Is continuous glucose monitoring (CGM) for everyone?

To whom should CGM be prescribed and how?

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Abstract

Are all type 1 diabetes (T1DM) patients potential candidates for continuous glucose monitoring (CGM)? Clearly, some patients improve their metabolic control with this tool, such as adults with poor metabolic control, especially those treated with continuous subcutaneous insulin infusion (CSII), and compliant patients with HbA1c levels <7%. There are also less good candidates for CGM, such as patients aged 8-18 years because they are reluctant to wear the sensors or those with new-onset T1DM. Other patient groups have not yet been evaluated, such as patients aged <8 years, women during pregnancy, and those with HbA1c >10% and/or severe hypoglycaemia. Beyond the indications, the mode of use of CGM is crucial. An appropriate patient selection, in order to choose those able to run the tool and motivated to use it, is necessary. How to prescribe the sensors is also an important question. Two approaches have been compared: patient-led and physician-driven prescription. Both modes of using CGM provide similar long-term metabolic improvement. However, physician-driven prescription is probably more cost-effective. The last key question is the education of patients by an experienced team. It can help them to translate the large amount of data from the monitor into effective self-management for optimizing the CGM experience. However, elaboration of a validated algorithm is necessary to take full advantage of this device.

Keywords: Type 1 diabetes; CGM; HbA1c, hypoglycaemia; CSII; Screening; Cost-efficiency ratio; Education; Prescription; Sensors; Review

Résumé

La mesure continue du glucose (MCG) pour tous ? A qui prescrire la MCG et comment ?

Les diabétiques de type 1 (DT1) sont-ils tous des candidats potentiels pour une MCG ? Certains le sont notamment les patients avec une HbA1c > 8 % surtout s’ils sont traités par pompe à insuline et ceux particulièrement compliants avec une HbA1c < 7 %. Certains sont de moins bon candidats: les sujets âgés de moins de 18 ans parce qu’ils sont réticents à porter l’appareil et les diabétiques de type 1 récents. D’autres n’ont pas été suffisamment évalués en particulier ceux âgés de moins de 8 ans, les femmes en cours de grossesse, ceux très déséquilibrés avec une HbA1c > 10 % ou avec hypoglycémiies sévères. Au-delà de l’indication, la question de la modalité d’utilisation de la MCG est cruciale. Une sélection des patients appropriées, permettant de choisir ceux qui sont capables de comprendre l’outil et motivés pour l’utiliser, est nécessaire. La modalité de prescription des capteurs est également une question importante. Deux approches ont été comparées: une utilisation libre par le patient et une prescription limitée, guidée par le médecin. L’amélioration métabolique à long terme est comparable. Toutefois, une prescription limitée est probablement plus rentable. La dernière question clé est l’éducation des patients par une équipe expérimentée. Elle permet d’aider les patients à traduire la grande quantité de données du moniteur en modification de doses d’insuline ou de mode de vie, ce qui permet d’optimiser l’utilisation de la MCG. Toutefois, la validation d’un algorithme d’interprétation de la MCG est nécessaire afin de profiter pleinement de ce dispositif.

Mots clés : Diabète de type 1 ; MCG; HbA1c, hypoglycémies ; Pompe à insuline ; Sélection ; Rapport cout-efficacité ; Éducation ; Prescription ; Capteurs ; Revue générale.
1. Introduction

The availability of devices for real-time continuous glucose monitoring (CGM) has aroused considerable interest among patients and physicians who expect potential benefits to blood glucose control from their use. Indeed, several randomized controlled studies have demonstrated that using CGM can improve HbA1c levels and/or the number of hypoglycaemic events in type 1 diabetes (T1DM) patients [1-3]. But are all T1DM patients potential candidates for CGM? In an ideal world where sensors are less costly, why not? Recent evidence from a clinical trial population showed that CGM was cost-effective in the T1DM patients who met the clinical-trial inclusion/exclusion criteria [4]. However, sensors are expensive, and it is neither reasonable nor desirable to ask the government to reimburse all sensors for all T1DM patients. This raises the question of to whom and how to prescribe CGM to provide the best cost-benefit ratio. The answer is still not clear. However, some studies have provided some data, in particular, the French multicentre EVADIAC (Evaluation dans le Diabète des Implants Actifs; Evaluation of Active Implants in Diabetics) Sensor Study (publication in progress) [5], which demonstrates that the 1-year use of CGM is able to improve both HbA1c and glycaemic stability in patients with uncontrolled T1DM (Fig. 1).

2. To whom should CGM be prescribed: Who to focus on and who to avoid

All T1DM patients could not potentially improve their metabolic status thanks to CGM. Some of these patients make particularly good candidates: those who have HbA1c levels of at least 7.0% and have demonstrated that they can use these devices on a nearly daily basis [6]; those who have HbA1c levels < 7.0% and have demonstrated that they can also use these devices on a nearly daily basis [6]; patients treated by continuous subcutaneous insulin infusion (CSII). In the EVADIAC Sensor Study, patients treated by CSII (50% of the randomized population) tended to show greater improvements than those treated by multiple daily insulin injections (MDI) [5]. This result is in line with the fact that, when using CSII, patients can more easily make online adjustments to the delivery of insulin according CGM data. Finally, patients who practice frequent daily blood glucometer testing are also good candidates for CGM [8].

On the other hand, some patients are less good candidates. In new-onset T1DM patients using CGM, glycaemic control did not differ from that of patients performing self-monitoring of blood glucose (SMBG), as shown in the paediatric ONSET study [7]. In the 6-month JDRF study, in comparison with adults patients, CGM was less effective in HbA1c reduction in patients aged 8-17 years. This disappointed result was associated with much less frequent use of the devices [2]. However, Subjects in that study who wore the CGM device 6-7 d/wk lowered HbA1c levels by 0.8% without increasing the frequency of low sensor glucose [8].

Some subpopulations have not yet been evaluated, including patients < 8 years, women before and during pregnancy, and those with poor metabolic control (HbA1c > 10%) and/or severe hypoglycaemia. However, one observational study, carried out after the JDRF study, reported a decrease in severe hypoglycaemia in T1DM patients using CGM [9].

So, before prescribing CGM, it is crucial to choose the most appropriate patients. However, the selection criteria is still hypothetical. Are there truly good and bad candidates for CGM? The issue remains moot. For this reason, a test period is needed to confirm the capability and motivation of the selected patients.

3. The screening period

More frequent CGM use is associated with a greater reduction in HbA1c, a finding pertinent to all age groups [2, 8], although not everyone is able to maintain such compliance. In addition, while it provides a lot of information on glycaemic control, CGM can also interfere with daily life. The instrument can sound an alarm in cases of hypoglycaemia or hyperglycaemia. SMBG must be performed,
at least for calibration of the device. Patients who are expecting CGM to “nurse” their diabetes in their stead are not good candidates. In the EVADIAC Sensor Study, before randomization, all patients had to wear a CGM device during a 10-day test period [5]. At the end of this period, several points were checked, such as the patients’ ability to change sensors, their skill in using the monitor, their willingness to wear the device continuously and, above all, their motivation. Altogether, 257 T1DM patients were screened for inclusion in the study. After the 10-day test period with CGM, 197 patients were randomized into the study. In comparison to the randomized population, patients who failed the screening test ($n = 60$) were younger, had a shorter duration of diabetes, made fewer daily home glucometer readings, experienced more ketoacidosis events and had attained a lower level of education (Table 1). These results suggest that there is a specific motivated population that is able to use CGM. A test period is essential before beginning a long-term CGM experience to select this subpopulation, whatever the indication and age of the patients.

4. How to prescribe sensors: Patient-led or physician-driven prescription?

How to optimize the prescription of sensors is a key question. Should it be unrestricted, such as with strips for SMBG, or discontinuously according to the given patient’s needs? The EVADIAC Sensor Study was designed to compare two approaches of sensor prescription: patient’s self-management vs physician-prescribed use of sensors [5]. In the former approach (group 1), patients were advised to use CGM continuously throughout the study. In the latter approach (group 2), the CGM device was prescribed by the patient’s physician, who asked the patient to use the sensor intermittently according to guidelines based on glucose outcomes. All patients of this group standed with a 15-day sensor use per month for the first 3 months and, thereafter, they continued either in the same manner or with a more extended use during the following 3 months if, at any visit, the patient presented with at least one of the following criteria: HbA1c $\geq 7.5\%$, or more than four mild hypoglycaemic episodes per week or at least one severe hypoglycaemic episode. Thus, the use of the sensors

| Table 1 | Comparison of the population that failed the screening test and the patients randomized into the EVADIAC Sensor Study [5]. |
|-----------------|-------------------------------------------------|-------------------------------------------------|
|                | Randomized patients ($n = 178$) | Screen-failure population ($n = 60$) |
| Male patients (n, %) | 95 (53.4) | 33 (55.0) |
| Age (years) | 36.4 ± 13.6 | 31.2 ± 12.3$^\dagger$ |
| Age < 18 years (n, %) | 24 (13.5) | 9 (15.0) |
| Body mass index (kg/m$^2$)$^a$ | 24.7 ± 3.6 | 23.8 ± 4.2 |
| Duration of diabetes (years) | 16.9 ± 9.6 | 13.2 ± 8.2$^\dagger$ |
| **Insulin regimen (n, %)** | | |
| CSII | 93 (52.5) | 26 (43) |
| MDI | 84 (47.5) | 34 (57) |
| HbA1c (%) | 9.0 ± 0.9 | 9.3 ± 1.3 |
| Patients with one or more episodes of severe hypoglycaemia (n, %)$^b$ | 25 (14.0) | 6 (10.0) |
| Patients with ≥ one diabetic ketoacidosis during the previous year (n, %) | 2 (1.1) | 4 (6.7)$^c$ |
| Daily home glucometer readings (n/week) | 28.2 ± 14.7 | 23.8 ± 13.0$^d$ |
| **Educational level** | | |
| No diploma (%) | 27.1 | 37.9 |
| College graduate (%) | 20.0 | 27.6 |
| Higher education (%) | 52.9 | 34.5 |

Values are means ± SD, unless otherwise specified;
$^\dagger$ $P < 0.05$ (randomized vs screen-failure population);
CSII: continuous subcutaneous insulin infusion; MDI: multiple daily insulin injection;
$^a$ body weight in kilogrammes divided by the square of the height in meters;
$^b$ during the previous year; a severe episode of hypoglycaemia was defined as an event requiring the assistance of another person;
was gradually extended every 3 months to cover 20, 25 and, eventually, 30 days per month.

After 1 year, the HbA1c decrease was similar with both types of prescription, and was significantly greater than that of the control group (Fig. 1). However, it was also observed that the total consumption of sensors over 1 year was significantly lower (by 34%) with the physician-driven vs patient-led prescription [median (Q1; Q3) consumption: patient-led prescription, 3.42 sensors/month (2.20-3.91) vs physician-driven prescription, 2.25 sensors/month (1.27-2.99); P = 0.0001]. Thus, the physician-driven prescription was as effective as patient-led prescription, but was evidently more cost-effective, thereby suggesting that physicians should prescribe sensors discontinuously according to the individual patient’s needs and preferences.

5. On the necessity to educate patients

As CGM provides 288 glucose measurements every day, it is difficult to analyze all these data, especially in unstable T1DM patients. Most patients only analyze real-time glucose measurements to compensate for hyperglycaemia or hypoglycaemia. During the EVADIAC Sensor Study, patients received specific education by the medical team on how to retrospectively analyze and apply the CGM data, and how to confirm glucose values using the meter included in the Navigator® device before making any therapeutic decisions. The patients’ skills were assessed quarterly during the study through a short questionnaire made up of six questions (Table 2). The education was considered optimal if the six items were answered positively at each visit during the entire study and non-optimal if at least one item of the six was not answered positively at any visit. The “optimally educated” patients showed greater improvement in HbA1c compared with the others, a difference that was still significant after adjusting for compliance with CGM (Table 3). Thus, structured education delivered by an experienced team to help patients translate the CGM technology into effective self-management is essential, as suggested by other studies as well [10,11]. However, as yet, there is no validated algorithm, and the analysis of CGM data remains complex.

6. Conclusion: It is necessary to help both patients and physicians interpret CGM data

CGM can improve both HbA1c and glycaemic stability in the long term in uncontrolled T1DM patients and in those with HbA1c levels < 7% [6]. However, to achieve such benefits, an initial screening test period of patients to identify those willing to wear the device is important. Furthermore, specific education by an experienced team to enable patients to adapt insulin doses according to CGM data appears to also be invaluable. Nevertheless, despite these conditions, metabolic results may remain suboptimal [12, 13]. One reason is that patients and perhaps even physicians, as well educated as they may be, are not always able to optimize the use of 288 blood glucose readings per day. Thus, the most important question is not “Is CGM for everyone?”, but rather “How can the use of CGM be optimized?”

The challenge is therefore to elaborate an algorithm that can help patients to determine which CGM data to look at and what decisions to make from these data to take full advantage of the device. Nevertheless, this will never be as effective as an artificial pancreas.

Conflicts of interest statement

J.-P. Riveline participates in advisory boards or as a consultant for Abbott Diabetes Care and has received honoraria, payment for presentations, travel and accommodation expenses covered or reimbursed by Abbott Diabetes Care.

References


