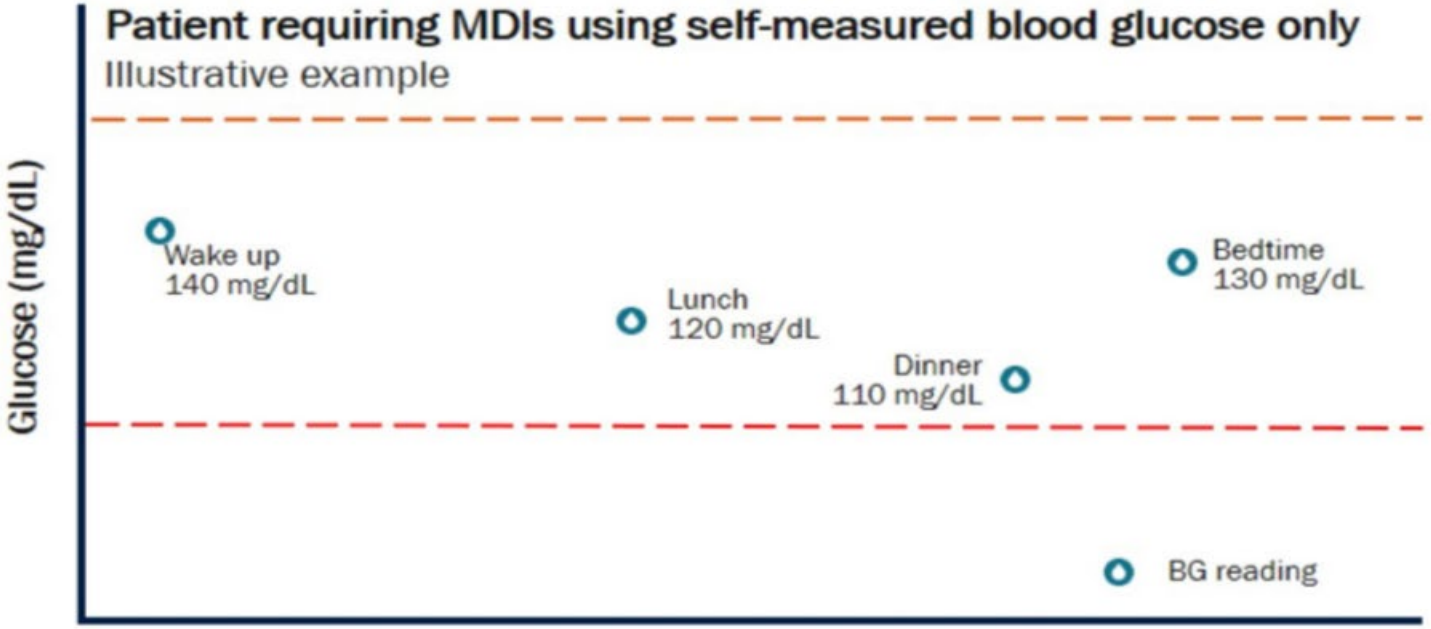
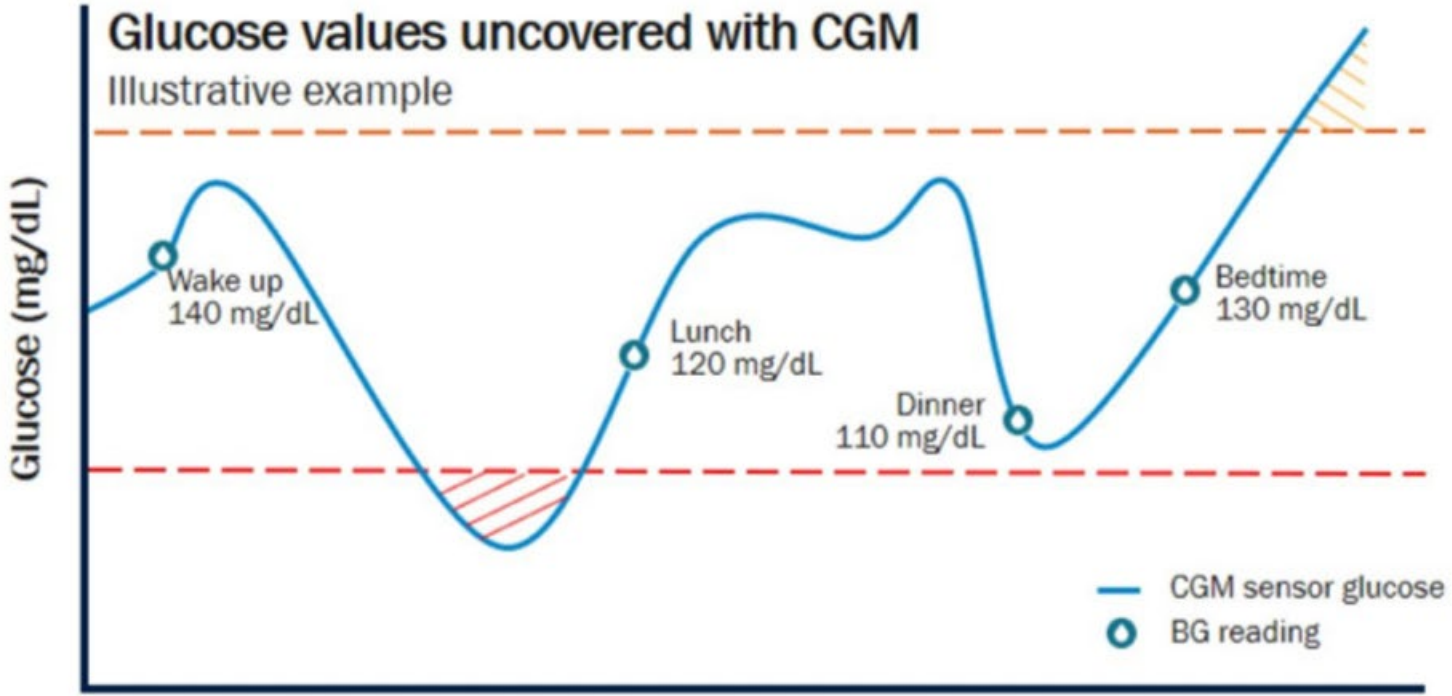
CONGRESSO REGIONALE
SID-AMD | Calabria 2024

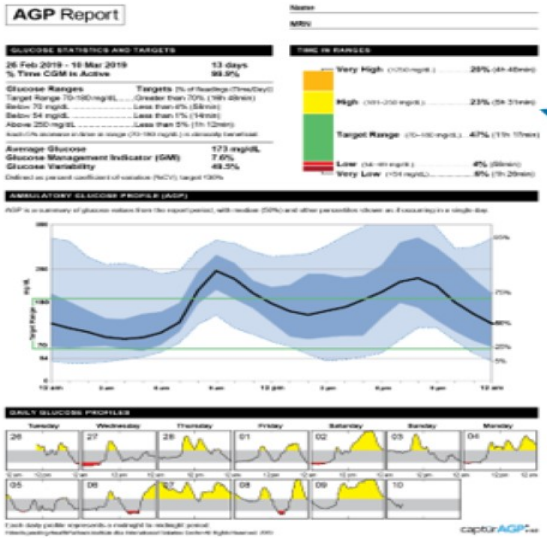
FGM e cgm:Una rivalità costruttiva?

Dr Raffaele Mancini


Patient requiring MDIs using self-measured blood glucose only
Illustrative example
Glucose (mg/dL)
Wake up
140 mg/dL
Lunch
120 mg/dL
Dinner
110 mg/dL
Bedtime
130 mg/dL
BG reading


Glucose values uncovered with CGM
Illustrative example
Glucose (mg/dL)
Wake up
140 mg/dL
Lunch
120 mg/dL
Dinner
110 mg/dL
Bedtime
130 mg/dL
CGM sensor glucose
BG reading

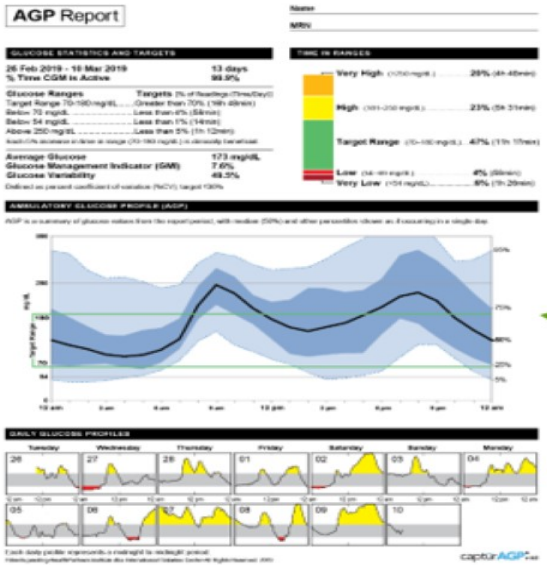
The AGP Report



- **The Ambulatory Glucose Profile (AGP) is a standardized report for retrospective CGM interpretation**
- This report has 3 distinct sections that:
  - **Summarize glucose values to help assess the overall quality of glucose control**

Johnson ML, et al. *Diabetes Technol Ther*. 2019;21:S217-S225.

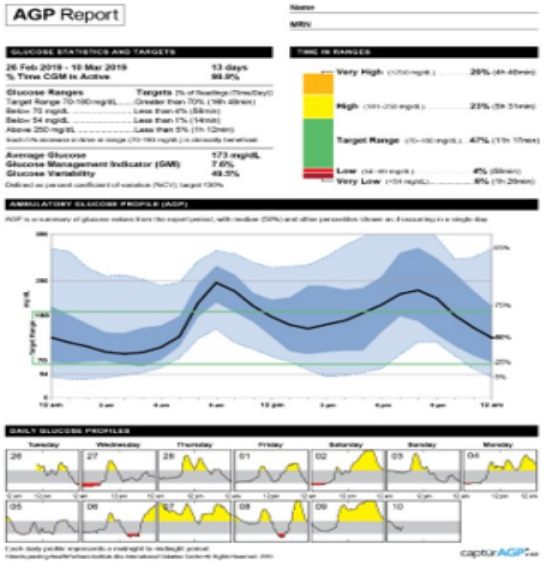
The AGP Report



- **The Ambulatory Glucose Profile (AGP) is a standardized report for retrospective CGM interpretation**
- This report has 3 distinct sections that:
  - **Show variability around the median glucose and patterned areas of highs and lows**

Johnson ML, et al. *Diabetes Technol Ther*. 2019;21:S217-S225.

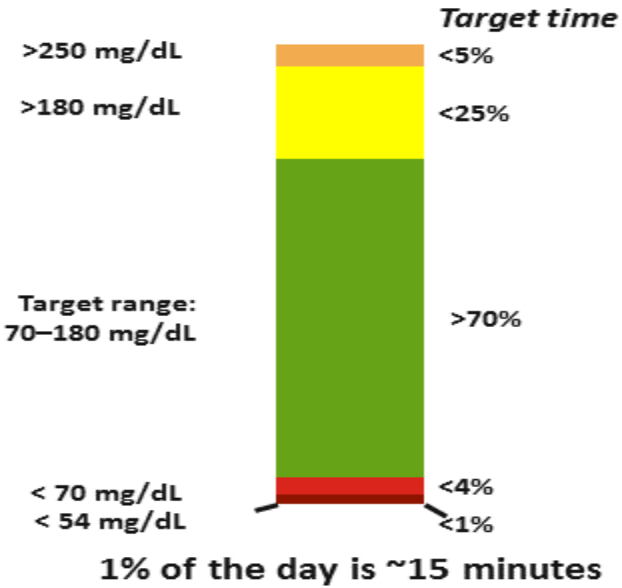
The AGP Report



- **The Ambulatory Glucose Profile (AGP) is a standardized report for retrospective CGM interpretation**
- This report has 3 distinct sections that:
  - **Show single-day glucose values to help identify patterns and progress**

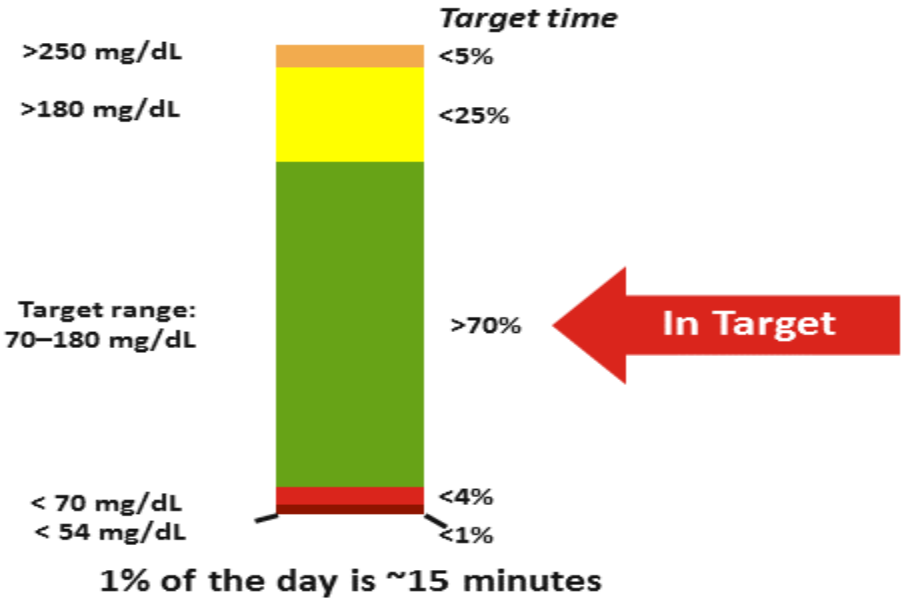
Johnson ML, et al. *Diabetes Technol Ther*. 2019;21:S217-S225.

CGM-Based Targets for T1D and T2D



Battelino T et al. *Diabetes Care.* 2019;42:1593-1603.

CGM-Based Targets for T1D and T2D



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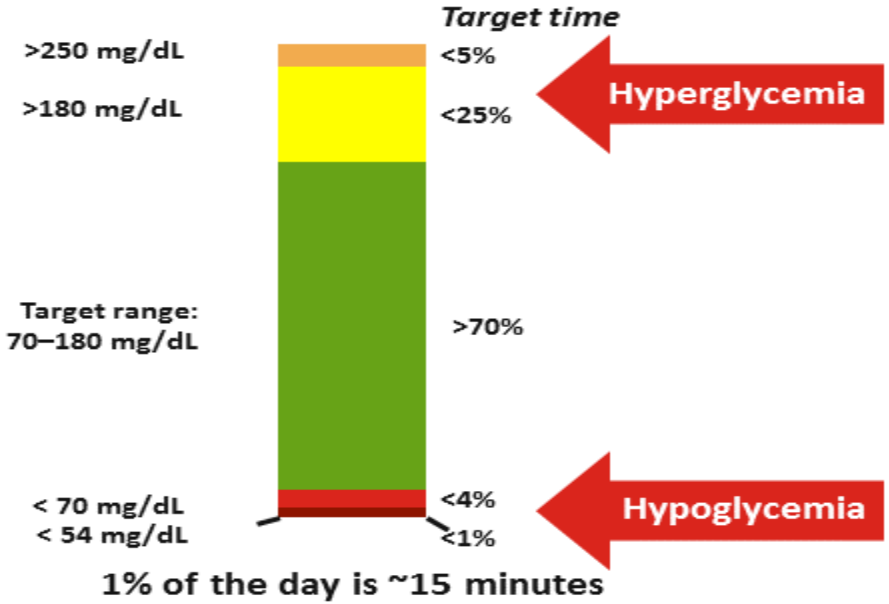
CGM-Based Targets for T1D and T2D



Battelino T et al. *Diabetes Care.* 2019;42:1593-1603.

Trend Arrows (App)

Trend Arrows show the direction and speed of glucose change. This provides additional insight into CGM-based treatment decision. Catch highs and lows before they happen.

Constant

0-30 mg/dL up or down in ½ hour
0-1.7mmol/L

Slowly Rising

30-60 mg/dL up in ½ hour
1.7-3.3mmol/L

Rising

60-90 mg/dL up in ½ hour
3.3-5.0mmol/L

Rapidly Rising

90 mg/dL or more up in ½ hour
5.0mmol/L +

Slowly Falling

30-60 mg/dL down in ½ hour
1.7-3.3mmol/L

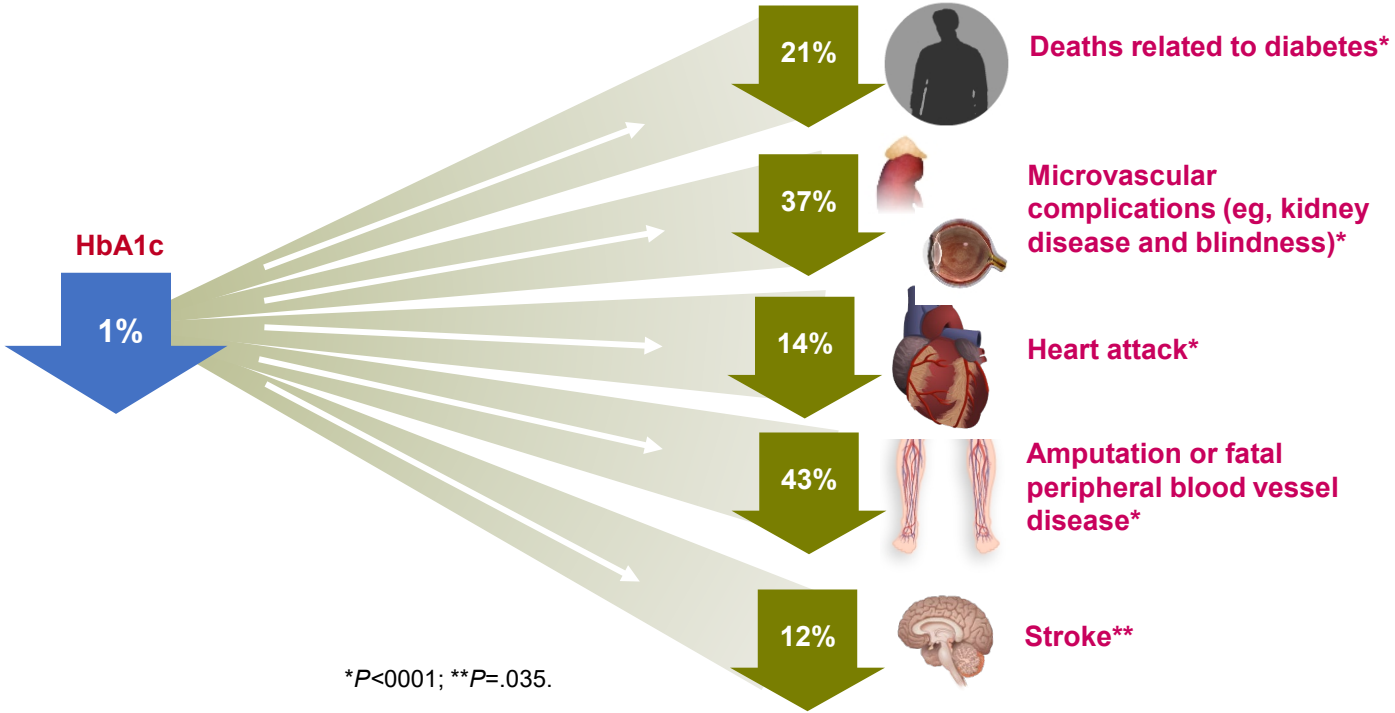
Falling

60-90 mg/dL down in ½ hour
3.3-5.0mmol/L

Rapidly Falling

90 mg/dL or more down in ½ hour
5.0mmol/L

Epidemiological extrapolation showing benefit of a 1% reduction in mean HbA1c



*P<0001; **P=.035.

Dal Treat to Target al Treat to benefit and Target

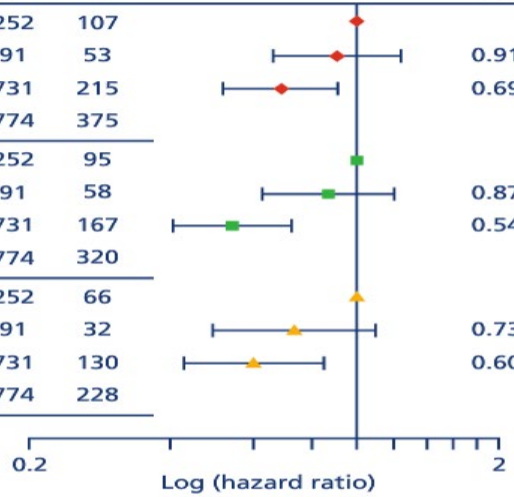
Time-in-range	*HbA1c (%)*	*HbA1c (mmol/mol)*
0%	12.1	109
10%	11.4	101
20%	10.6	92
30%	9.8	84
40%	9.0	75
50%	8.3	67
60%	7.5	59
70%	6.7	50
80%	5.9	42
90%	5.1	32
100%	4.3	23

Derived time-in-range is associated with MACE in T2D: data from the DEVOTE trial

Richard M. Bergenstal[1]; Elise Hachmann-Nielsen[2], Kajsa Kvist[2]; John Buse[3]

Derived time-in-range is associated with MACE, severe hypoglycemia and microvascular events in type 2 diabetes

Outcome (TIR category)	N	E	Hazard ratio vs TIR ≤50%	Overall accociation *p*-value
MACE (TIR ≤50%)	1252	107		
MACE (TIR >50–≤70%)	791	53	0.91 [0.66;1.24]	<0.01
MACE (TIR >70%)	3731	215	0.69 [0.52;0.91]	
Total	5774	375		
Severe hypo (TIR ≤50%)	1252	95		
Severe hypo (TIR >50–≤70%)	791	58	0.87 [0.63;1.20]	<0.0001
Severe hypo (TIR >70%)	3731	167	0.54 [0.40;0.73]	
Total	5774	320		
Microvascular (TIR ≤50%)	1252	66		
Microvascular (TIR >50–≤70%)	791	32	0.73 [0.49;1.09]	0.019
Microvascular (TIR >70%)	3731	130	0.60 [0.43;0.85]	
Total	5774	228		



Limiti HbA1c

Non informa circa la variabilita' glicemica

Non e' utile per favorire aggiustamenti terapeutici giornalieri

Non utilizzabile in situazioni particolari (anemia, emoglobinopatie, gravidanza)

Nuovi outcomes:

Migliorare il tempo in range (TIR)

Limitare la variabilità glicemica

Evitare le ipoglicemie

Nuovi parametri:

Tempo in target 70-180 (> 70%)
Tempo sotto target (< 4%)
Tempo sopra target (25%)
CV < a 36%
Media delle glicemie: < a 150 mg/dl
Utilizzo sensore 100%

Chapter 2: Glycemic monitoring and targets in patients with diabetes and CKD

2.1. Glycemic monitoring

Recommendation 2.1.1: We recommend using hemoglobin A1c (HbA1c) to monitor glycemic control in patients with diabetes and CKD *(1C)*.

Practice Point 2.1.1: Monitoring long-term glycemic control by HbA1c twice per year is reasonable for patients with diabetes. HbA1c may be measured as often as 4 times per year if the glycemic target is not met or after a change in glucose-lowering therapy.

Practice Point 2.1.2: Accuracy and precision of HbA1c measurement declines with advanced CKD (G4–G5), particularly among patients treated by dialysis, in whom HbA1c measurements have low reliability.

Practice Point 2.1.3: A glucose management indicator (GMI) derived from continuous glucose monitoring (CGM) data can be used to index glycemia for individuals in whom HbA1c is not concordant with directly measured blood glucose levels or clinical symptoms.

Practice Point 2.1.4: Daily glycemic monitoring with CGM or self-monitoring of blood glucose (SMBG) may help prevent hypoglycemia and improve glycemic control when glucose-lowering therapies associated with risk of hypoglycemia are used.

Practice Point 2.1.5: For patients with T2D and CKD who choose not to do daily glycemic monitoring by CGM or SMBG, glucose-lowering agents that pose a lower risk of hypoglycemia are preferred and should be administered in doses that are appropriate for the level of eGFR.

Practice Point 2.1.6: CGM devices are rapidly evolving with multiple functionalities (e.g., real-time and intermittently scanned CGM). Newer CGM devices may offer advantages for certain patients, depending on their values, goals, and preferences.

FGM impatto metabolico

Incremento del TIR (0.9-1.0 h/day) negli adulti e nei soggetti pediatrici (Bolinder 2016, Campbell 2018)

Riduzione di HbA1c (−0.4%; Campbell 2018)

Riduzione del tempo in iperglicemia (>240 mg/ dL) (Bolinder 2016)

Riduzione della variabilità glicemica (Bolinder 2016)

Maggiore soddisfazione del trattamento in adulti (Bolinder 2016) e bambini/adolescenti (Hayek 2017, Edge 2017)

Riduzione del tempo in ipoglicemia (Hayek 2017, Bolinder 2016, Dunn 2018)

Dunn at al, 2018, Diabetes Research and clinical practice

Hayek Al et al, 2017, Clinical Medicine Insights: Endocrinology and Diabetes

Bolinder J et al, 2016, Lancet

Campbell F et al, 2018, Pediatric Diabetes

Bruttomesso et al, 2019, Nutrition, Metabolism & Cardiovascular Diseases

CGM impatto metabolico

Several studies (**JDRF, DIAMOND, GOLD, SWITCH**) have shown that the use of rtCGM in adults and children with type 1 diabetes **reduces HbA1c levels (from 0.4 to 1.0%) and increases TIR of** 1.3-2.3 h/day

Bruttomesso et al, 2019, Nutrition, Metabolism & Cardiovascular Diseases

Meno paura dell'ipoglicemia in favore del CGM

Riduzione % di tempo in range ipoglicemico <70 mg/dl e <54 mg/dl con CGM

Ridotto numero di episodi di ipoglicemia grave nei pz in CGM

De Ridder F., Ther Adv End Met, 2019, 10: 1-17

Chamberlain J et al, 2016, Journal of Diabetes Science and Technology

M. Lind, JAMA, 2017

R. Beck, JAMA, 2017

CGM vs FGM

Research: Treatment

A randomized controlled pilot study of continuous glucose monitoring and flash glucose monitoring in people with Type 1 diabetes and impaired awareness of hypoglycaemia

M. Reddy, N. Jugnee, A. El Laboudi, E. Spanudakis, S. Anantharaja and N. Oliver

CGM FGM

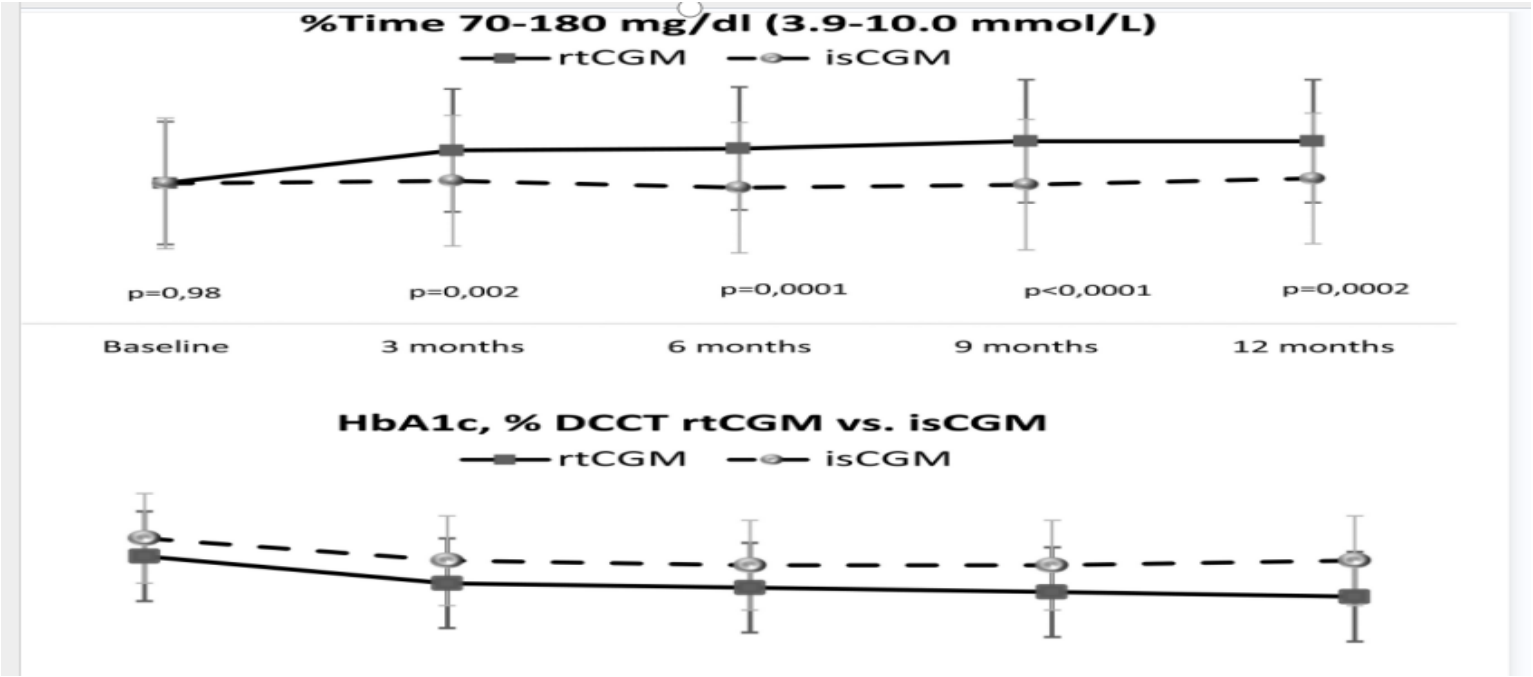
At the end-point the percentage time < 3.3 mmol/l was 2.4%, and 6.8% respectively (P = 0.006). Time spent in hypoglycaemia at all thresholds, and hypoglycaemia fear, were different between groups, favouring CGM.

Conclusion: CGM more effectively reduces time spent in hypoglycaemia in people with Type 1 diabetes and impaired awareness of hypoglycaemia compared with flash glucose monitoring. (Clinical Trial Registry No: NCT03028220)

Diabet. Med. 35, 483–490 (2018)

Diabetes and Technology and therapeutics

Lower Glycated Hemoglobin with Real-Time Continuous Glucose Monitoring Than with Intermittently Scanned Continuous Glucose Monitoring After 1 Year: The CORRIDA LIFE Study.Published Online: 25 November 2022



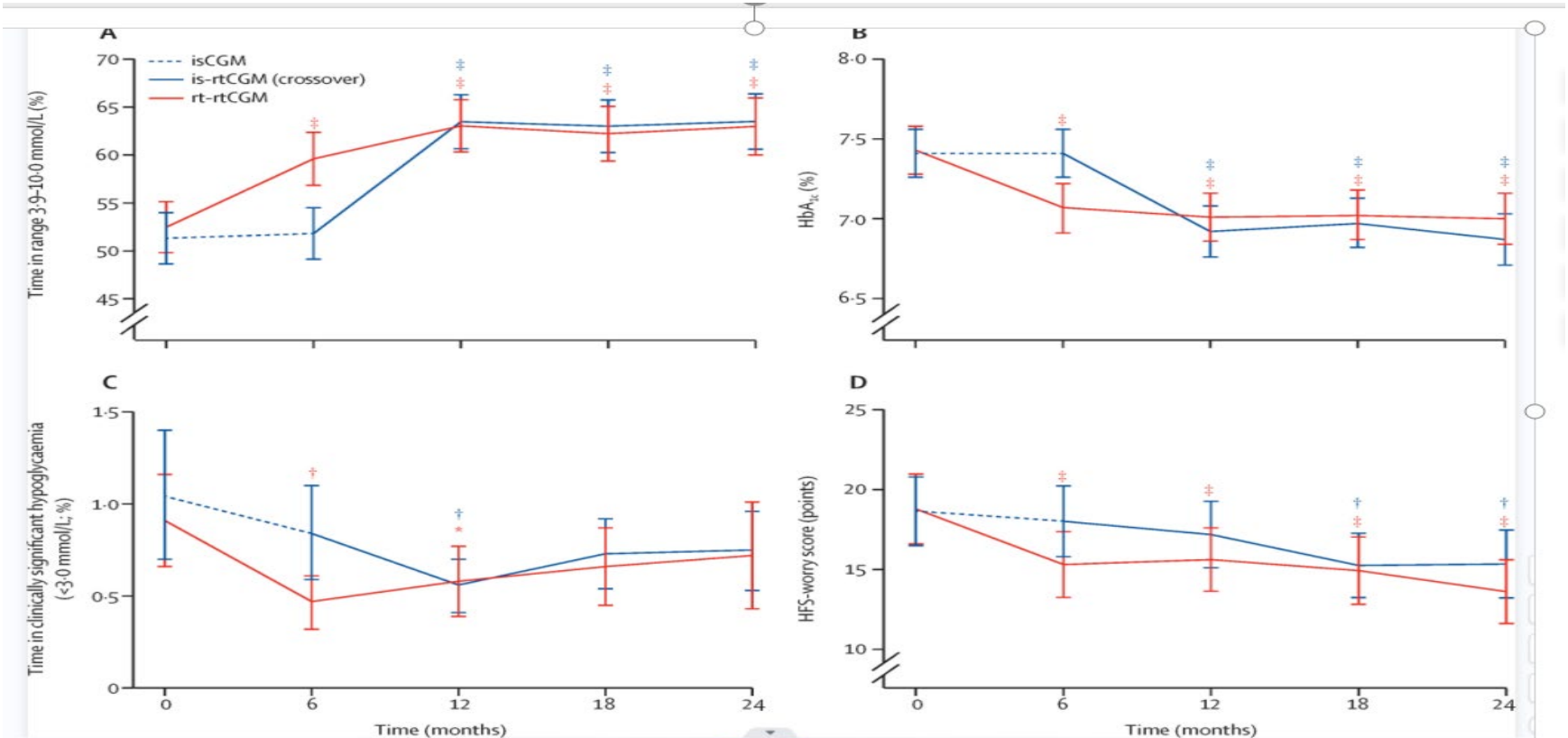
Results:

One hundred ninety-one adults with T1D (mean age 40 ± 13 years, HbA1c 8.1% ± 3.4% [65 ± 14 mmol/mol]) participated in this study; 81 patients initiated rtCGM and 110 initiated isCGM.

After 12-months, HbA1c was significantly lower with rtCGM versus isCGM (7.1% ± 3.1% [54.1 ± 10.1 mmol/mol] vs. 7.7% ± 3.3% [61.2 ± 12.2 mmol/mol]), *P* = 0.0001. The percentage of time in hypoglycemia (<70 mg/dL [<3.9 mmol/L]) was lower among rtCGM vs. isCGM participants [4.3% ± 2.8% vs. 6.4% ± 5.3%], *P* = 0.003). **Patients with rtCGM spent less time in clinically significant hypoglycemia (<54 mg/dL [<3.0 mmol/L]) (0.9% ± 1.0% vs. 2.3% ± 2.5%, *P* < 0.0001) and more time in target range (70–180 mg/dL [3.9–10 mmol/L]) than isCGM users (67.5% ± 14.8% vs. 57.8% ± 17.0%), *P* = 0.0002.**

Effetto del passaggio dal monitoraggio intermittente della glicemia al monitoraggio continuo in tempo reale negli adulti con diabete di tipo 1: risultati a 24 mesi dello studio randomizzato ALERTT

Margaretha M. Visser et al.Lancet ,feb 2023



Glycaemic control and hypoglycaemia worry improved significantly up to 24 months after switching from isCGM without alerts to rtCGM with alerts, supporting the use of rtCGM in the care of adults with type 1 diabetes.

1. Allarmi predittivi (CGM)

- Avvertono con modalità differente tra i sistemi disponibili da 10 a 30 min prima del raggiungimento del valore basso/alto stabilito dal medico diabetologo;
- L'allarme predittivo è indipendente dal valore di partenza, esso si basa sulla velocità di cambio della glicemia;

Traccia automaticamente[§] i dati sia dell'insulina sia del glucosio, fornendo indicazioni sul dosaggio in tempo reale.[‘‘]

§ Restano necessarie alcune interazioni da parte dell'utilizzatore.

‘ MDI (Multiple Daily Injections) = iniezioni multiple giornaliere.

‘‘ Indicazioni sul dosaggio calcolato secondo le impostazioni iniziali del medico e la quantità di carboidrati stimata dall'utilizzatore.

Nuovo sistema Smart MDI*

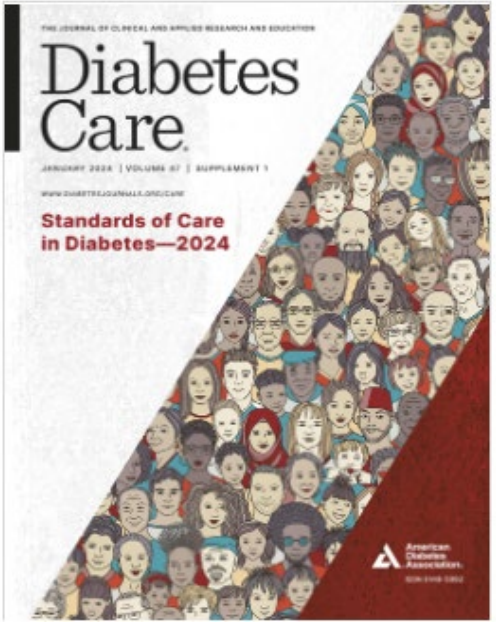
Traccia i dati sia dell'insulina sia del glucosio, fornendo indicazioni personalizzate sul dosaggio.[‘‘]

‘ MDI (Multiple Daily Injections) = iniezioni multiple giornaliere.

Real-time continuous glucose monitoring or intermittently scanned continuous glucose monitoring ***should be offered*** for diabetes management ***in youth with type 1 diabetes on multiple daily injections or continuous subcutaneous insulin infusion*** who are capable of using the device safely (either by themselves or with a caregiver). The choice of device should be made based on patient circumstances, desires, and needs.

Real-time continuous glucose monitoring or intermittently scanned continuous glucose monitoring ***should be offered*** for diabetes management ***in youth with type 2 diabetes on multiple daily injections or continuous subcutaneous insulin infusion*** who are capable of using devices safely (either by themselves or with a caregiver). The choice of device should be made based on patient circumstances, desires, and needs.

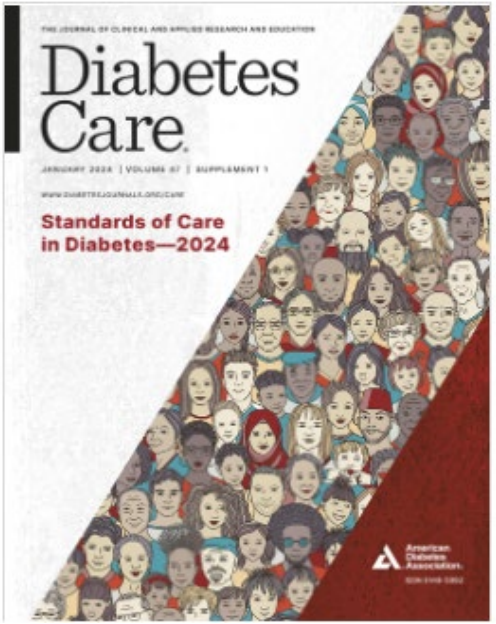
Gennaio 2024



•7.16 rtCGM A o isCGM E dovrebbero essere offerti per la gestione del diabete nei giovani con diabete di tipo 1 in MDI o CSII che sono in grado di utilizzare i dispositivi in modo sicuro (da soli o con un caregiver). La scelta del dispositivo dovrebbe essere fatta in base alle circostanze, alle preferenze e alle esigenze dell'individuo.

•7.17 rtCGM o isCGM dovrebbero essere offerti per la gestione del diabete nei giovani con diabete di tipo 2 in MDI o CSII che sono in grado di utilizzare i dispositivi in modo sicuro (da soli o con un caregiver). La scelta del dispositivo dovrebbe essere fatta in base alle circostanze, alle preferenze e alle esigenze dell'individuo. E

Gennaio 2024



•7.14 Il CGM in tempo reale (rtCGM) A o il CGM a scansione intermittente (isCGM) B devono essere offerti per la gestione del diabete negli adulti con diabete sottoposti a iniezioni multiple giornaliere (MDI) o CSII che sono in grado di utilizzare i dispositivi in modo sicuro (da soli o con un caregiver). La scelta del dispositivo deve essere effettuata in base alle circostanze, alle preferenze e alle esigenze dell'individuo.

•7.15 rtCGM A o isCGM B dovrebbero essere offerti per la gestione del diabete negli adulti con diabete in terapia insulinica basale che sono in grado di utilizzare i dispositivi in modo sicuro (da soli o con un caregiver). La scelta del dispositivo dovrebbe essere fatta in base alle circostanze, alle preferenze e alle esigenze dell'individuo.

American Diabetes Association. Connected for Life

80TH SCIENTIFIC SESSIONS
A VIRTUAL EXPERIENCE
June 12-16, 2020

Use of Real-Time CGM Is Associated with Fewer Hospitalizations Compared with SMBG in the Insulin-Treated Medicare Population

GARY PUCKREIN, **DAVID G. MARRERO**, CHRISTOPHER PARKIN, GREGORY J. NORMAN, LIOU XU, PETER M. LYNCH, BRUCE T. TAYLOR, *Washington, DC, Tucson, AZ, Henderson, NV, San Diego*

Table 1. Hospitalization rates for CGM vs. SMBG use

Variable	CGM Users			SMBG Users			P-Value	
	n	Hospitalized n (%)	Inpatient Visits, avg.	n	Hospitalized n (%)	Inpatient Visits, avg.	Hospitalized, %	Inpatient Visit, n
Age, yrs								
65-79	557	25.0	0.43	98,675	33.7	0.70	<.0001	<.0001
≥80	284	28.5	0.53	125,809	36.8	0.70	0.0037	0.0006
Gender								
Male	415	26.3	0.43	80,382	35.2	0.70	0.0001	<.0001
Female	426	26.1	0.50	144,102	35.6	0.70	<.0001	<.0001
Race								
White	806	26.3	0.47	167,690	36.0	0.70	<.0001	<.0001
Non-white	35	26.1	0.46	56,609	33.8	0.70	0.5944	0.0880
Comorbidities*								
0	517	17.8	0.29	135,126	21.6	0.34	0.0367	0.0663
1	169	36.1	0.59	47,002	47.8	0.91	0.0025	<.0001
≥2	155	43.2	0.92	42,356	66.0	1.63	<.0001	<.0001
TOTAL	**841**	**26.2**	**0.46**	**224,484**	**35.5**	**0.70**	**<.0001**	**<.0001**

*Charlson Comorbidity Index (CCI)

A multicentre international randomised controlled trial* (CONCEPTT)

*Denice S Feig, Lois E Donovan, Rosa Corcoy, Kellie E Murphy, Stephanie A Amiel, Katharine F Hunt, Elizabeth Asztalos, Jon F R Barrett, J Johanna Sanchez, Alberto de Leiva, Moshe Hod, Lois Jovanovic, Erin Keely, Ruth McManus, Eileen K Hutton, Claire L Meek, Zoe A Stewart, Tim Wysocki, Robert O'Brien, Katrina Ruedy, Craig Kollman, George Tomlinson, Helen R Murphy, on behalf of the CONCEPTT Collaborative Group**

Valutazione dell'efficacia di real time-CGM con SMBG vs SMBG (controllo) in uno studio controllato multicentrico, open-label e randomizzato con donne T1D in MDI in programmazione di gravidanza (n=110) o in gravidanza (n=215)

- RT-CGM + SMBG: 108 in gravidanza (tra il 6 giorno di gestazione e la 13 settimana) e 53 in pianificazione di gravidanza
- SMBG: 107 in gravidanza e 57 in programmazione di gravidanza

Forniti algoritmi dettagliati come guida all'autogestione.

Outcome primario:

HbA1c tra baseline e 34 settimana di gestazione (per il gruppo in gravidanza) e tra il baseline e la 24settimana o il concepimento per il Gruppo in programmazione di gravidanza

- TIR/TBR/TAR
- *Outcomes* neonatali

Feig D.S. et al. Lancet 2017; 390: 2347–59

CONCEPTT – I RISULTATI

A multicentre international randomised controlled trial* (CONCEPTT)

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- RIDUZIONE della HbA1c modesta ma significativa
- RIDUZIONE della permanenza oltre 140 mg/dL
- AUMENTO del tempo in range (TIR) è stato maggiore
- non differenze significative per l'ipoglicemia

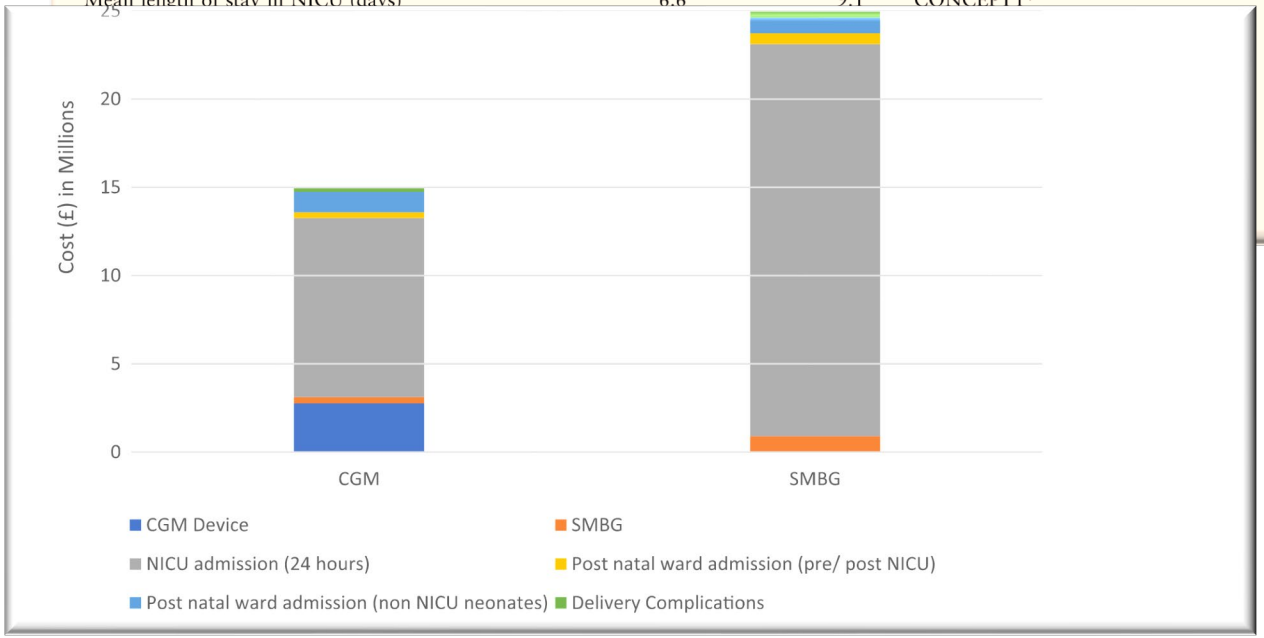
- MIGLIORI gli esiti neonatali
- RIDUZIONE della durata dell'ospedalizzazione rispetto alla gestione standard

In una successiva analisi sul rapporto costo/beneficio si è calcolato che questo vantaggio clinico dovrebbe tradursi, in un significativo risparmio economico, malgrado il costo della tecnologia usata sia maggiore rispetto al SMBG

Feig DS et al. Lancet 2017; 390: 2347–59
Murphy HR et al Diabet Med 2019; 36: 1652-58

Diabete tipo 1 in Gravidanza
Uso del CGM si associa a riduzione dei costi rispetto a SMBG

Complication rates	RT-CGM + SMBG	SMBG alone	Source
Admission to NICU > 24 h (%)	27	43	CONCEPTT [11]
Mean length of stay in NICU (days)	6.6	9.1	CONCEPTT‡



Murphy HR. et al. Diabet Med 2019; 36:1652–1658

CGM IN GRAVIDANZA ED ESITI IN UNO STUDIO OSSERVAZIONALE SVEDESE

Diabetologia (2019) 62:1143–1153
https://doi.org/10.1007/s00125-019-4850-0

ARTICLE

Check for updates

Continuous glucose monitoring in pregnant women with type 1 diabetes: an observational cohort study of 186 pregnancies

Karl Kristensen[1,2,3] · Linda E. Ögge[4,5] · Verena Sengpiel[4,5] · Karin Kjölhede[4,5] · Annika Dotevall[5,6] · Anders Elfvin[5,7] · Filip K. Knop[8,9] · Nana Wiberg[1,3] · Anastasia Katsarou[10,11] · Nael Shaat[10,11] · Lars Kristensen[2] · Kerstin Berntorp[10,11]

Analisi retrospettiva di dati CGM di 186 donne con DT1 in gravidanza (2014-2017) in due centri di terzo livello in Svezia

92 donne in rtCGM
94 donne in isCGM
Confronto fra i due gruppi

Analisi di pattern glicemici da CGM ed associazione con LGA neonatale e avversi NCO (neonatal composite outcome)

Diabetologia (2019) 62:1143–1153
https://doi.org/10.1007/s00125-019-4850-0

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Continuous glucose monitoring in pregnant women with type 1 diabetes: an observational cohort study of 186 pregnancies

Karl Kristensen[1,2,3] · Linda E. Ögge[4,5] · Verena Sengpiel[4,5] · Karin Kjölhede[4,5] · Annika Dotevall[5,6] · Anders Elfvin[5,7] · Filip K. Knop[8,9] · Nana Wiberg[1,3] · Anastasia Katsarou[10,11] · Nael Shaat[10,11] · Lars Kristensen[2] · Kerstin Berntorp[10,11]

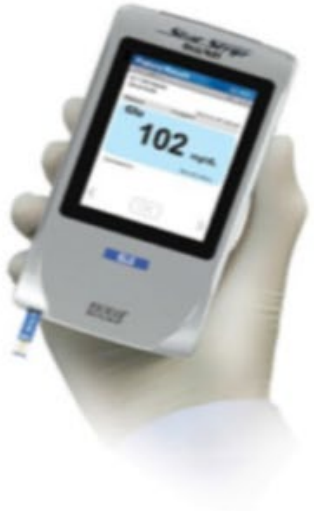
In linea con i dati del CONCEPTT un aumento del 5-7% del TIR nel secondo e terzo trimestre è associato con una riduzione del rischio di LGA e NCO (macrosomia, distocia di spalla, ipoglicemia neonatale, TIN)

In questo studio nonostante l'uso del monitoraggio, il controllo glicemico non era stato ottimale e l'incidenza di LGA era rimasta elevata

Unica differenza osservata fra i gruppi rtCGM e isCGM è stata una riduzione nel primo gruppo del tempo speso sotto il target e dell'LBGI.

- In the hospital, uncontrolled blood sugar levels contribute to higher morbidity, mortality, and healthcare costs[a-g]
- The causes of poor inpatient glycemic control are multifactorial
  - Effects of acute illness on glucose ("stress hyperglycemia")
  - Fluctuating appetite and/or nutritional status
  - Steroid use and/or other medication changes
  - Unpredictable timing of tests and procedures
  - Varying familiarity with newer medications and insulin formulations among provider and staff
- Finally, many times, the focus is on the primary admission diagnosis, not diabetes.

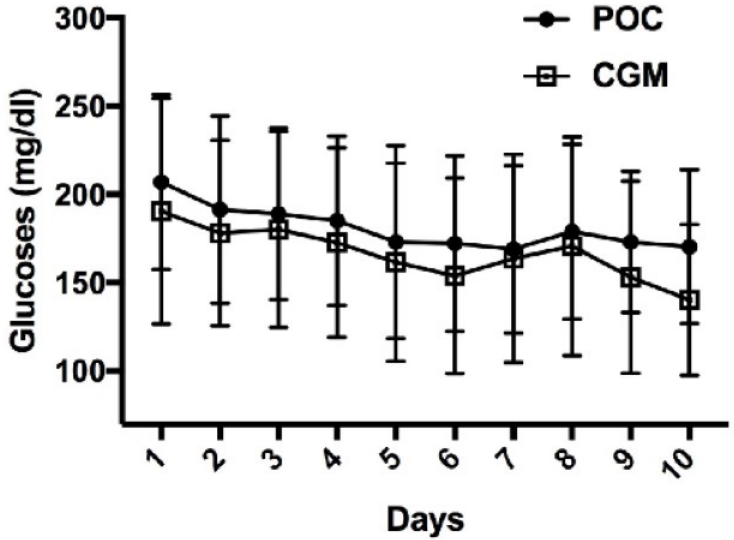
- The current standard for hospital glucose management is POC testing.
- However, blinded rt-CGM has retrospectively shown POC testing to miss ~33% of hyperglycemic and up to 90% of hypoglycemic events.



Fortmann, A.L. *Diabetes Care* 2020 Nov; 43(11): 2873-2877.

Freestyle Libre Pro Flash CGM System vs POC Glucose Testing in Hospitalized Insulin-Treated Patients With T2D

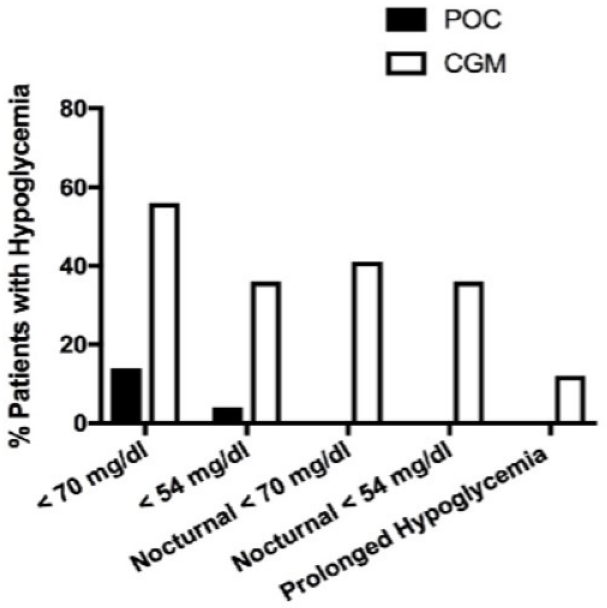
Mean hospital daily glucose as measured by POC and CGM



Mean daily BG by POC vs CGM (188.9 ± 27.3 vs 176.1 ± 46.9 mg/dL) estimated BG difference of 12.8 mg/dL (CI 8.3; 17.2), $P < 0.001$.

Galindo RJ, et al. *BMJ Open Diab Res Care*. 2020;8:e000763.

Hypoglycemia detection by POC and by CGM



CGM…has the potential to detect hyper- and hypoglycemia [in the hospital], that would otherwise be missed by POC.[a] However, expansion of CGM into US hospitals has been limited by the lack of RCTs comparing rt-CGM with POC in hospital settings.

ADA Standards of Care note insufficient data to recommend widespread use of CGM for hospitalized patients.[b]

a. Wallia A, et al. *J Diabetes Sci Technol*. 2017;11(5):1036-1044.
b. American Diabetes Association. *Diabetes Care*. 2020;43(suppl 1):S193-S202.

Conclusioni

le performance sono a favore del RT-cgm rispetto all'IsCGM a riguardo dell'aumento del TIR e nella riduzione del TBR

L'Is-Cgm,grazie ai costi minori,potrebbe essere preferito nei pazienti a basso rischio di ipoglicemia e per usi temporanei(paziente ospedalizzato)

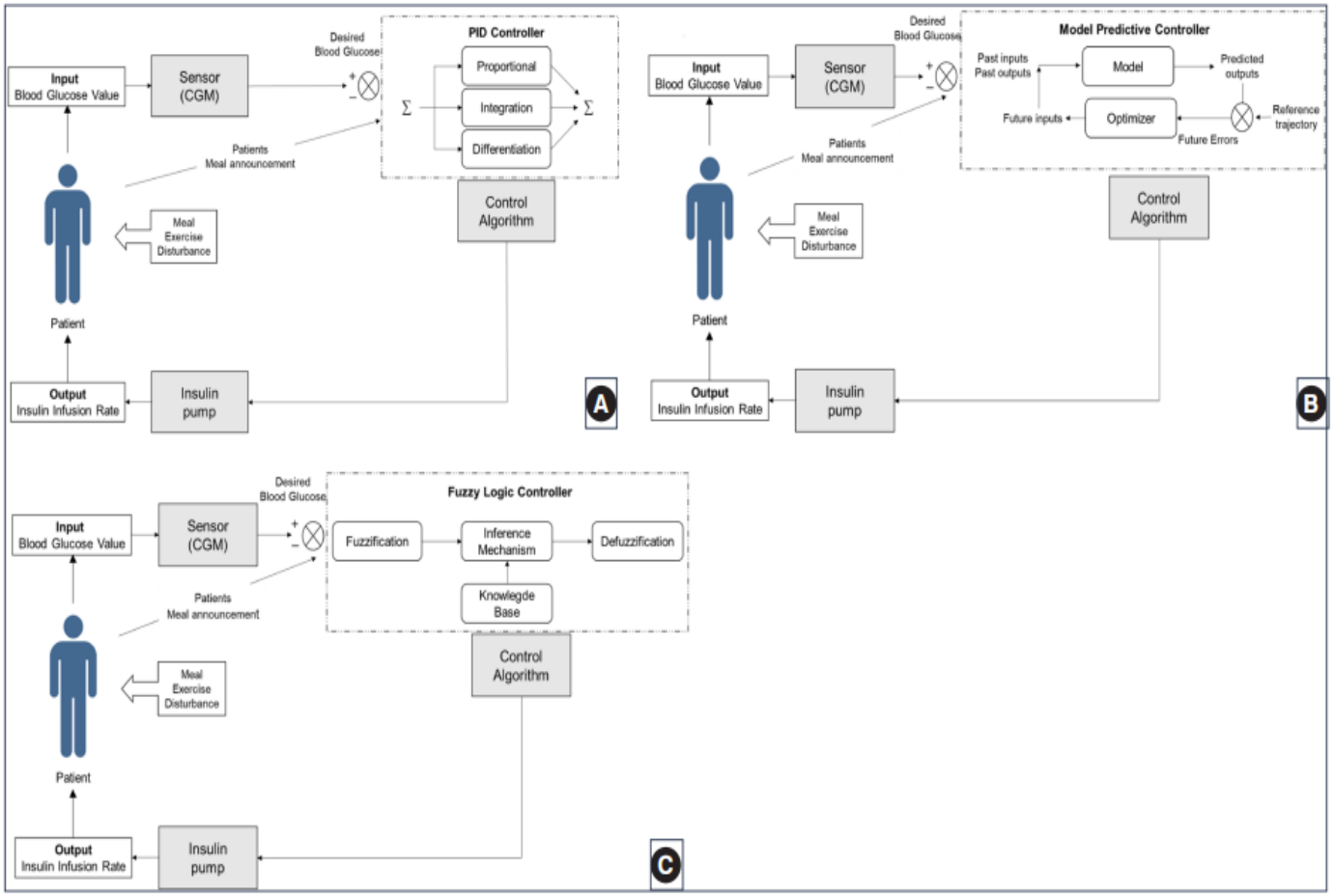
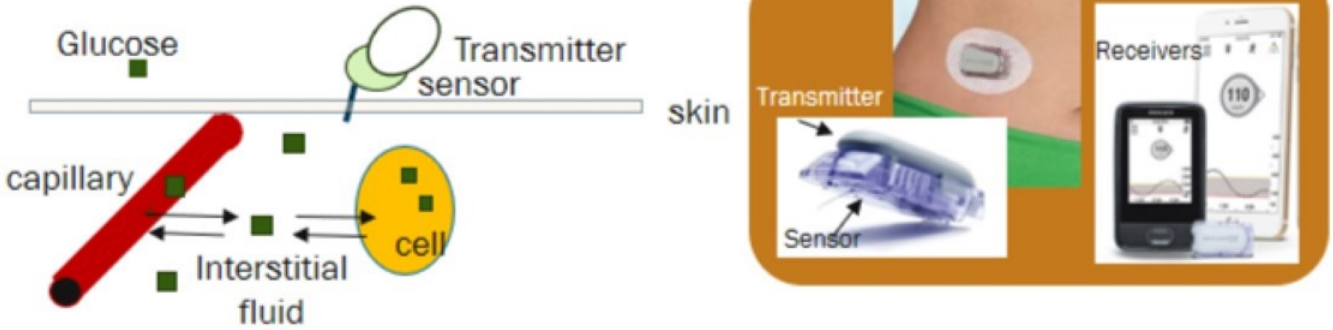


Fig. 5. Schematic diagram of major control algorithms of artificial pancreas system. (A) Proportional integral derivative control (PID) algorithm, (B) model predictive control (MPC) algorithm, (C) fuzzy logic algorithm. CGM, continuous glucose monitor.

Anno	Gruppo	CGM	Pompa	Sistema	Disegno	No.	Età, anni	Ambientazione	Durata	Intervento	Controllo	Risultato (intervento vs. controllo)
2010 [15]	Medtronic	Sensore Medtronic	Paradigma Minimed	Guardiano in tempo reale	RCT, parallelo	485	7–70	Casa	12 mesi	LINFA	MDI	HbA1c: 7,5% contro 8,1%, *P* <0,05 Ipoglicemia grave: 13,3 vs 13,5/100 anni persona, *P* = 0,30
2013 [59]	Medtronic	Medtronic Enlite	Minimo 530G	Minimo 530G	RCT, parallelo	95	4–50	Casa	6 mesi	LGS SAP	CSII	Eventi ipoglicemici da gravi a moderati: 9,5 vs 34,2/100 mesi-paziente

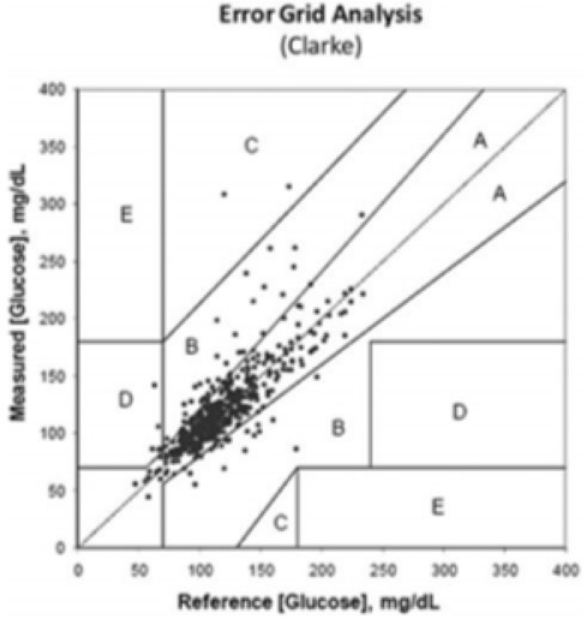
Can rt-CGM Be Used in the ICU?



- Physiologic lag 10-15 minutes between blood and interstitial fluid
- Inaccuracy at low BG, rapid glucose swings
- Other sources of error shared by CBG
- Home BG monitoring devices *NOT* approved in hospital—adjunctive use

GlucoDay CGM in MICU

- RCT; N = 35
- GlucoDay CGM
  - No alarms
  - CGM used as prompt to check BG if change in SG >25 mg/dL/30 min
- Similar glucose control
- 98.6% of data in zones A/B
- MARD 11.2%



EGA zone	A	B	C	D	E
Cases	454	60	2	5	0
Percentage (%)	87.1	11.5	0.4	1.0	0.0
Percentage (%)	98.6		1.4		

de Block CEM, et al. *Diabetes Technol Ther*. 2015;17(12):889-898.

RCT Comparing rt-CGM With Selective Arterial BG + Blinded CGM

- N = 124 patients receiving ventilatory support
- IV insulin
- Target BG: 80-110 mg/dL; **no alerts**
- Guardian CGM, calibrated 4×/d

	Real-time CGM	Control	*P*
n	63	61	
Mean sensor glucose (mg/dl)	105.8 ± 18.1	110.6 ± 10.4	0.076
Mean blood glucose (mg/dl)	113.2 ± 14.3	114.0 ± 11.0	0.731
Time of glucose <110 mg/dl (%)	59.0 ± 20.4	55.0 ± 18.0	0.245
Time of glucose <150 mg/dl (%)	94.2 ± 7.9	92.9 ± 8.4	0.395
Time to reach 110 mg/dl (min)	150 (48–275)	118 (45–240)	0.557
Rate of hypoglycemia (% of patients)	1.6	11.5	0.031
Insulin (IU/72 h, study period)	104 ± 78	110 ± 52	0.320
Length of stay	17.4 ± 14.4	16.8 ± 12.2	0.785
ICU mortality (%)	22	26	0.677
Hospital mortality (%)	33	31	0.849

Data are means ± SD, median (interquartile range), or %.

Holzinger U, Diabetes Care. 2010;33(3):467-472

RCT Comparing CGM With POC BG

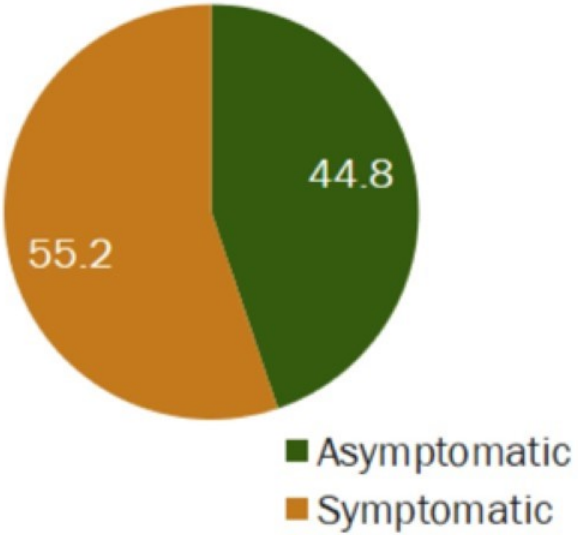
- N = 177 patients in mixed ICU
- IV insulin
- Target BG: 90-162 mg/dL
- Freestyle Navigator
- Alerts for SG < 90 mg/dL, > 180 mg/dL
- Reference ABG 6×/d

Table 2 Safety, efficacy and clinical study outcomes

	Intervention - CGM (*n* = 78)	Control - POCM (*n* = 78)	*P*
Study period (days)	3.2 (2-5)	2.8 (1-5)	0.18
Incidence severe hypoglycemia (<2.2 mmol/L)[1]	None	None	
% of time for the sensor glucose levels (SD)[3]			
In target range (5.0-9.0 mmol/L)	75 (18)	71 (20)	0.18
Below target range (2.2-5.0 mmol/L)	11 (13)	9 (12)	0.44
Mild/moderate hypoglycemia (2.2-3.9)	2 (7)	1 (2)	0.14
Above target range (>9.0 mmol/L)	15 (16)	20 (21)	0.06
Mild/moderate hyperglycemia (9.0-11.1)	12 (11)	16 (16)	0.03
Hyperglycemia (>11.1)	3 (7)	4 (9)	0.35
Mean reference blood glucose (mmol/L)	8.2 (1.6)	8.3 (1.3)	0.53
Mean sensor glucose (mmol/L)	7.1 (1.1)	7.5 (1.3)	0.07
MAG change (mmol/L/h)[2]	0.33 (0.2-0.5)	0.32(0.2-0.4)	0.31

Boom DT, et al. *Crit Care*. 2014;18:453.

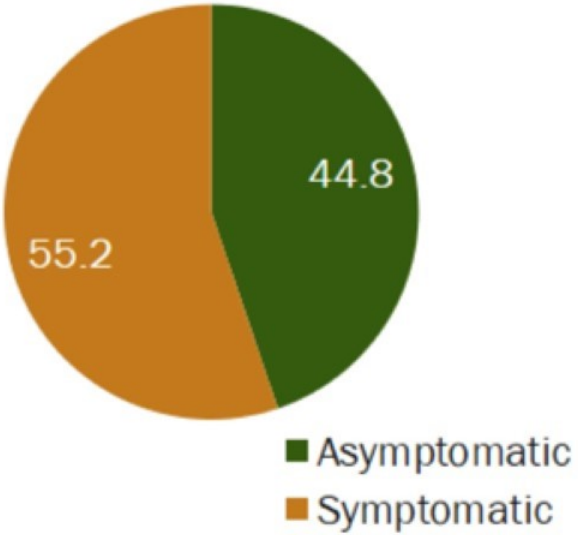
Asymptomatic Hypoglycemia Is Common Among Inpatients With Diabetes Treated With Insulin



Prospective observational study (n= 250) reported that 45% of insulin-treated non-ICU patients with BG <70 mg/dL had asymptomatic hypoglycemia. In multivariate analysis, older age and male gender were associated with higher risk of asymptomatic hypoglycemia.

Cardona et al. *BMJ Open Diab Res Care* 2018;6:e000607.

Asymptomatic Hypoglycemia Is Common Among Inpatients With Diabetes Treated With Insulin



Predictors of Asymptomatic Hypoglycemia

	OR	95% CI
Age < 50 y	1 (ref.)	
50-58 y	1.73	(0.76, 3.96)
59-64 y	2.55	(1.11, 5.84)
≥ 65 y	4.01	(1.62, 9.92)
Male sex	2.08	(1.13, 3.83)
GFR > 60 vs < 60 mL/min	0.70	(0.39, 1.26)

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CGM in the Hospital Setting

- Invasive
  - Intravascular: venous and arterial
- Minimally invasive
  - Subcutaneous
- Noninvasive
  - Transdermal

- Sampling frequencies typically range from 1 to 15 min
- More than 15 continuous or semi-CGM devices have been described

The general consensus among experts and medical societies is that, compared with intermittent POC BG testing, CGM technology offers benefits in the prevention of severe hyperglycemia and hypoglycemia.

Wallia A, et al. J Diabetes Sci Technol. 2017;11(5):1036-1044; Umpierrez GE, et al. Diabetes Care. 2018;41(8):1579-1589.

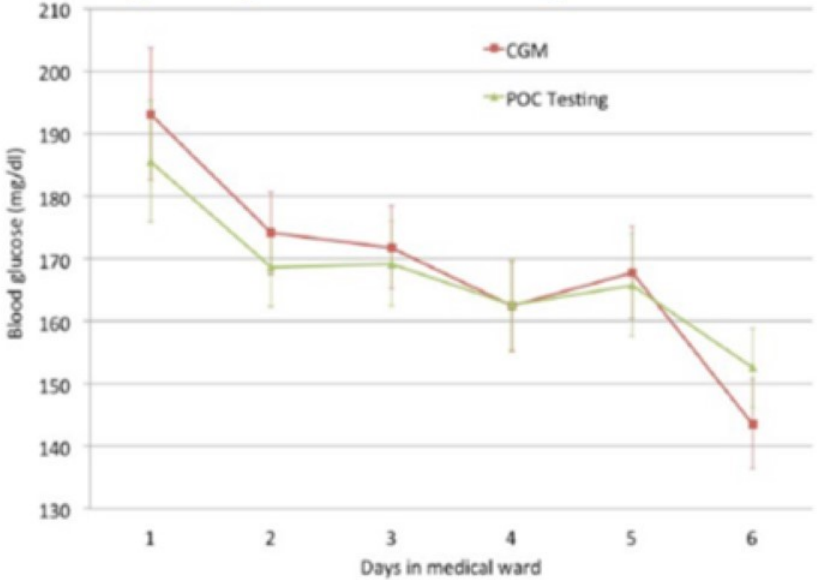
Clinical Trials Using CGM in Non-ICU Settings

Author, Year	Population	Sample Size	No. of Sites	Type of CGM	Performance Measurement	Comparator
Rodriguez, 2010	General wards- ACS	23	1	Guardian	Glycemic control, time to BG < 140	Capillary BG
Burt, 2013	General ward	26	1	System Gold	Performance measurement	Comparator
Schaupp, 2015	General ward	84	1	iPro	Accuracy	Capillary BG
Gomez, 2016	General ward	38	1	iPro-2	Accuracy	Capillary BG
Gu, 2017	Ward	81	8	Sensor-augmented pump	Performance measurement	MDI with blinded CGM
Galindo, 2020	General ward	100	1	Libre	Accuracy	Capillary BG

a Rodriguez, et al. *Diabetes Technol Ther.* 2010;12:347-351; b. Burt MG, et al. *Diabetes Technol Ther.* 2013;15:241-245; c. Schaupp L, et al. *Diabetes Technol Ther.* 2015;17:611-618; d. Gomez AM, et al. *J Diabetes Sci Technol.* 2016;10:325-329; e. Gu W, et al. *Diabetes Metab.* 2017;43:359-363; f. Galindo RJ, et al. *Diabetes Care.* 2020;43(11):2730-2735.

CGM in Non-ICU Insulin-Treated Patients With T2D

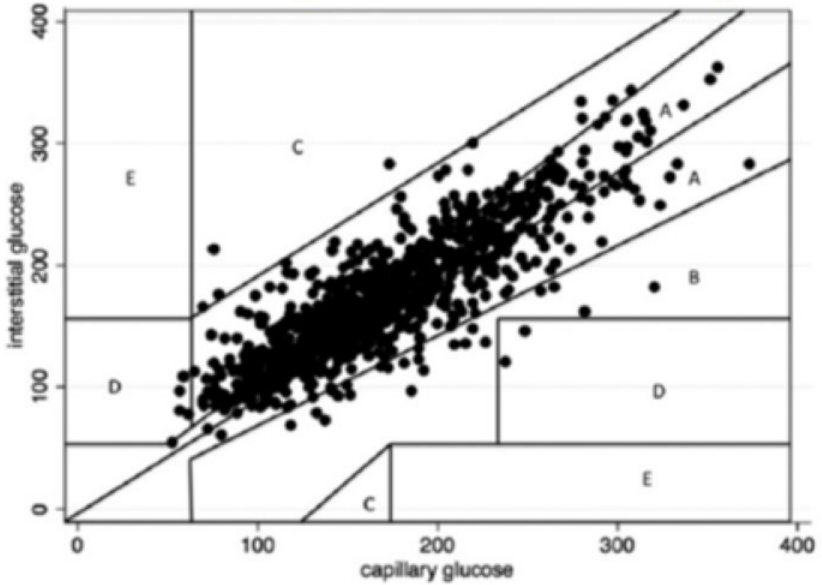
Average daily BG measured by CGM and POC



No differences in daily BG between CGM and POC.

More hypoglycemia events detected by CGM than POC (55 vs 12; $P < .01$).

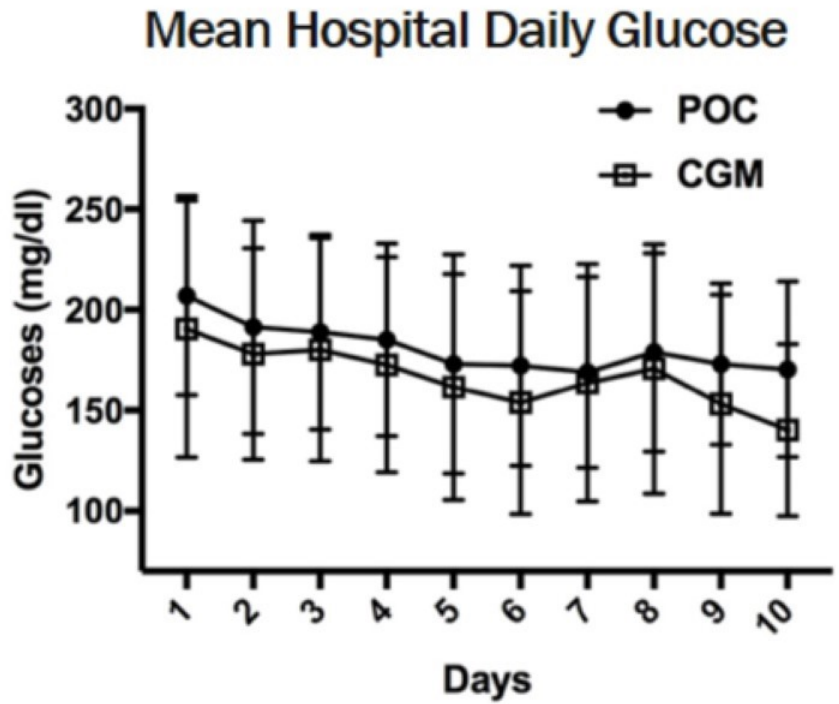
Clinical accuracy BG levels measured by CGM



Glucose measurements were clinically valid, with 91.9% of patients falling within the Clarke error grid A and B zones.

Gomez AM, et al. *J Diabetes Sci Technol;* 2016;10:325-329.

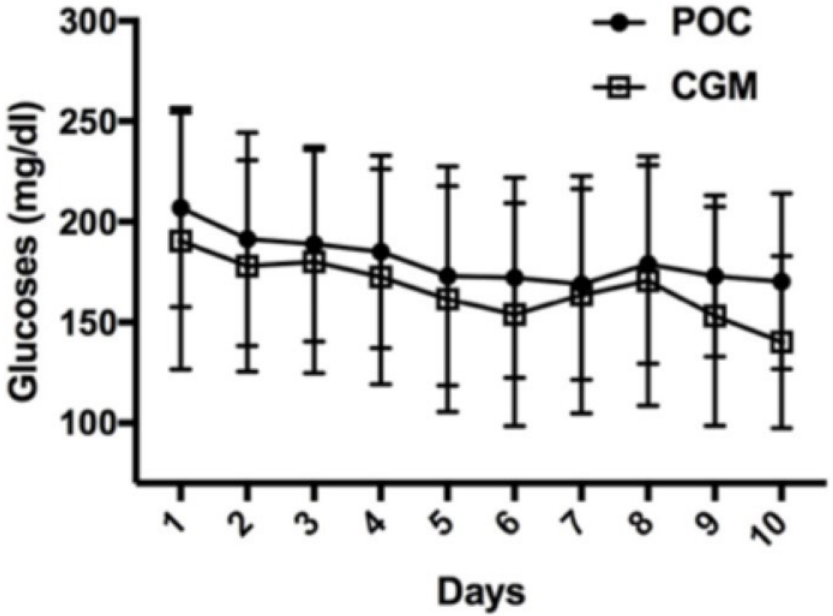
FreeStyle Libre Pro Flash CGMS vs POC Capillary Glucose Testing in Hospitalized Patients With T2D



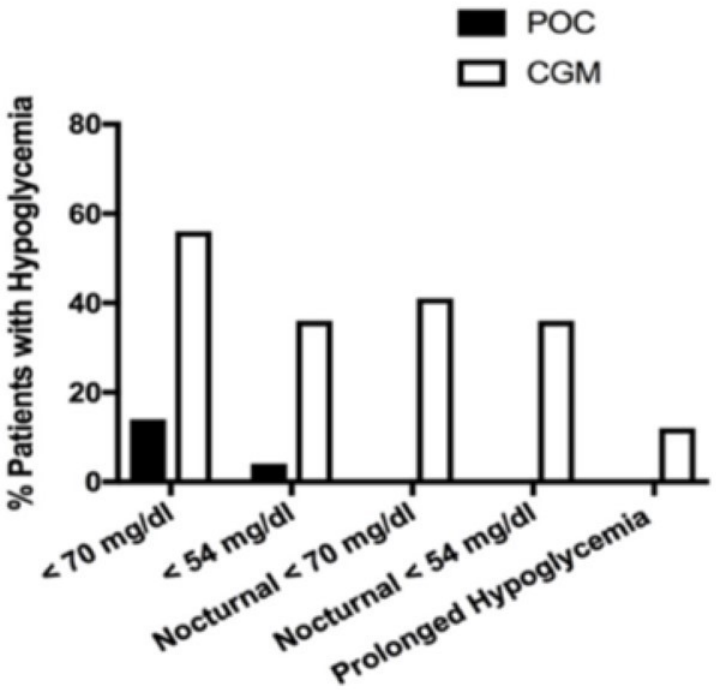
Galindo RJ, et al. *Diabetes Care*. 2020;43(11):2730-2735.

FreeStyle Libre Pro Flash CGMS vs POC Capillary Glucose Testing in Hospitalized Patients With T2D

Mean Hospital Daily Glucose



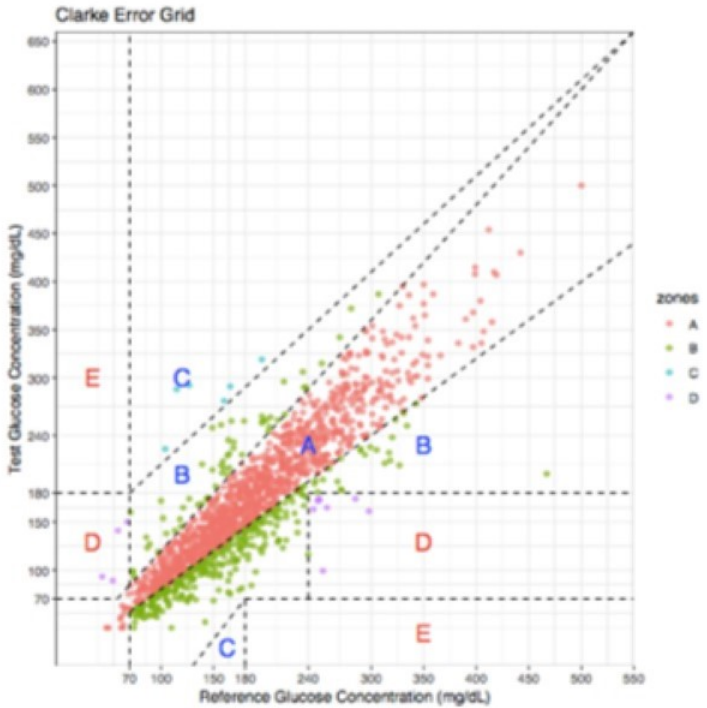
Hypoglycemia by POC and CGM



Galindo RJ, et al. *Diabetes Care*. 2020;43(11):2730-2735.

FreeStyle Libre Pro Flash CGMS vs POC Capillary Glucose Testing in Hospitalized Patients With T2D (cont)

Clarke Error Grid analysis



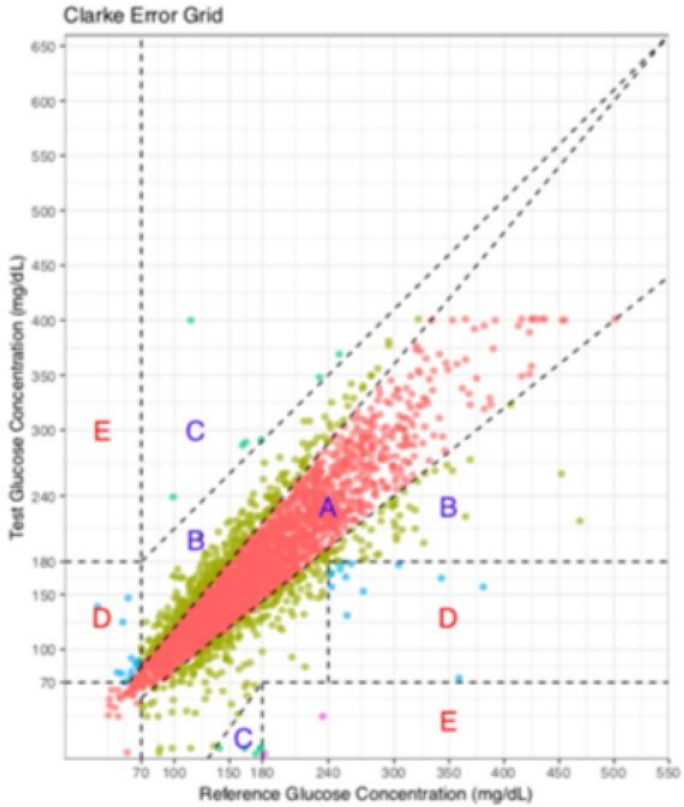
Glucose Range (mg/dL)	Matched Pairs (n)	MARD (%)
Overall	1576	14.8
51-69	13	27.9
70-180	829	16.7
>180	731	12.1
>250	253	11.4

Galindo et al. *Diabetes Care*. 2020.

Dexcom G6 – Hospital Accuracy Study

N = 205
insulin-treated
patients with T2D
in general
medicine and
surgery wards

University of
Maryland
Emory University



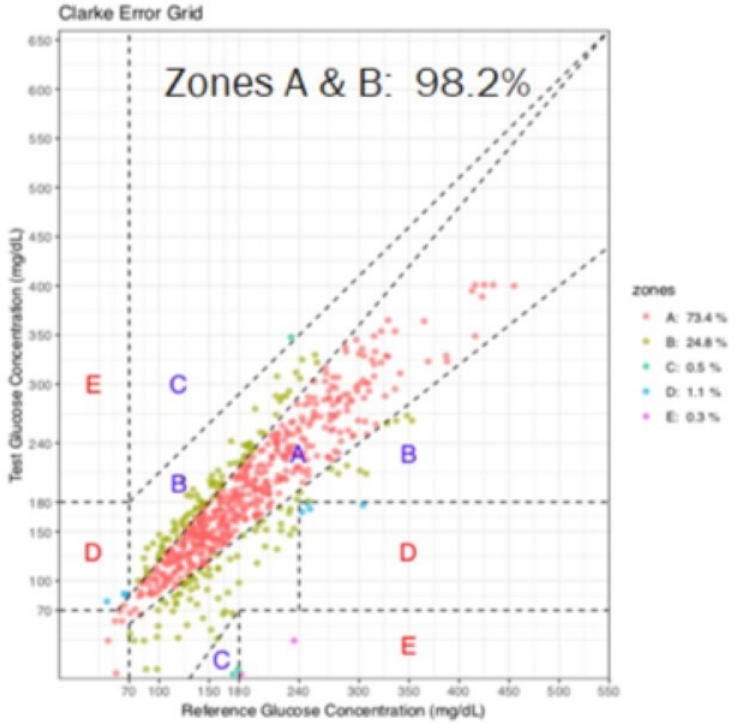
A: 79.7%
B: 18.9
C: 0.4%
D: 0.9%
E: 0.1%

Zones A & B: 98.6%

Nair BG, et al. *Diabetes Care*. 2020;43(11):e168-e169.

Dexcom G6 – Hospital Accuracy Study (cont)

First 24 h of CGM Use



After 24 h of CGM Use