

Can Trending Arrows in Continuous Glucose Monitoring Systems Predict Later Glycemia below 0.80g/L?

Concepcion Gonzalez, Elisa Maury, Isabelle Barcos, Henri Gin and Vincent Rigalleau*

Nutrition-Diab tologie, H pital Haut-L v que, Avenue Magellan, 33600 Pessac, France

Abstract

Objective: Can Continuous Glucose Monitoring (CGM) systems predict capillary glucose levels < 0.80g/L

Research Design and Methods: During their education to the use of CGMS, thirty-three patients with Type 1 Diabetes (T1D) collected 386 observations that included: the trending arrow, the Interstitial and the Capillary Glucose Level (IGL and CGL), at time 0 and 15 minutes later, without any intervention.

Results: Initial descending arrows preceded decreasing CGL: $-0.15 \pm 0.28\text{g/L}$ vs $-0.01 \pm 0.23\text{g/L}$ if stable and $+0.02 \pm 0.23\text{g/L}$ if ascending arrow, $p=0.008$. For the 222 observations with correct initial IGL (0.80-1.60g/L), a final CGL lower than 0.80g/L was observed in 31% of cases after a descending arrow, 10% after a stable arrow and never after an ascending arrow ($p<0.0001$).

Conclusion: When the Interstitial Glucose Level is correct, the trending arrow of the CGMS predicts the risk of hypoglycaemia 15 minutes later, but there is a large room for improvement of its accuracy.

Keywords: T1D: Type 1 Diabetes; CGM: Continuous Glucose Monitoring; Hypoglycaemia; Glucose prediction; Capillary glucose

***Corresponding author:** Vincent Rigalleau, Nutrition-Diab tologie, H pital Haut-L v que, Avenue Magellan, 33600 Pessac, France, Tel: +33 5 57 65 60 78; Fax: +33 5 57 65 60 79; E-mail: vincent.rigalleau@chu-bordeaux.fr

Introduction

Real-time Continuous Glucose Monitoring (CGM) systems help to improve HbA1c levels in patients with Type 1 Diabetes [1-3], and reduce the rate of nocturnal hypoglycaemia by the threshold-suspend feature of sensor-augmented insulin pumps [4]. However it is not clear how a sensor predicts a hypoglycaemia in the day-time. We have shown that trending arrows on CGM devices predict later capillary glucose levels [5]. As the accuracy of CGM devices in the hypoglycemic range has been questioned [6,7], we tested whether trending arrows could predict subsequent capillary glucose level lower than 0.80g/L fifteen minutes later, which would enable proactive or corrective actions.

Research Design and Methods

Thirty three patients with T1D were admitted in the Diabetology Unit for education to the use of a CGM system. Twenty three patients were treated with Continuous Subcutaneous Insulin Infusion (CSII), 10 with Multiple Daily Injections

(MDI). The patients were provided with glucose sensors Freestyle® Navigator (Abott Diabetes Care, Alameda, CA) when treated by MDI, Veo™ pump glucose sensors (Medtronic Diabetes, Minneapolis, MN) for patients on CSII. To calibrate the CGM system, they used their own glucometers that were checked for accuracy the day after admission. Capillary glucose levels at fasting state were compared with fasting glucose venous levels measured by the glucose oxidase method: they did not differ significantly (1.78 ± 1.08 vs. 1.84 ± 1.18 g/L) and they were well correlated ($r=0.99$).

During the educational program the patients were requested to note at time 0: the Interstitial Glucose Level (IGL), the trend arrow on the screen (downward, upward or stable), and the Capillary Glucose Level (CGL), and to repeat these measurements 15 minutes later. These observations (one observation = one trend arrow, plus 2 successive interstitial and capillary glucose level measures) were performed to evaluate the glucose sensor accuracy and to check whether the trend arrow did predict the glucose level course (Time 15 – Time 0). The results are expressed as mean $\pm$ SD. The IGL and CGL were compared by paired t tests. The glucose level courses were compared between arrows by analysis of variance with Bonferroni's correction. The analysis was performed using SPSS software (version 10.0; SPSS, Inc., Chicago, IL).

Results

The patients with Type 1 Diabetes were 14 women and 19 men, 41 ± 3 years old, the diabetes duration was 22 ± 12 years, their HbA1C was $8.4 \pm 1.3\%$. They collected 386 observations. The glucose levels were at time 0: IGL= 1.45 ± 0.58 g/L, CGL= 1.56 ± 0.61 g/L, and 15 minutes later: IGL= 1.42 ± 0.57 g/L, CGL 1.53 ± 0.61 g/L. The initial downward arrows were associated with decreasing

CGL: -0.15 ± 0.28 g/L ($n=47$) whereas CGL course were -0.01 ± 0.23 g/L ($n=303$) after initial stable arrows and $+0.02 \pm 0.23$ g/L ($n=36$) after initial upward arrows ($p=0.008$). As shown in the table, similar outcomes were observed for the 222 observations with initially acceptable IGL (0.80-1.60 g/L): 10/32 observations had a final CGL lower than 0.80g/L after a downward arrow; 16/162 after a stable arrow and 0/28 after an upward arrow ($p<0.0001$ by Chi²). Five of the 10 observations with the lowest initial IGL (≤ 1.00 g/L) and a downward arrow had CGL below 0.80g/L 15 minutes later. None of the 82 observations with the highest initial IGL (1, 30-1, 60 g/L) and a stable arrow had CGL below 0.80g/L 15 minutes later.

Discussion

Randomized controlled trials have demonstrated that the CGM systems can help patients with T1D to improve their HbA1C, but it remains debatable whether CGMS are valuable tools to prevent hypoglycaemia (8). Less time spent in hypoglycaemia [3, 9] and less nocturnal hypoglycaemia [4] argues for the CGM systems. Low accuracy and ~ 0.20 g/L overestimation of low glucose ranges [6, 10] however lead to low sensitivity and high false alert rates [7]: rates of symptomatic hypoglycaemia [11] and fear of hypoglycaemia [10] do not always reduce in patients using CGM systems. Our study quantified the interest of CGM systems to predict, rather than just detect, a later hypoglycaemic event: a capillary glucose below 0.80g/L is not a hypoglycaemia; however its prediction 15minutes before in a T1D subject with a satisfying glucose level has a real practical value. As compared to stable, a descending arrow was associated to a thrice risk of later CGL below 0.80g/L. But most of the CGL below 0.80g/L occurred after stable arrows, even with initial IGL at 1.30g/L in some cases.

Table: The glucose level outcomes in the 222 observations with initial interstitial glucose level between 0.80 and 1.60g/L. (IGL: Interstitial Glucose Level; CGL: Capillary Glucose Level)

Initial arrow	downward	stable	Upward	p
n	32	162	28	
IGL at time 0 (g/L)	1.13 ± 0.23	1.21 ± 0.22	1.19 ± 0.23	NS
IGL 15 minutes later	1.00 ± 0.32	1.21 ± 0.28	1.33 ± 0.27	<0.001
CGL at time 0 (g/L)	1.36 ± 0.53	1.30 ± 0.37	1.42 ± 0.27	NS
CGL 15 minutes later	1.21 ± 0.49	1.30 ± 0.40	1.45 ± 0.35	0.07
ΔIGL	-0.12 ± 0.25	0.00 ± 0.16	+0.13±0.16	<0.001
ΔCGL	-0.14 ± 0.29	0.00 ± 0.22	+0.03 ± 0.26	<0.005
CGL<0.80g/L 15minutes later (n(%))	10 (31%)	16 (10%)	0	<0.001

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