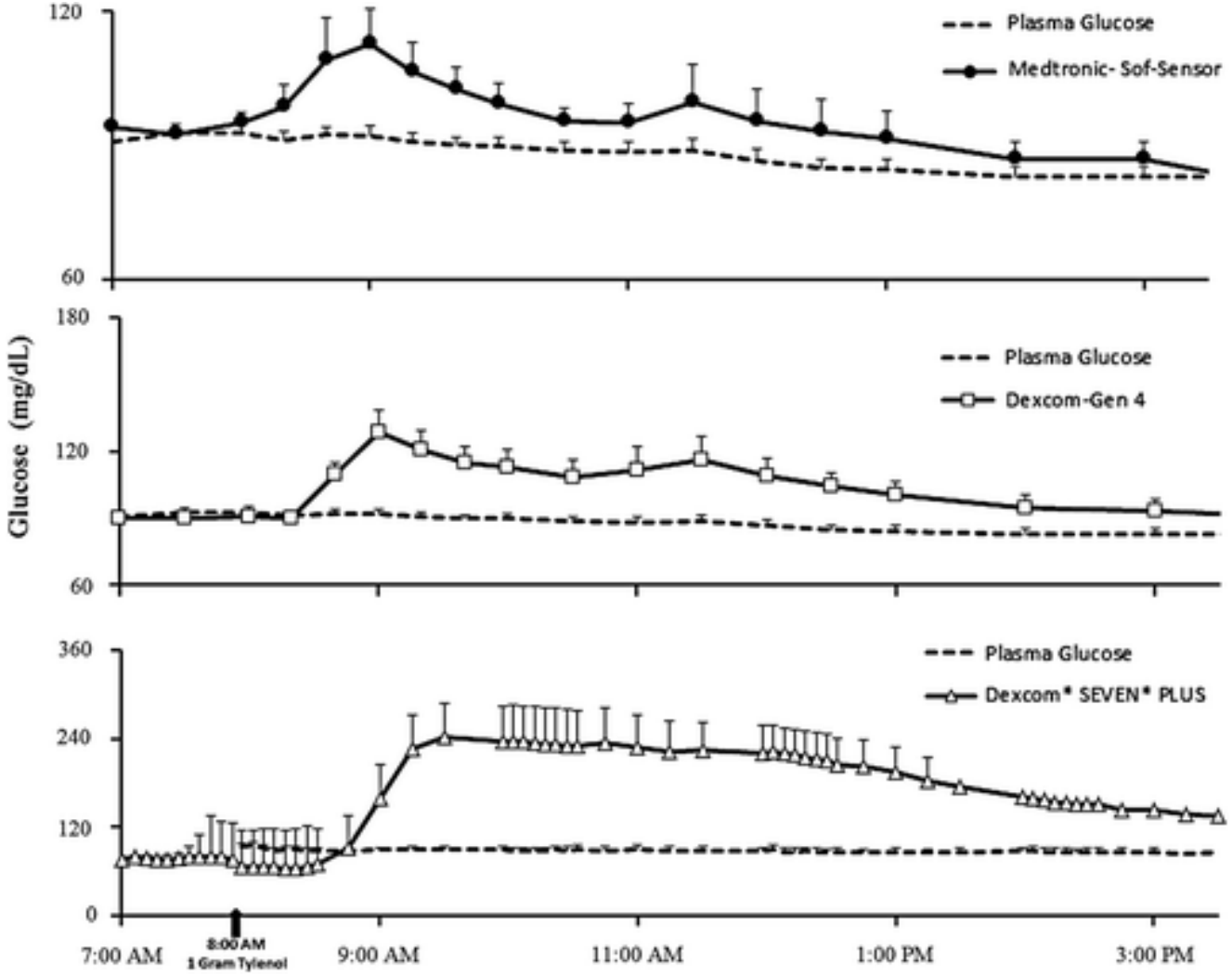
* For full indications for use and safety information, seek out product information from the manufacturer.

Medtronic Guardian Sensor 3

Taking medications with acetaminophen, such as Tylenol™*, fever reducers, or cold medicine, while wearing the sensor may falsely raise your sensor glucose readings. The level of inaccuracy depends on the amount of acetaminophen active in your body and may be different for each person. Always check the label of any medications to confirm whether acetaminophen is an active ingredient

Eversense

- Mannitol or sorbitol, when administered intravenously, or as a component of an irrigation solution or peritoneal dialysis solution, may increase blood mannitol or sorbitol concentrations and cause falsely elevated readings of your sensor glucose results. Sorbitol is used in some artificial sweeteners, and concentration levels from typical dietary intake do not impact sensor glucose results
- Antibiotics of the tetracycline class may falsely lower sensor glucose readings. You should not rely on sensor glucose readings while taking tetracyclines.



Ananda Basu, Sona Veettil, Roy Dyer, Thomas Peyser, and Rita Basu.Diabetes Technology & Therapeutics.Feb 2016.S2-43-S2-47.

Substance	Description	Dexcom CGM System(s)	Risk	Safety Recommendation
Acetaminophen/Paracetamol	Medication used to treat pain and fever	G4 PLATINUM	Taking medications with acetaminophen (such as Tylenol) while wearing the sensor falsely raise your sensor glucose readings. The level of inaccuracy depends on the amount of acetaminophen active in your body and may be different for each person.	Acetaminophen is contraindicated with G4 PLATINUM CGM system. Use alternative glucose monitoring approaches.
		G5 Mobile	Acetaminophen is contraindicated with G4 PLATINUM CGM system. Use alternative glucose monitoring approaches.	Acetaminophen is contraindicated with G5 Mobile CGM system. Do not rely on CGM data produced by G5 Mobile if you have recently taken acetaminophen.
		G6, G6 Glucose Program, G6 Pro	Taking higher than the maximum dose of acetaminophen (e.g. > 1 gram every 6 hours in adults) may affect sensor readings and make them look higher than they really are.	You can take a standard or maximum acetaminophen dose of 1 gram (1,000 mg) every 6 hours and still use sensor readings to make treatment decisions.
Hydroxyurea	Medication used in the treatment of diseases including cancer and sickle cell anemia.	G4 PLATINUM	If you are taking hydroxyurea, your sensor glucose readings will be higher than your actual glucose, which could result in missed hypoglycemia alerts. The level of inaccuracy depends on the amount of hydroxyurea in your body.	Talk to your physician about alternative glucose monitoring approaches.
		G5 Mobile, G6	If you are taking hydroxyurea, your sensor glucose readings will be higher than your actual glucose, which could result in missed hypoglycemia alerts or errors in diabetes management, such as giving yourself a higher dose of insulin due to falsely high sensor glucose values. The level of inaccuracy depends on the amount of hydroxyurea in your body.	Do not use your Dexcom CGM System for diabetes treatment decisions if you are taking hydroxyurea. Talk to your physician about alternative glucose monitoring approaches.
		G6 Glucose Program	If you are taking hydroxyurea, your sensor glucose readings will be higher than your actual glucose, which could result in errors in diabetes management. The level of inaccuracy depends on the amount of hydroxyurea in your body.	Do not use your Dexcom CGM System for diabetes treatment decisions if you are taking hydroxyurea. Talk to your physician about alternative glucose monitoring approaches.
		G6 Pro	The use of hydroxyurea will result in sensor glucose readings that are higher than actual glucose levels. The level of inaccuracy in sensor glucose readings is based on the amount of hydroxyurea in the body. Relying on sensor glucose results while taking hydroxyurea could result in missed hypoglycemia alerts or errors in diabetes management, such as giving a higher dose of insulin than necessary to correct falsely high sensor glucose values. It can also result in errors when reviewing, analyzing and interpreting historical patterns for assessing glucose control.	Do not use the Dexcom CGM System for making diabetes treatment decisions or assessing glucose control when taking hydroxyurea

Patient point of view

- Contact dermatitis
- Skin infections
  - Cellulitis
  - Abscess
- Overwhelming
  - Too much data
  - Unknown how to deal with it
- Diabetes burnout
- Technology will be attached to you all the time
- Increase appetite, develops obesity

Summary

- Cost
  - Fixed income
  - Multiple medical conditions
- Medical Insurance Coverage
- Medical complications
  - Infections
- Compliance
- Overconfidence

Take home message…

- ✓Simply having a device or an application does not change outcomes unless the patient engages with it to create positive health benefits

- ✓Technology is a tool for diabetes management is not MAGIC!!!

Reference

- ADA. iabetes Technology: Standards of Medical Care in Diabetes 2020. Diabetes Care Jan; 43(Supplement 1): S77-S88
- Ananda Basu, Sona Veettil, Roy Dyer, Thomas Peyser, and Rita Basu.Diabetes Technology & Therapeutics.Feb 2016.S2-43-S2-47.http://doi.org/10.1089/dia.2015.0410
- Hanseen NMJ, Scheijen JLIM, Jossal A et al. Higher plasma methylglyoxal levels are associated with incident cardiovascular disease in individuals with type 1 diabetes: a 12-year follow-up study. Diabetes 2017;**66**:2278–2283pmid:28588100
- Boris Kovatchev, A Century of Diabetes Technology: Signals, Models, and Artificial Pancreas Control, Trends in Endocrinology & Metabolism, Volume 30, Issue 7, 2019,Pages 432-444,https://doi.org/10.1016/j.tem.2019.04.008.
- Foster NC, Beck RW, Miller KM, Clements MA, Rickels MR, DiMeglio LA, Maahs DM, Tamborlane WV, Bergenstal R, Smith E, Olson BA, Garg SK. State of Type 1 Diabetes Management and Outcomes from the T1D Exchange in 2016-2018. Diabetes Technol Ther. 2019 Feb;21(2):66-72. doi: 10.1089/dia.2018.0384. Epub 2019 Jan 18. Erratum in: Diabetes Technol Ther. 2019 Apr;21(4):230. PMID: 30657336; PMCID: PMC7061293.
- Landau, Z., Raz, I., Wainstein, J., Bar-Dayan, Y., and Cahn, A. (2017) The role of insulin pump therapy in type 2 diabetes mellitus, *Diabetes Metab Res Rev*, 33: e2822. doi: 10.1002/dmrr.2822.
- Street T, Crabtree T.SJ., Wilmot E. Diabetes Technology. *Br J Diabetes* 2019;**19**:136-140
- Klonoff DC, Parkes JL, Kovatchev BP, et al . Investigation of the accuracy of 18 marketed blood glucose monitors. Diabetes Care 2018; **41**:1681–1688
- Hess, Amy. What is a CGM. 2020. Remedy Health Media
- Yogish C Kudva, Andrew J Ahmann, Richard M Bergenstal, James R Gavin, III, Davida F Kruger, L Kurt Midyett, Eden Miller, Dennis R Harris, Approach to Using Trend Arrows in the FreeStyle Libre Flash Glucose Monitoring Systems in Adults, *Journal of the Endocrine Society*, Volume 2, Issue 12, December 2018, Pages 1320–1337, https://doi.org/10.1210/js.2018-00294
- Young LA, Buse JB, Weaver MA, et al.; Monitor Trial Group. Glucose self-monitoring in non-insulin-treated patients with type 2 diabetes in primary care settings: a randomized trial. JAMA Intern Med 2017;**177**:920–929


Feliz Navidad
Y
Prospero Ano
2021