Continuous glucose monitoring system: an attractive support tool in diabetes education

L Saez-de-Ibarra, R Gaspar, A Obesso, L Herranz*

Abstract

The study was designed to determine the usefulness of the CGMS (continuous glucose monitoring system) as a support tool in type 1 diabetes education. The CGMS is a sensor system that measures interstitial glucose levels every five minutes for three or more days, by means of a microelectrode inserted in the subcutaneous tissue.

People with type 1 diabetes (n=52), who actively participated in diabetes self-management programmes, were monitored with CGMS during three to five days. Patients were selected for CGMS when unsatisfied with the glycaemic results achieved, given the effort made. Ten patients used CSII, 14 used insulin glargine plus rapid acting insulin analogue and 28 used NPH insulin plus short acting insulin. All patients used blood glucose self-monitoring, with a mean of 6.5±1.4 glucose readings per day. The CGMS register was evaluated with the patient. Mean capillary glucose during the 15 days prior to CGMS, mean capillary glucose during CGMS and mean capillary glucose during the 15 days after CGMS are compared.

Discussion of the record with the patient frequently allowed detection of inappropriate solving attitudes. Mean capillary glucose dropped from 155±20mg/dL (8.60±1.11mmol/L) prior to CGMS to 143±20mg/dL (7.94±1.11mmol/L) after CGMS (p=0.000). The effectiveness of CGMS (number of patients in whom mean glucose improved) rose from 66.7% in 2001 to 70.6% in 2002, 78.9% in 2003 and 88.8% in 2004.

When the patient is involved in the analysis of glucose fluctuations, CGMS is a useful tool in diabetes education that will help achieve attitude changes because of the evidence depicted by the continuous glucose record. Experience in the use of this tool by the professional will improve its effectiveness.

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Key words

continuous glucose monitoring; diabetes education; patient involvement

Introduction

Major clinical trials have shown that approaching normal glycaemic control postpones or slows the progression of diabetes complications.[1] Self-monitoring of blood glucose (SMBG) has been the most useful instrument in diabetes management and three or more daily glucose measurements are recommended for people with type 1 diabetes.[2]

A continuous glucose monitoring system (CGMS) can play a role in attempting to achieve optimal glycaemic control. The CGMS developed by Medtronic (MinMed®, Northridge, CA) is a sensor system that measures interstitial glucose levels every five minutes (288 measurements/day) for three or more days, by means of a sensor (microelectrode) which is inserted in the subcutaneous tissue. The sensor calibration requires at least four blood glucose measurements with the customary glucose meter. The data are stored in a glucose monitor connected to the sensor by a cable and are only visualised when downloaded to a computer.

Several studies have found that the information provided by the CGMS allows treatment adjustments that make possible an improvement in glycaemic control.[3–5] Other studies have suggested its role as a motivation tool for patients in diabetes education.[6,7] However, some authors affirm that CGMS does not provide an additional benefit to frequent SMBG,[8] though it does show a high incidence of unrecognised hypoglycaemias, particularly nocturnal.[9,10]

The aim of this study was to evaluate the effect that the CGMS has on the patient's self-management and to ascertain if the information provided – and the discussion of the continuous glucose record by the patient and team members – would help achieve attitude changes that improve glycaemic control.

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Research design and methodology

A total of 52 patients (42 women and 10 men) with type 1 diabetes completed the study (from May 2001 to May 2004). The CGMS was used when patients were unsatisfied with the glycaemic results achieved in spite of the effort made. All patients actively participated in diabetes self-management programmes and performed SMBG with a mean of 6.5±1.4 glucose readings per day (before and two hours after breakfast, lunch and dinner). These are follow-up programmes which imply twice a month (preconception care) or once a month visits, aiming to analyse specific individual situations. All patients to whom the CGMS was offered accepted to participate.

The mean age was 34.8±8 years and the mean duration of diabetes was 14±7 years. Ten patients used continuous subcutaneous insulin infusion (CSII) and 42 patients were on multiple daily insulin injection therapy (14 with insulin glargine plus rapid acting insulin analogue, and 28 with NPH insulin plus short acting insulin).

The sensor was usually inserted on Tuesdays to register regular days (Tuesday to Friday), and only exceptionally was the weekend included to analyse particular situations. The first patients had the sensor inserted in the abdominal subcutaneous tissue, making sure the area was free of lipohypertrophy and not injecting insulin in that quadrant. Subsequently, the buttocks were used as the insertion site, with an improvement of the register. All sensors inserted were functional. The glucose meter time was synchronised with the sensor monitor, and patients were instructed to enter glucose meter values (at least six a day) and event markers of meals and insulin into the monitor. Additionally, patients noted down meals and any unusual event.

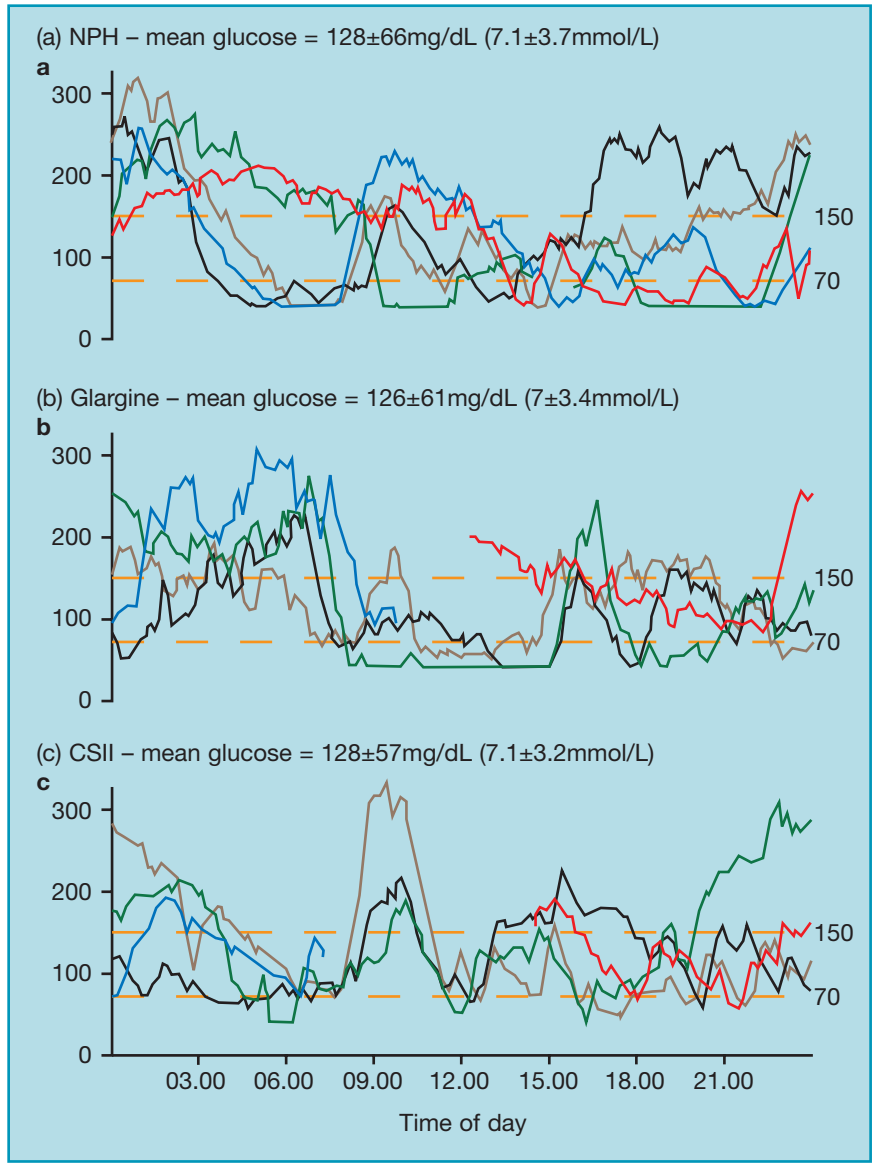

Figure 1. CGMS register examples with the mean glucose level during the monitoring period. Patient (a) regular insulin plus NPH; Patient (b) short acting insulin plus glargine; Patient (c) CSII. Each colour represents a different day

Data were downloaded to the computer and the register obtained was evaluated by team members. The graph, which shows glucose fluctuations over the day (each colour represents a different day), was discussed with the patient and treatment decisions were made.

Mean capillary glucose levels during the following periods were analysed: the 15 days prior to the sensor insertion, the monitoring period, and the 15 days after the monitoring period. Mean capillary pre-breakfast glucose levels were obtained for the same periods. All patients used the same glucose meter (One Touch Profile®, LifeScan, Milpitas, CA) and glucose readings were assessed using a computer program (InTouch®, LifeScan, Milpitas, CA).

The effectiveness of CGMS across each year of the study was calculated as the percentage of patients

in whom mean glucose improved after the monitoring period.

Statistical analyses were conducted using SPSS version 8.0 statistical software (SPSS Inc, Chicago, IL). Values are reported as mean±SD or as percentages. The paired *t* test was used to compare mean glucose levels. The one-way analysis of variance (*F* test) was used to compare the change in mean glucose values (mean glucose value prior to the monitoring period minus mean glucose value after the monitoring period) between groups. Linear correlation coefficients (Pearson) were used to evaluate the relation between the change in mean glucose values and age or diabetes duration. A p value of <0.05 was considered significant.

Results

Records of three patients with different types of insulin treatment (NPH [a]; glargine [b]; CSII [c]) are shown in Figure 1. Each colour in the graph represents a different day. The record of each patient is relatively similar through the days registered, but between patients we see different patterns of glycaemic behaviour; however, the mean glucose level during the monitoring period was similar for the three patients.

Inappropriate problem solving attitudes were frequently detected when discussing glucose records with the patients. For example, in Figure 1(a) high post-dinner glucose is overcorrected leading to nocturnal hypoglycaemia (blue and black lines), while low post-dinner glucose is treated by eating to prevent hypoglycaemia leading to nocturnal hyperglycaemia (red and green lines). In Figure 1(b) post-dinner snack (blue and black lines) or high post-dinner glucose levels (green line) will maintain high glucose levels throughout the night in patients treated with glargine. In Figure 1(c) overcorrecting hypoglycaemia will lead to notable hyperglycaemic excursions, especially after breakfast (black line).

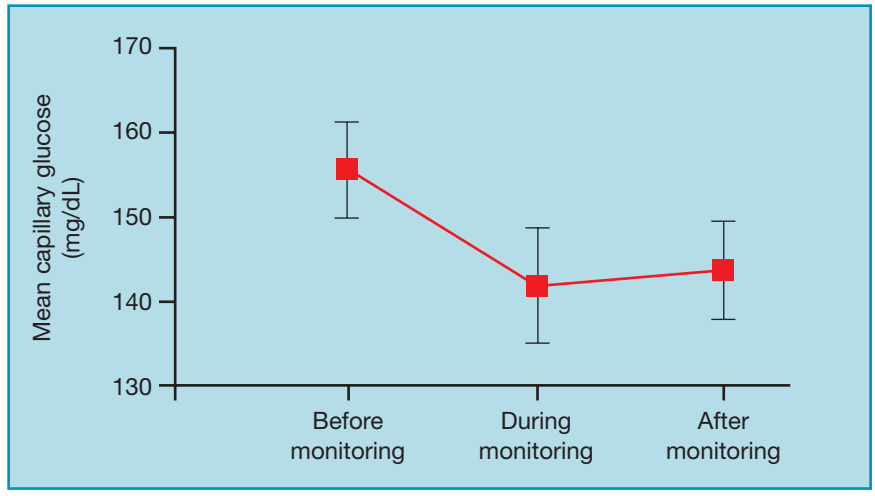

Figure 2. Evolution of mean capillary glucose during the periods analysed

Mean capillary glucose during the 15 days after the monitoring period (143±20mg/dL) (7.94±1.11mmol/L) was significantly lower than mean capillary glucose during the 15 days prior to the sensor insertion (155±20mg/dL) (8.60±1.11mmol/L) (p=0.000). Mean capillary glucose during the monitoring period (142±23mg/dL) (7.88±1.28mmol/L) was also significantly lower than before the monitoring period (p=0.000) (Figure 2).

Mean capillary pre-breakfast glucose after the monitoring period (156±46mg/dL) (8.66±2.55mmol/L) was also significantly lower than mean capillary pre-breakfast glucose levels before the monitoring period (176±42mg/dL) (9.77±2.33mmol/L) (p=0.001).

The number of glucose readings/day was similar during the three periods (before: 6.5±1.5; during: 7.5±1.2 and after: 6.1±1.7) and a good correlation coefficient was observed between the sensor glucose mean and the glucose meter mean (r=0.79).

The drop in mean capillary glucose after the monitoring period was not different for patients who did more than six capillary measurements than for those who did less than six capillary measurements (11.2 *vs* 12.6mg/dL [0.62 *vs* 0.70mmol/L]; p=0.814). Duration of CGMS recording for more than three days was not associated with a larger drop in mean capillary glucose (8.8 *vs* 13mg/dL [0.49 *vs* 0.72mmol/L]; p=0.543). The drop in mean capillary glucose was similar for women in preconception care to that for the other patients (11 *vs* 12.6mg/dL [0.61 *vs* 0.70mmol/L]; p=0.789). Type of insulin treatment did not influence the reduction in mean capillary glucose (CSII: 7.7mg/dL [0.43mmol/L]; glargine: 5.9mg/dL [0.33mmol/L]; NPH: 16.7mg/dL [0.93 mmol/L]; p=0.233). Age and duration of diabetes were not correlated with capillary glucose drop (r=-0.184 and r=-0.120, respectively).

The CGMS was effective in four out of six patients during 2001, in 13 out of 18 patients during 2002, in 15 out of 19 patients during 2003, and in eight out of nine patients during 2004 (Figure 3).

Discussion

This study was designed to determine the usefulness of the CGMS as a support tool in type 1 diabetes education. It is surprising that mean

capillary glucose dropped during the monitoring period in patients who were actively participating in diabetes self-management programmes. If this reduction were to be kept in the long term, a drop in HbA_{1c} from 7.2% to 6.9% would be expected. This fact goes to show that patients do have some knowledge of how to modify their daily routine in order to improve glycaemic levels. However, it is not difficult to understand that it is very hard to keep up these changes in everyday life. Therefore, people with type 1 diabetes need support and strategies to alleviate daily self-care.

The maintenance of mean capillary glucose drop after the monitoring period is in agreement with previous studies that demonstrated the utility of CGMS to facilitate sustainable improvements in glycaemic control[3–5] and its role in diabetes education and patient motivation.[6,7] The fact that effectiveness increased throughout the years of the study proves that diabetes educators also learn by experience, allowing a better interpretation of the registers and consequently improving communication of definite and practical aspects. Experience in the use of this tool has encouraged us to investigate with the patient those situations where the self-care changes suggested are not accepted. On occasions incomplete knowledge of glucose fluctuations or unexplained glucose values will lead to an erroneous conclusion and sometimes a previous negative experience will cause fear or insecurity.

Each patient has their own peculiarities (timetable, habits, treatment and meal schedule), therefore rules or strategies will not be equally useful for all patients. An individual analysis is needed to acknowledge which changes will cause better results with less burden on the patient's life quality. As an example patient (a) in Figure 1, who is in preconception care, mixes regular and NPH insulin before breakfast (07.30h) and lunch (14.30h), uses regular insulin before dinner (22.00h) and NPH at bedtime (00.00h). She does not recognise hypoglycaemic symptoms and, in her aim to improve glycaemic control, she does not have the patience to confirm which changes are needed in her insulin dose. Therefore, she overcorrects high glucose levels with extra insulin, giving way to asymptomatic hypoglycaemic episodes ending up in chaos. This is observed in Figure 1 (a), when the post-dinner (00.00h) glucose value is over 200mg/dL (blue and black days) and she adds regular insulin to her night time NPH dose. On the other hand, when the post-dinner glucose value is below 150 (red and green days) she eats some biscuits with milk to prevent hypoglycaemia, but the result in this case is that glucose levels will be high throughout the night. Since her pre-breakfast glucose levels are always high, she was not willing to lower her insulin dose until we analysed her register. The need to confirm glucose values during the two or three days before making changes was also made self-evident.

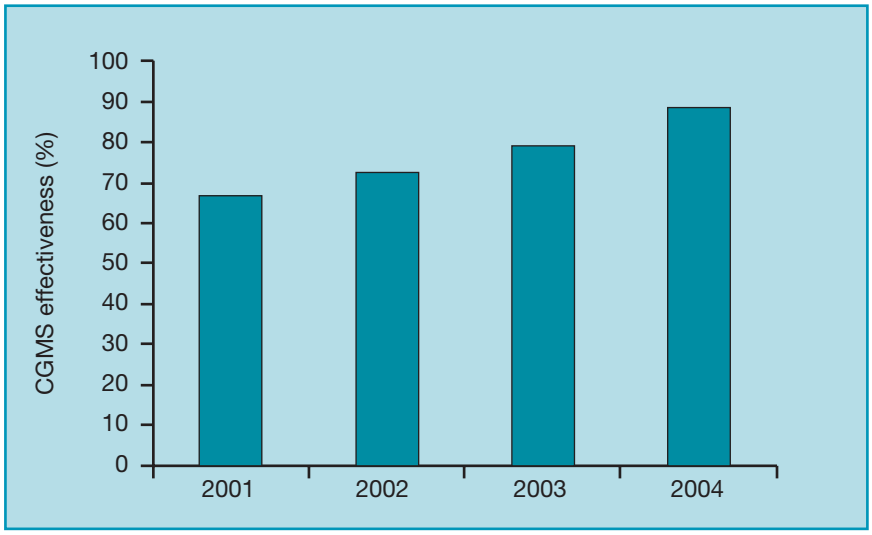

Figure 3. Percentage of patients in whom mean glucose improved after the monitoring period across the years of the study

Use of CGMS should be decided not solely by team members: patients who disagree with certain self-care prescriptions need the reassurance that can be provided by CGMS – alternatively, the patient may have a personal situation which he or she is not willing to share with health care providers.

Patients who performed more than six capillary glucose measurements did not achieve a larger drop in glucose levels, which reaffirms that diabetes educators need to work on redirecting obsessive behaviours which cause confusion. Women on preconception care, who are highly motivated, would have been expected to achieve better results than the other patients. However, this was not the case, probably because interest in glycaemic control was already very high prior to CGMS. On the other hand, participation in a new education strategy will equal patients' motivation.

Using the CGMS as an educational tool implies an additional cost, which we have not quantified. However, it is effective not only because of the results obtained in

the short term but also because of the feeling of reality provided to the patient. Long-term results need to be evaluated.

Implications

- Continuous glucose monitoring is a useful tool in diabetes education, with a drop in mean glucose of 12mg/dL (0.67mmol/L) after the monitoring period, which would represent a drop in HbA_{1c} levels of 0.3%, and a pre-breakfast drop of 20mg/dL (1.11mmol/L).
- Continuous glucose monitoring allows highly motivated patients on self-management programmes to analyse and discuss glucose fluctuations in daily situations. Furthermore, the evidence depicted will give the strength needed for attitude changes.
- Experience in the use of this tool by the professional will improve its effectiveness. When the team (patient/health care providers) establish what exactly they aim to analyse, the results are optimised.

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